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Exploring the factors influencing urban farmers' perception and attitude toward the use of excreta-based organic fertilizers in Arba Minch City, Ethiopia

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This study assesses the factors influencing urban farmers' intentions to adopt excreta-based organic fertilizers in Arba Minch City, Ethiopia, to address the pressing global resource use challenge, particularly the linear system of organic nutrient use and the practice of closing the nutrient loop. To do this, the study applies the Combined Model of Theory of Planned Behavior and Technology Acceptance Model (C-TPB-TAM) to examine the links between attitude, subjective norm, perceived behavioral control, perceived usefulness, perceived ease of use, and farmers' intentions. Surveys that were given to a sample of urban farmers in Arba Minch City were used to get the data. The results shed light on the factors that influence farmers' decisions to use organic fertilizers and offer useful information for resolving the problem of resource use in the context of urban agriculture. The findings specifically show how attitudes, perceived behavioral control, perceived usefulness, and perceived ease of use significantly affect farmers' intentions. However, it was discovered that the subjective norm did not significantly affect the farmer's intention. These results highlight how critical it is to address farmers' attitudes, perceived behavioral control, perceived usefulness, and perceived ease of use to encourage the adoption of sustainable farming methods and close the nutrient loop. Farmers can help mitigate the negative environmental effects of the linear nutrient system and speed up the transition to a more resource- and sustainably efficient agriculture system by implementing organic fertilizers. This study not only adds to the body of knowledge but also has applications for practitioners and policymakers who want to encourage the use of organic fertilizers. To better understand the adoption of organic fertilizer in various locations and nations, future research projects should think about extending the geographical reach and examining real adoption behavior. We can encourage sustainable agricultural practices and work toward a more resource-oriented and resilient future by building on these lessons.

KEYWORDS

theory of planned behavior, technology acceptance model, perceived behavioral control, intention, perceived usefulness, perceived ease of use, subjective norm, attitude

1 Introduction

Globally, urbanization is accelerating; as of 2019 (United Nations, 2019) more than 4.2 billion people lived in urban areas or more than half of the world's population. According to forecasts, this tendency will continue, and by 2041, around 6 billion people—or 70% of the world's population—would reside in urban areas (Satterthwaite et al., 2010; United Nations, 2019). Over the past few decades, developing countries have seen a sizable portion of this worldwide urbanization and population expansion. This tendency is likely to continue, with more than 90% of the upcoming population growth expected in these regions (Zimmerer et al., 2021). But because economic growth has not kept pace with the growing urbanization in developing nations, simultaneous increases in hunger, poverty, and food insecurity have occurred (Hoornweg and Munro-Faure, 2008). Urban agriculture (UA) emerges as a promising response to this issue, providing special opportunity to solve difficulties with food security and advance the realization of Sustainable Development Goals 2 and 11 (Kuusaana et al., 2022). UA gives the urban poor a way to increase their access to food and their standard of living.

More than 800 million people worldwide take part in urban agriculture activities, of which 200 million have businesses set up to sell their produce on the open market (Freidrich and Pandolf, 1997). Additionally, it provides more than 150 million individuals with the opportunity to work full time, and the majority of urban farmers are found in developing nations (Hoornweg and Munro-Faure, 2008). Urban farmers aim to participate in UA in the majority of developing nations to increase food output and security. On the other hand, UA in the industrialized world primarily favors purposes relating to education, society, and health (Wadumestrige Dona et al., 2021). Particularly, the urban poor in developing nations UA facilitate non-market access to healthy food, income generation for women, water reuse, nutrient recovery from solid waste, recycling of solid waste, and fusing urban agriculture with urban greening initiatives. The activities of UA also help to realize sustainable resource exploitation of urban environments and integrate environmental health, economic profitability, and social wellness of urban farmers and customers in the vicinity of urban areas (Nandwani, 2016).

Utilizing resources from the surrounding environment and disposing of garbage in accordance with the environment's reasonable capacity are key components of sustainable urban resource utilization (Zeeman, 2012). However, urban resource usage and waste management generally follow a linear flow pattern in developing nations, where resources are utilized and wastes are discarded carelessly. Wielemaker et al. (2019) claim that the majority of urban centers import synthetic fertilizer for their urban farming endeavors and dispose the nutrients as a solid and liquid waste stream without effective nutrient and organic matter recovery. Integrating a new sanitation system with UA for improved control of soil nutrients is one method of closing the nutrient loop in urban areas (Ryals et al., 2021). Regarding the use of organic wastes and supplying residents with fresh food, UA and cities have a long-standing connection (Cole et al., 2008).

The earth's natural resources are under significant stress as a result of climate change, environmental deterioration, and unsustainable resource usage (McConville et al., 2017). Agriculture land is one sector that has been particularly affected. There has been substantial degradation there, which has led to a loss of fertility and biological life and an increase in the incidence of soil-borne infections, weeds, and pests. In low- and middle-income countries, humans excrete between 85 and 93% and 77 to 90%, respectively, of nitrogen (N) and phosphorus (P), which is released into the environment untreated and has detrimental effects on ecosystem and human health (Fuhrmeister et al., 2015). Conventional urban water and sanitation systems' sufficiency and long-term viability are coming under increasing scrutiny (Harder et al., 2019). Low genetic variety, the overuse of artificial fertilizers and pesticides, and unsustainable and intense agricultural techniques such as the monoculture farming of high-yielding crops are all responsible for this deterioration (Kennard and Bamford, 2020). The use of inorganic fertilizers increases the risk of eutrophication, which is the over-nutrition of water bodies that leads to an increase in algae growth and oxygen depletion during decomposition (Spångberg et al., 2014). Organic waste recycling, which is frequently offered in large quantities in many African towns, is a viable answer because inorganic fertilizers are sometimes too expensive for smallholder farmers to afford (Cofie et al., 2010).

Intense control by taxes is imposed on private investment and a higher level of corruption, and inorganic fertilizers are mostly distributed by governmental sectors in Africa, which restricts access to fertilizer adoption, especially in low-income nations (Hailu and Mezegebo, 2021). Moreover, with the rise in agricultural activities in Ethiopia, there has been an increase in the usage of inorganic fertilizers. At 81 kilograms/hectare, Ethiopia has one of the highest fertilizer use rates in Africa (Hailu and Mezegebo, 2021). While the 1960s Green Revolution was successful in boosting food production and decreasing famine, it also contributed to ecological and environmental issues such as soil acidification, degradation, and water eutrophication, mostly as a result of the overuse of inorganic fertilizers (Aryal et al., 2021). Many low-income farmers are unable to purchase inorganic fertilizer, which can have an impact on whether they choose to use it or not (Hailu and Mezegebo, 2021). Synthetic fertilizer is also a leading cause of nitrous oxide emissions from agriculture, contributing significantly to global warming. Additionally, excessive use of inorganic fertilizers may result in heavy metal deposition in plant tissues, a reduction in the nutritional value of grains, and pollution due to nutrient leaching, soil erosion, and the buildup of hazardous compounds in bodies of water (Sharma and Chetani, 2017). Additionally, the careless use of inorganic fertilizers results in soil acidity, nutrient imbalances, and a reduction in the uptake of other crucial nutrients, all of which reduce crop yields (Sharma and Chetani, 2017; Kakar et al., 2020). Utilizing organic fertilizers recovered from resource-oriented sanitation could possibly offer a solution when considering the problems previously stated.

As humans deplete the world's natural resources, it is more crucial than ever to implement resource recovery technologies (de Morais et al., 2022). The necessity for better nutrient management, particularly thorough recycling of nutrients contained in human excreta to agriculture, has been reemphasized in light of growing concerns about future fertilizer availability (McConville et al., 2015). By directly linking sanitation and agriculture, ecological sanitation systems have the potential to transform nutrient management (Langergraber and Muellegger, 2005). The goal of resource-oriented sanitation is to advance closed-loop methodologies that allow for the separation of human wastes at the source (households) and allow for their re-routing back to agricultural areas for use as crop fertilizers (Simha et al., 2017). In addition, resource-oriented sanitation can offer an ecological method of managing soil nutrients, enhance ecosystem functions and

soil health, decrease waste, and promote more resilient agro-ecosystems, making it a workable economic option (Ryals et al., 2021). By increasing access to agricultural nutrients, resource recovery may help agriculture and provide cash to offset sanitation costs (Lohman et al., 2020). Municipalities are also benefited from it by reducing unlawful waste disposal, replacing natural fertilizer with artificial fertilizer that uses less scarce hard currency, and preventing soil erosion and degradation (Van Veenhuizen and Danso, 2007). Drechsel et al. (2001) claim that by combining sanitation with urban agriculture, the two main issues facing most urban centers—the provision of an adequate food supply and basic sanitation services—can be resolved.

Contrarily, there are a number of difficulties associated with using organic waste, particularly excreta, for urban agriculture (Ward et al., 2008; Drechsel et al., 2011; Kassie et al., 2015; Rozin et al., 2015; Bravo-Monroy et al., 2016; Lorenz and Lal, 2016; Moya et al., 2019; Prince, 2021; Gwara et al., 2022a). Due to alleged health dangers and unsafe practices in some communities, farmers may be reluctant to adopt this method (Rozin et al., 2015). Barriers to its use include complicated regulation, a surplus of manure, fluctuating availability and quality of compost, inadequate institutional and policy support, and others (Bravo-Monroy et al., 2016). Additionally, consumer perceptions may limit the market viability of items made from waste (Moya et al., 2019), and the collecting of excreta is difficult because policies frequently prioritize quantity over quality (Prince, 2021). Concerns about pathogens, heavy metals, and other toxins, as well as stigma and ambiguous rules around the use of human excreta as fertilizer, further impede its commercialization (Ward et al., 2008). Finally, compost is expensive to transport across long distances due to its low demand, marketability, and bulkiness (Gwara et al., 2022a).

Although utilizing excreta in agriculture offers several advantages, its public acceptance is hindered by deeply ingrained cultural beliefs associating feces with dirt and disgust (Jackson and Robins, 2018; Roxburgh et al., 2020). Furthermore, the general public's perception deems products made from human excreta as hazardous and unclean, limiting their popularity (Gale, 2007; Ryals et al., 2021). The challenge is compounded by limited research on the cognitive and psychological factors influencing farmers' decisions to adopt sustainable agriculture techniques (Zeweld et al., 2017). Therefore, this study aims to explore the fore mentioned factors using socio-psychological frameworks. Specifically, it will measure farmers' intentions to adopt excreta-based organic fertilizer, identify the primary determinants influencing these intentions, and examine initiatives taken by relevant bodies to contribute to sustainability in Arba Minch City, Ethiopia. The application of the theory of planned behavior (TPB) and the technology acceptance model (TAM) is central to this investigation, evaluating the intention to adopt pro-environmental behavior (Klöckner, 2013; Schlüter et al., 2017).

2 Theoretical framework and hypotheses

The theory of planned behavior is a widely used theoretical framework in various fields, including environmental science. To give subsequent researchers a comprehensive and useful information base, it is required, according to Si et al. (2019), to examine the development and implementation of the TPB in the field of environmental science. The theory highlights that behavioral response is directly propelled by behavioral intention, and behavioral intention is shaped by subjective cognition, which serves as the influential factor (Ren and Zhong, 2022). According to Adnan et al. (2019), a person's "normative belief system," which is a formulation of anticipation and value, controls their understanding of society standards. To include human perceptual influence over behavior outcomes, Ajzen (1991) combined rational behavior theory with multi-attribute attitude theory to create the TPB. Attitude, subjective norm, and perceived behavioral control all influence behavior intentions (Ajzen, 1991). As indicated by Montano and Kasprzyk (2015), subjective norms refer to a person's perception of whether people who are significant to them believe they should or should not perform the behavior, whereas attitude toward the behavior indicates a person's general favorableness or unfavorability toward performing the behavior. A person's perception of their ability to do the behavior is termed as perceived behavioral control (Si et al., 2019).

TPB has been used in the context of environmental research to address a number of issues, including waste management, climate and the environment, environmentally friendly consumption, saving and conservation, and sustainable transportation (Si et al., 2019). By applying TPB to these subjects, researchers hope to gain an understanding of the elements that affect people's behavior and decision-making in relation to environmental challenges. Si et al. (2019) claim that TPB offers a framework for understanding the determinant factors affecting human behavior and creating successful strategies to promote ecologically sustainable behavior. According to Ajzen and Fishbein (1980), attitude is the way in which a person feels about engaging in a particular conduct. The person's ideas about the benefits or qualities of engaging in the conduct, which are then weighed by judgments of those benefits or qualities, influence their attitude. In other words, someone who thinks acting in a certain way will result in optimistic outcomes will have a favorable attitude toward that action, whereas someone who thinks acting in that way would result in poor outcomes will have a negative attitude (Montano and Kasprzyk, 2015). A person's positive attitude toward an activity is more likely to result in the intention to engage in the behavior, that is why attitude is seen to be a key determinant in behavior prediction (Montano and Kasprzyk, 2015). Based on the theoretical background presented, the following hypothesis is proposed:

> *Urban farmers' attitudes towards excreta-based organic fertilizers positively influence their adoption intentions.*

The second TPB construct, the subjective norm, describes the perceived social pressure to engage in or refrain from engaging in a behavior. Ajzen and Fishbein (1980) claim that the subjective norm is the person's perception of whether important individuals think they must carry out the behavior. The individual's normative beliefs, or whether significant referents approve or disapprove of engaging in the action, are weighted by their desire to follow those referents, and these beliefs define the person's subjective norm (Montano and Kasprzyk, 2015). In other words, people are a high probability to perform a behavior if they believe significant other approve of it and are motivated to live up to their expectations (Adnan et al., 2019). Farmers' intentions to limit fertilizer application may be greatly influenced by social expectations from influential coworkers, family, or friends, for instance (Cook et al., 2021). On the basis of the theoretical foundation described, the following hypothesis is put forth:

SN positively influence urban farmers' intentions to adopt excreta-based organic fertilizers.

The third TPB component, perceived behavioral control (PBC), describes how an individual perceives how easy or difficult an activity is to carry out. PBC is believed to be founded on accessible control beliefs, which are concerned with the existence of elements that may help or obstruct the performance of the activity, according to Ajzen (2020). Control elements include necessary knowledge and skills, the presence or absence of time, money, and other resources, and other people's participation. PBC depicts how the conduct is perceived to be constrained both internally and externally (Taylor and Todd, 1995). An individual will feel themselves to have a great deal of control over a behavior if they hold strong controlling beliefs about the circumstances that facilitate that conduct. In contrast, a person with weak controlling beliefs would feel little control over their action, which would prevent it from happening (Tavallaee et al., 2017). The primary predictor of conduct is intention, which is impacted by attitude, perceived behavioral control, and subjective norm. The stronger the intention to conduct the behavior, and thus the more probable the behavior will be completed, is correlated with the individual's attitude and subjective norms toward the behavior, as well as the degree of perceived behavioral control (Ajzen, 2020). Based on the outlined theoretical background, the following hypothesis is proposed:

Urban farmers' PBC over excreta-based organic fertilizers positively influences their adoption intentions.

The technology acceptance model (TAM) is more concerned with the intention to adopt technology, while the TPB is more concerned with actual behavior. The TAM, according to Lee et al. (2003), emphasizes the impact of intention and attitude on behavior. However, Davis et al. (1989) proposed the notions of perceived usefulness (PU) and perceived ease of use (PEOU), contending that both constructs have an impact on attitude and intention. According to Tavallaee et al. (2017), PU is the degree to which a person believes that utilizing a system will enhance their performance, whereas PEOU is the degree to which they think using a system will be simple. According to Dong et al. (2022), PU can directly affect farmers' intentions to use a technology since it shows the amount of benefits a person thinks they can have from engaging in a given action. According to Dong et al. (2022), PEOU is related to a technology's simplicity, and people are more inclined to adopt behaviors that are thought to be simple to master. While Davis et al. (1989) defines PEOU as the degree to which a user thinks that utilizing a system will not involve any effort, Taylor and Todd (1995) define PU as the degree to which a person believes that adopting a specific system would increase their work performance. Taking into account the theoretical background outlined, we propose the following hypothesis:

PU of excreta-based organic fertilizers has a direct positive effect on urban farmers' attitudes towards their use.

PEOU of excreta-based organic fertilizers has a direct positive effect on urban farmers' attitudes towards their use.

PU of excreta-based organic fertilizers has a direct positive effect on urban farmers' adoption intentions.

PEOU of excreta-based organic fertilizers has a direct positive effect on urban farmers' PU towards their use.

PU of excreta-based organic fertilizers indirectly influences adoption intentions mediated by attitude.

PEOU of excreta-based organic fertilizers indirectly influences adoption intentions mediated by attitude.

PEOU of excreta-based organic fertilizers indirectly influences adoption intentions mediated by PU and attitude.

The combined theory of the technology acceptance model and theory of planned behavior (C-TAM-TPB) in Arba Minch, Ethiopia, provides a better explanation of the intention of farmers to use organic fertilizer with urban agriculture (see Figure 1). To analyze farmers' actual behavior toward the adoption of new technology, Tavallaee et al. (2017) merged the two models of TPB and TAM. It was discovered that combining TPB and TAM was more rational and precise than doing each analysis separately. Dong et al. (2022) extended the variables horizontally and identified factors influencing the intention to adopt a technology to study the specific relationship between farmers' intention to adapt a new technology and the influencing elements of adopting the system. This approach combines the theoretical underpinnings of TAM, which evaluates factors influencing of farmers' adaption of new system, with TPB, which investigates the establishment of a behavioral intention.

In the realm of technological acceptance, various theories and models have been developed, such as the technology acceptance model (TAM) (Davis, 1989), theory of planned behavior (TPB) (Ajzen, 1985), diffusion of innovation theory (DOI) (Rogers, 2003), theory of reasoned action (TRA) (Fishbein and Ajzen, 1975), social cognitive theory (SCT) (Bandura, 1977), and unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003). Each of these models offers unique insights into the factors influencing technology adoption, and researchers often choose or combine these models based on the specific context and objectives of their studies. While TAM is widely cited and supported empirically, it has limitations in addressing social influences, leading to the need for external variables (Taherdoost and Masrom, 2009). DOI focuses more on system characteristics and organizational attributes, providing a broad perspective but less explanatory power at the individual level (Rogers, 2003). UTAUT, a unified theory, integrates various models but may not capture the intricate interplay of factors comprehensively.

Therefore, the integration of the theory of planned behavior (TPB) and the technology acceptance model (TAM) into the combined model of C-TAM-TPB is justified for several reasons. Both TAM and TPB trace their roots back to the theory of reasoned action (TRA) by Ajzen and Fishbein, establishing a strong theoretical foundation for integration (Valizadeh et al., 2023). While TPB has demonstrated predictive power in explaining various behavioral intentions, it has faced criticism, leading to the incorporation of TAM's ability to study external factors influencing the intention to adopt new technology (Irawan et al., 2022). This integration enhances the framework by considering both internal and external factors, addressing TAM's limitations, such as the absence of social variables (subjective norm) and control variables (perceived behavioral control) (Taylor and Todd, 1995). The addition of social and control

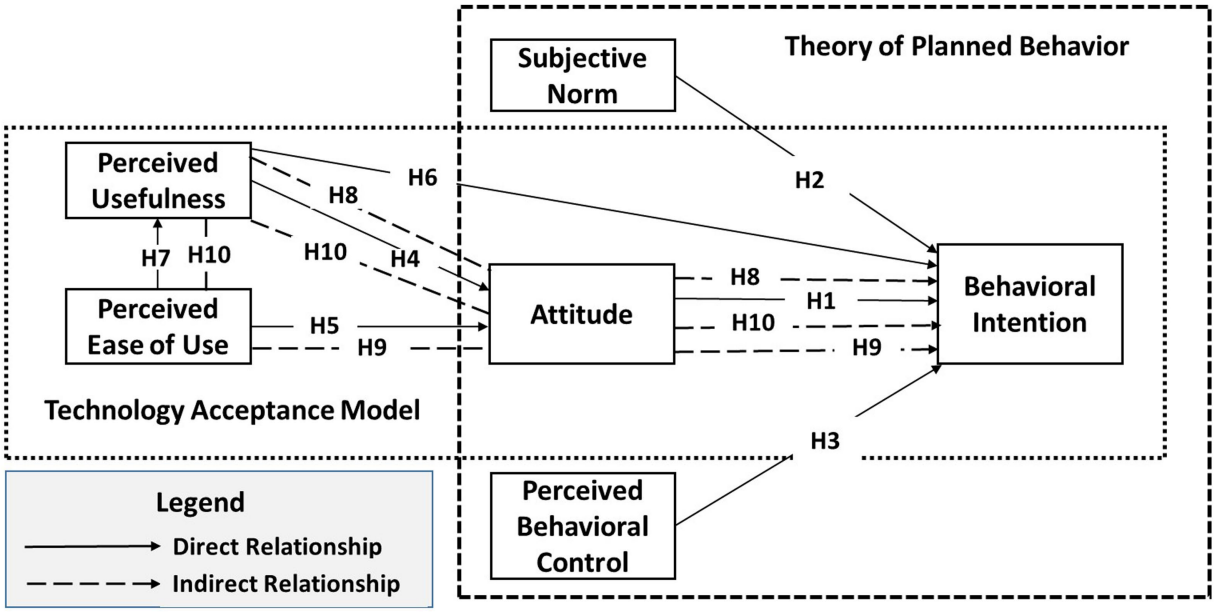

FIGURE 1
Combined model of technology acceptance model and theory of planned behavior (C-TAM-TPB).

variables strengthens the analytical power of C-TAM-TPB in understanding technology adoption behavior (Chen, 2013). Recent research underscores the necessity of combining different conceptual models to achieve a more profound and comprehensive understanding of technology adoption and behavioral intention (Laksono et al., 2022). Therefore, the integration of TPB and TAM into the C-TAM-TPB model provides a more robust and comprehensive analytical framework for studying individual technology adoption behavior.

3 Materials and methods

3.1 Study area

The use of mineral fertilizers is rising gradually on a global scale as a result of the rising demand for both food and non-food crops (Huang et al., 2017). Although it is constantly expanding, the use of synthetic fertilizers in Ethiopia is still quite low (Nyamangara et al., 2020). Globally, chemical fertilizer use has sharply increased along with crop-based agriculture's intensification which is more pronounced in developing countries such as Ethiopia (Hazenbosch et al., 2021). Due to the growing demand for safe and healthful food, long-term sustainability, and worries about environmental contamination brought on by the indiscriminate use of agrochemicals, organic agriculture has become a significant industry globally (Li and Shen, 2021). Organic fertilizers provide advantages such as soil preservation, improve soil fertility, and decreased water pollution (Shaji et al., 2021). The creation of inexpensive, effective, and environmentally friendly organic fertilizers is crucial for the continued expansion of agriculture around the world due to the high costs and environmental damage caused by non-renewable chemical fertilizers (Abebe et al., 2022).

Arba Minch City, located in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia, is the focal point of this study. The city benefits form a favorable climate, including high annual rainfall ranging from 1,200 mm to 1,320 mm and a mild average temperature of 23 degrees Celsius. Due to recent economic growth, the population has increased significantly, from 74,843 inhabitants in 2007 to over 232,811 in 2022, and estimated to be 246,453 by 2023. The city's planning boundary covers an area of 18,757 hectare; among them, 3,246.304 hectares or 17.31% hectares are reserved for urban agriculture (Ajzen, 1980). Urban agriculture activities in Arba Minch City are diverse, taking place in various locations, including inside the city's river banks, allocated zones, and peri-urban areas. These activities are found both on-plot and off-plot, spanning across private lands, public lands, and semi-public lands. Certain areas within the city are specifically designated for horticulture, grazing, and other farming activities, typically situated along streams, swampy areas, and flood-prone regions. These locations are well-suited for agricultural use but are often unsuitable for other urban purposes. The primary areas for urban agricultural lands in Arba Minch City are concentrated in the northern and southern parts, including "Shara Kebele," "Kanchama," and "Gamo" Development Association (Arba Minch City Administration, 2022) (Figure 2).

Several programs have been implemented in Arba Minch City to advance resource-oriented sanitation practices and improve the use of organic fertilizer in urban agriculture. The Resource-Oriented Sanitation Concepts for Peri-urban Areas in Africa (ROSA) project, which ran from 2006 to 2010, is one such program. In addition to establishing the "Egnanew Mayet" composting association in partnership with the Arba Minch City Administration, ROSA concentrated on building ecosan toilets, such as UDDTs, Arborloos, and Fossa Alternas. This organization is essential in collecting solid waste and organic waste from ecosan toilets, which are subsequently composted and given to urban farmers growing vegetables and bananas

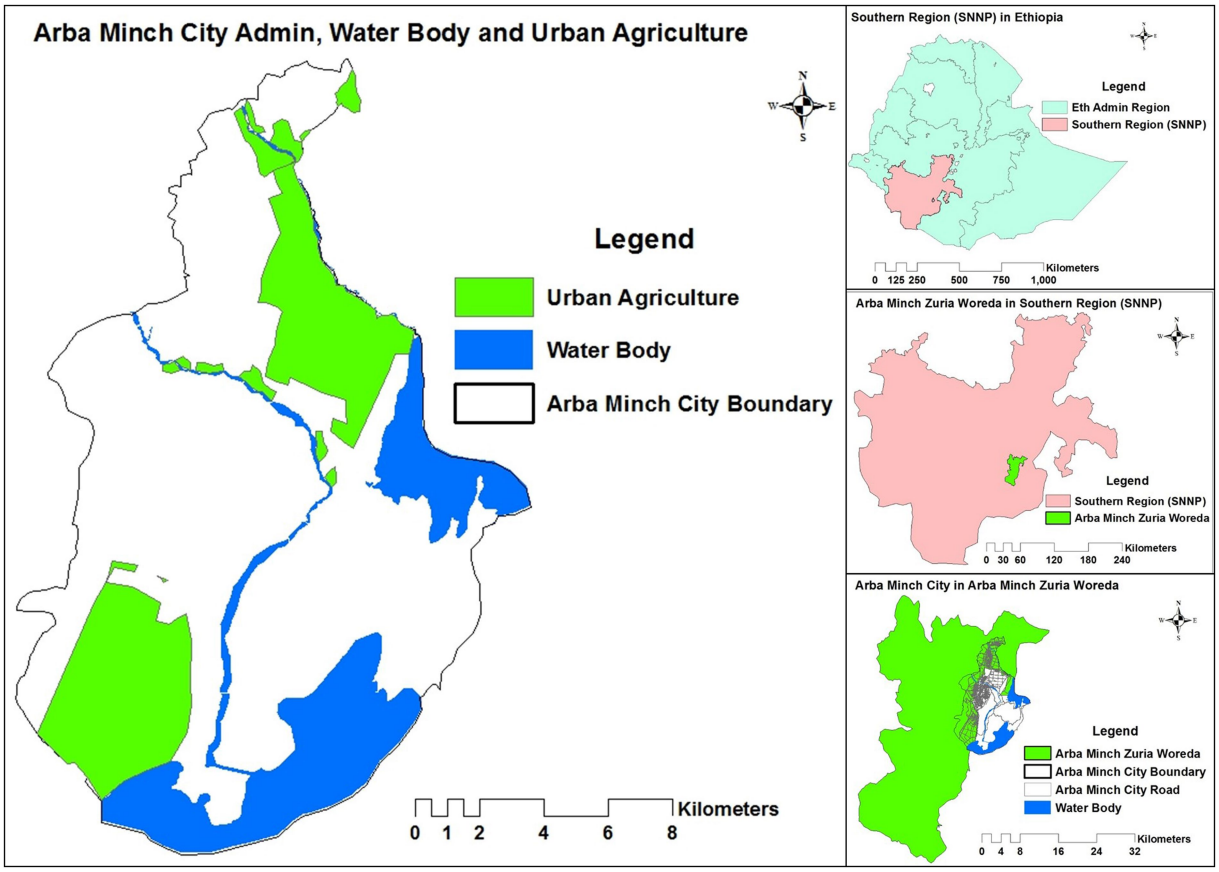

FIGURE 2
Location of Arba Minch City.

in the peri-urban parts of the city. In Arba Minch City, other initiatives have also aided in promoting the usage of organic fertilizer. From 2009 to 2014, the Dutch-funded Sanitation for Peri-urban Areas in Africa (SPA) project concentrated on improving ecosan toilets. To assist the adoption of these toilets, the project made it easier to obtain lower-interest loans from the "Omo" Micro Finance Institution. The Capacity-Linked Water and Sanitation for Africa's Peri-urban and Rural Areas (CLARA) initiative also sought to create a method for recovering nutrients from human waste in urban areas. Two small and micro-businesses participating in the sanitation supply chain services received financial assistance, and their performance was also monitored.

The "Rural–Urban Nexus Establishing a Nutrient Loop to Improve City Region Food System Resilience" (RUNRES) project was launched in 2019 in Arba Minch City to enhance food system resilience and sustainability. This project aims to close the nutrient loop and promote circular economy principles. It includes the establishment of three micro- and small-scale enterprises (MSSEs): the "Egna Newu Mayet" Composting Association, which recycles 1,100 tons of organic compost per year from municipal solid waste; Anjonus, which processes bananas using compost from "Egna Newu Mayet" to enhance the value chain; and the MASSP Urine Recycling Enterprise, which transforms urine into struvite fertilizer. These initiatives reflect the city's commitment to utilizing organic fertilizer and ensuring a sustainable and efficient urban agriculture system, contributing to long-term food system resilience and environmental wellbeing. The RUNRES project is planned to continue until 2027. Therefore, the study focuses on urban farmers in Arba Minch City and the surrounding Arba Minch Zuria Woreda Administration.

3.2 Data source and data collection instruments

The data source for this study was primarily derived from a survey administered to urban farmers in Arba Minch City. A carefully prepared questionnaire was used to gather primary data on a variety of topics, including demographic factors, socioeconomic data, and constructs based questions on the theories of planned behavior (TPB) and technology acceptance model (TAM). We employed trained data collectors to deliver the questionnaire to gather the necessary and detailed information. Additionally, a pilot test of the questionnaire was conducted to improve its content with the aid of city employees and experts. Urban farmers actively participated in the data collection process by providing their responses as a reply to the questions provided by experienced data collectors. The study also employs secondary data by evaluating pertinent literature that backs up the conceptual, theoretical, and empirical studies that are directly related to the research in addition to the main data. We are able to offer detailed information about urban farmers in Arba Minch City primarily to the mix of primary and secondary data.

In our research, the measurement of crucial variables, such as attitudes (ATT), subjective norms (SN), perceived behavioral control (PBC), perceived usefulness (PU), and perceived ease of use (PEOU), was meticulously executed through a structured questionnaire rooted in the combined technology acceptance model and theory of planned behavior (C-TAM-TPB). The questionnaire, a comprehensive tool, delved into various facets, dedicating specific questions to each construct within the C-TAM-TPB framework. For instance, attitudes were probed through an array of five questions, aiming to capture the nuanced sentiments and inclinations of participants regarding the adoption of excreta-based organic fertilizer. The construct of subjective norms was examined through a targeted set of three questions, shedding light on the social influences and expectations that surround the decision-making process for adopting this particular fertilizer. Perceived behavioral control, perceived usefulness, and perceived ease of use were each rigorously assessed with five and four questions, respectively, fostering a nuanced understanding of the multifaceted factors influencing urban farmers' adoption behavior.

To ensure the robustness of our data analysis, we employed descriptive statistics as a fundamental component of our methodological approach. This statistical technique facilitated a comprehensive presentation of participants' responses. Each question's responses, recorded on a four-point Likert scale spanning from "strongly disagree" to "strongly agree," underwent a meticulous calculation of means and standard deviations. These descriptive statistics offered invaluable insights into the central tendencies and variability of participants' perceptions and attitudes regarding the use of excreta-based organic fertilizer. Furthermore, frequency distributions were leveraged to augment the depth of our results, providing a detailed overview of the distribution of responses. This meticulous approach to data measurement and analysis using descriptive statistics underscores the reliability, validity, and comprehensiveness of our research endeavor.

3.3 Sampling procedure

In this study, respondents were chosen by a stratified random sampling procedure, and the stratum was divided into three groups according to the types of fertilizer they applied to their farmland. They, therefore, divided farmers into three groups: those who used organic fertilizer, those who used no fertilizer at all, and those who used synthetic fertilizer on their farms. Information can be gathered from urban farmers and helps to fairly represent respondents by applying stratified random sampling. The majority of the respondents (urban farmers) are located inside the city's administrative limit as well as a neighboring district next to Arba Minch City, where they cultivate vegetables, fruits, and, to some extent, cereals. A simple random sample technique was used to choose respondents among the three strata. In general, the sampling process aids in capturing a variety of urban farmers' perceptions and attitudes toward their adoption of excreta-based organic fertilizer in Arba Minch City.

3.4 Data analysis method

Both descriptive and inferential statistics were applied in this research. This is because both methods enable to understand the varying viewpoints of participants regarding how farmers perceive and act toward the adoption of excreta-based organic fertilizer. Means, standard deviations, frequencies, and percentages are some of the measurements that the descriptive statistic makes use of. Structural equation modeling (SEM) was used in the inferential statistics with STATA 16 and "R" software. The investigation of complex interactions between numerous variables is possible using the SEM model. In the SEM model, there are two phases that must be taken before the actual estimates of associations between variables. First, to determine the internal consistency of the measuring devices, Cronbach's alpha (CR) was used, followed by composite reliability, which guarantees the elimination of random measurement error in the analysis. To find variance in the latent variables, average variance extracted was investigated. The constructs' discriminant validity was also evaluated to make sure they were separate from one another. In addition to absolute fit indices (RMSEA and RMR), incremental fit indices (NFI and CFI), and parsimony fit indices (AGFI and PNFI), several model fitting metrics, including chi-square, degrees of freedom, and probability, were taken into account.

4 Result

4.1 Descriptive results

The study examined the demographic, socioeconomic, and agricultural practices of urban farmers, focusing on their types of agricultural product use and fertilizer adoption. The descriptive results revealed interesting patterns among the respondents. In terms of gender distribution, the majority were male (92.88%) while a smaller proportion were female (7.12%). Age-wise, most respondents fall between 35 and 65 years old (84.27%), with smaller percentages in the 18–35 age range (10.86%) and those aged 65 and above (4.87%). Marital status indicated that the majority of respondents were married (91.39%), followed by those who were not married (3.37%), divorced or separated (3.37%), and widowed (1.87%). Household sizes varied, with a significant proportion having six or more members (56.18%), while smaller percentages had two (1.50%), three (2.62%), four (9.74%), or five (29.96%) members.

Turning to socioeconomic factors, the educational status of respondents varied considerably. A notable proportion were illiterate (19.10%), while others had completed elementary education (49.81%), had completed high school (19.85%), held a certificate or diploma (10.49%), or had a degree or higher (0.75%). In terms of monthly income, the distribution showed diverse ranges. A small percentage had a monthly income less than 1,600 Birr (1.50%), while larger proportions fell into the ranges of 1,600 to 3,200 Birr (2.25%), 3,200 to 3,800 Birr (5.62%), 3,800 to 5,400 Birr (7.49%), 5,400 to 10,800 Birr (14.98%), and above 10,800 Birr (68.16%). Regarding agricultural practices, the respondents reported producing various types of agricultural products. The most common product category was fruits (56.55%), followed by vegetables (25.47%) and cereals (17.98%). In terms of fertilizer use, the majority utilized urea and DAP (48.69%), while a significant portion relied on excreta compost (22.10%). Notably, a considerable proportion reported not using any fertilizer (29.21%) (See Table 1).

The descriptive statistics also offer a comprehensive overview of urban farmers' perceptions related to the adoption of excreta-based organic fertilizer, focusing on key variables of the C-TAM-TPB. The

mean scores present a neutral outlook across these variables: attitude (mean = 2.3775), SN (mean = 2.4657), PBC (mean = 2.3745), PU (mean = 2.4185), and PEOU (mean = 2.4213). This neutrality indicates a balanced perspective among urban farmers, suggesting neither strong favor nor disfavor toward the adoption of excreta-based organic fertilizer. Analyzing standard deviations and variances reveals a limited range of responses, implying a degree of consensus or uniformity in farmers' perceptions. The low standard deviations (attitude = 0.38323, SN = 0.38989, PBC = 0.32157, PU = 0.40400, PEOU = 0.35804) and variances suggest a cohesive pattern in views, indicating a shared understanding or consistent considerations regarding the adoption of this sustainable agricultural practice. The observed neutrality and low variability suggest a potential openness among urban farmers to adopt excreta-based organic fertilizer. The cohesive pattern in perceptions may indicate a shared understanding or common considerations among farmers. This finding highlights the importance of recognizing and addressing specific factors that contribute to this moderate consensus, providing valuable insights for future research and interventions aimed at promoting sustainable agricultural practices in urban farming contexts.

4.2 Reliability and validity of the study

We used correlation analysis to ensure the robustness of convergent validity of the measurement tool. This is substantiated by substantial positive correlations observed among items within distinct constructs. For example, in the perceived usefulness (PU) category, items PU1, PU2, PU3, and PU4 demonstrate strong positive correlations, ranging from 0.537 to 0.661 ($p < 0.001$), indicating a consistent measurement of the concept. Similarly, within the subjective norm (SN) construct, positive correlations are evident among items SN1, SN2, and SN3, ranging from 0.454 to 0.569 ($p < 0.001$), affirming the coherence in capturing the intended construct. These noteworthy correlations within constructs validate the reliability and internal consistency of our measurement items. Additionally, divergent validity is evident through the minimal correlations between items from different constructs. For instance, the correlation between items in attitude (A) and perceived ease of use (PEOU) remains negligible, ranging from 0.001 to 0.126 ($p > 0.05$), underscoring the distinctiveness of these constructs. In summary, these quantitative findings endorse the validity of our measurement tool in effectively capturing the targeted psychological constructs within our research.

The study applied Cronbach's alpha (CA) and composite reliability (CR), as recommended by Hair et al. (2013), to evaluate the data reliability and construct validity. We also used Fornell and Larcker's (1981) criterion to investigate the average variance extracted (AVE) to assess convergent validity. Cronbach's alpha and composite reliability scores should be more than 0.7, according to Hair et al.'s (2011) recommendations, signifying adequate reliability. Moreover, AVE should be at least 0.5, accounting for on average more than half of the variance of the indicators. All items, both in CA and CR, met the minimum criterion of 0.7, according to the results, showing good reliability. The AVE result for perceived behavioral control, with a value of 0.443, was just below the intended threshold but still very close to 0.5. Similarly, the AVE result for perceived ease of use was close to 0.499, meeting the lower threshold of 0.5. However, the threshold value

TABLE 1 Demographic, socioeconomic, and agricultural practices of farmers.

Variable	Frequency	%	Variable	Frequency	%
Sex			Educational status		
Male	248	92.88	Illiterate	51	19.10
Female	19	7.12	Elementary Education (1–8 Grade)	133	49.81
Age			High School (9–12 Grade)	53	19.85
18–35	29	10.86	Certificate or Diploma Holder	28	10.49
35–65	225	84.27	Degree Holder or Above	2	0.75
65 and Above	13	4.87	Monthly income		
Marital status			Less than 1,600 Birr	4	1.50
Not Married	9	3.37	1,600 To 3,200 Birr	6	2.25
Married	244	91.39	3,200 to 3,800 Birr	15	5.62
Divorced or Separated	9	3.37	3,800 to 5,400 Birr	20	7.49
Widowed	5	1.87	5,400 to 10,800 Birr	40	14.98
Household size			Above 10,800 Birr	182	68.16
Two	4	1.50	Types of agricultural product produced		
Three	7	2.62	Vegetable	68	25.47
Four	26	9.74	Fruit	151	56.55
Five	80	29.96	Cereal	48	17.98
Six and above	150	56.18	Types of fertilizer farmer use		
Religious status			Urea and Dap	130	48.69
Orthodox	95	35.58	Excreta Compost	59	22.10
Protestant	172	64.42	No Fertilizer Use	78	29.21

TABLE 2 Results of composite reliability, Cronbach's alpha, average variance extracted, and discriminant validity.

Constructs	Composite reliability	Cronbach's alpha	Average variance extracted	Discriminant validity				
				Attitude	SN	PBC	PU	PEOU
Attitude	0.837	0.836	0.508	0.299				
SN	0.751	0.745	0.502	0.233	0.171			
PBC	0.796	0.793	0.443	0.312	0.222	0.288		
PU	0.847	0.847	0.582	0.336	0.235	0.335	0.378	
PEOU	0.803	0.803	0.499	0.221	0.160	0.225	0.234	0.182

of 0.5 was exceeded by the variables attitude, subjective norm, and perceived usefulness, indicating good convergent validity (see Table 2).

Hair et al. (2010) state that the evaluation of the measuring model is done by looking at a group of indicators. This includes examination of the degree of freedom (df) and probability for chi-square, the goodness-of-fit index (GFI), the root mean square error of approximation (RMSEA), the root mean square residual (RMR), the normed fit index (NFI) and the comparative fit index (CFI) for incremental fit, and the adjusted goodness-of-fit index (AGFI) and the parsimony normed fit index (PNFI) for parsimony fit. According to the model fit results, the model's chi-square value is 348.316 with 189 degrees of freedom (p 0.001). The user model significantly outperforms the baseline model, as seen by the baseline chi-square value of 3481.602 with 210 degrees of freedom (p 0.001). The values of 0.951 and 0.946 for the Tucker–Lewis index (TLI) and comparative fit index (CFI), which are both close to 1, indicate that the model is well fitted. A reasonable fit of the model is indicated by the root mean square error of approximation (RMSEA), which is 0.056 with a 90% confidence interval spanning from 0.047 to 0.065. The overall evaluation of the model fondness further supported by the fact that the standardized root mean square residual (SRMR) is 0.043, which is within a reasonable range. The parsimonious normed fit index (PNFI) is 0.810, and the normed fit index (NFI) is 0.900. In conclusion, the integrated model combining TPB and TAM well describes the factors influencing urban farmers' intents to adopt organic fertilizers in Arba Minch City, Ethiopia. This is demonstrated by the model's good fit to the data based on a variety of fit indices.

4.3 Structural equation model and hypothesis testing

The first hypothesis (H1) proposed that urban farmers' attitudes toward the adaption of organic fertilizers based on excreta will favorably affect their intentions to utilize these fertilizers. This theory is supported by the SEM analysis, which found a significant direct relationship between attitude and behavioral intention with a coefficient of 0.237 ($p = 0.002$), suggesting that more favorable attitudes are associated with higher intents to use organic fertilizers. The second hypothesis (H2) posited that subjective norm (SN) would positively influence urban farmers' intentions to adopt the organic fertilizers. A statistically significant direct relationship between subjective norm and behavioral intention was not discovered by the SEM analysis (Coef. = 0.239, $p = 0.106$). As a result, the data do not support the premise that there is a causal relationship between behavioral intention and subjective norm.

The third hypothesis (H3) suggested that urban farmers' perceived behavioral control (PBC) over using the organic fertilizers would positively influence their intentions to adopt them. The PBC has a significant direct impact on behavioral intention with a coefficient of 0.136 ($p = 0.000$) in the SEM analysis, which supports this hypothesis by showing that farmers' perceptions of control over the use of fertilizers strongly influence their adoption intentions. The results of the SEM model support both hypotheses 4 and 5, which posit that both PU and PEOU have direct and substantial impacts on the attitudinal behavior of farmers in the adaptation of excreta-based organic fertilizer. The SEM result shows that the effect of PU on attitude is estimated to be 0.590 (p 0.001), and the results of PEOU are 0.354 (p 0.001). The result of the study implies that farmers in Arba Minch Cities perceive that adapting excreta-based organic fertilizer is useful and easy to use, which will positively affect their attitude (Table 3).

Hypothesis 6 suggests that PU directly affects urban farmers' intentions to adapt excreta-based organic fertilizer in Arba Minch City. The result of SEM analysis confirms the positive result of the hypothesis as PU has substantial positive effects on behavioral intention, with Coef. = 0.462 ($p = 0.000$). The SEM analysis implies that the behavioral intention of farmers toward the use of organic fertilizer is positively affected by the farmer's perception of whether the fertilizer is beneficial for his or her farmland. Hypothesis 7 posits a direct correlation between PEOU and PU. PEOU had a considerable favorable impact on PU, according to the SEM model analysis (Coef. = 0.795, Std.Err. = 0.049, $z = 6.170$, $p = 0.001$). This result implies a positive link between the two constructs, showing that farmers who believe the adapting excreta-based organic fertilizer is easy to use are more likely to consider them as beneficial.

The research discovered three significant indirect effects between the independent variables (IVs) and the dependent variable (DV), which were mediated by attitude. First, with a coefficient of 0.140 (Std.Err. = 0.046, z = 3.020, $p = 0.003$), perceived usefulness (PU) of organic fertilizers significantly influences farmers' intentions to use them through the mediation of attitude (H8). These findings imply that farmers' attitudes are favorably influenced by the fertilizers' perceived benefits, which in turn increases their intentions to use them. Similar to this, through the mediating variable of attitude (H9), the PEOU of organic fertilizers has a substantial indirect impacts on farmers' intents to adopt these fertilizers. This indirect effect has a coefficient of 0.469 (Std.Err. = 0.043, $z = 10.920$, $p = 0.001$), demonstrating that farmers' attitudes are favorably impacted and their intentions to use the fertilizers are increased when they believe the fertilizers are simple to use. Additionally, through the joint mediation of perceived usefulness (PU) and attitude (H10), the PEOU of organic fertilizers has an indirect

TABLE 3 Summary of hypothesis testing.

Hypothesis sentence	Path	Standardized estimate	*p*-value	Decision
H1: Urban farmers' attitudes towards excreta-based organic fertilizers positively influence their adoption intentions	Attit ->Int	0.739	< 0.001	Accept
H2: SN positively influence urban farmers' intentions to adopt excreta-based organic fertilizers	SN ->Int	0.601	= 0.106	Reject
H3: Urban farmers' PBC over excreta-based organic fertilizers positively influences their adoption intentions	PBC ->Int	0.715	< 0.001	Accept
H4: PU of excreta-based organic fertilizers has a direct positive effect on urban farmers' attitudes towards their use	PU ->Attit	0.793	< 0.001	Accept
H5: PEOU of excreta-based organic fertilizers has a direct positive effect on urban farmers' attitudes towards their use	PEOU ->Attit	0.588	< 0.001	Accept
H6: PU of excreta-based organic fertilizers has a direct positive effect on urban farmers' adoption intentions	PU ->Int	0.793	< 0.001	Accept
H7: PEOU of excreta-based organic fertilizers has a direct positive effect on urban farmers' PU towards their use	PEOU ->PU	0.783	< 0.001	Accept
H8: PU of excreta-based organic fertilizers indirectly influences adoption intentions mediated by attitude	PU ->Attit - > Int	0.465	< 0.001	Accept
H9: PEOU of excreta-based organic fertilizers indirectly influences adoption intentions mediated by attitude	PEOU ->Attit ->Int	0.277	< 0.001	Accept
H10: PEOU of excreta-based organic fertilizers indirectly influences adoption intentions mediated by PU and attitude	PEOU ->PU ->Attit ->Int	0.161	0.003	Accept

beneficial influence on farmers' intentions to adopt these fertilizers. This indirect impact has a coefficient of 0.385 (Std.Err. = 0.064, z = 5.990, $p = 0.001$), which is significant. The result implies that when farmers perceive the fertilizers as easy to use, it not only directly impacts their attitudes but also enhances their perception of the benefits of using these fertilizers (PU), further strengthening their intentions to adopt them.

5 Discussion

The combined theory of planned behavior and technology acceptance model (C-TPB-TAM) serves as the theoretical foundation for this study. According to Taylor and Todd (1995), perceived behavioral control, subjective norm, perceived technological usefulness, behavioral attitude, and perceived technology ease of use are all aspects that affect an individual's behavioral intention. The C-TPB-TAM offers a thorough analysis approach that takes into account many aspects impacting intention by merging the TPB and TAM. The purpose of this study was to examine the C-TPB-TAM's applicability and efficiency in analyzing farmers' behavioral intentions to use organic fertilizers. The C-TPB-TAM addresses this problem and provides a method for evaluating behavior, in contrast to the TAM, which does not directly evaluate behavior (Taylor and Todd, 1995). This study intends to add to the body of knowledge in the field by analyzing how these variables interact to shed light on the factors that influence farmers' decisions to use organic fertilizers.

The study's findings revealed a substantial positive attitude effect on farmers' intentions (Cofe = 0.237, $p = 0.002$), showing that farmers' intention to use excreta-based organic fertilizers is strongly influenced by their overall favorable appraisal of the practice. These results are consistent with earlier studies that have similar topics. For instance, Castillo et al. (2021) discovered that in addition to attitude, subjective norms and perceived behavioral control also had an impact on farmers' adoption of pressurized irrigation technology. Similar to this, Oteng-Peprah et al. (2020) revealed that attitude and subjective norms were important drivers of families' readiness to use gray water treatment technologies in a developing nation, along with perceived behavioral control. Rezaei et al. (2019) study also underlined the importance of attitudes in influencing farmers' intentions to utilize integrated pest management. These results support the theoretical paradigm put forward by Ajzen (1991), highlighting the critical role that attitude plays as a key driver of intention.

The study's findings add to the growing body of literature on the influence of attitude in determining farmers' intentions to use organic fertilizers and support the need for developing strategies that encourage a positive attitude toward sustainable agricultural practices (Ajzen, 1991; Rezaei et al., 2019; Oteng-Peprah et al., 2020; Castillo et al., 2021; Nguyen and Drakou, 2021). However, several research findings have offered opposing perspectives, challenging the notion that attitudes are the main factors influencing intention. For example, Nguyen and Drakou (2021) found that while PBC and SNs influenced intention, attitude had little to no effect on farmers' intents to adopt sustainable agriculture. This shows the complex relationship between attitudes and intentions, and it necessitates more research to comprehend the interplay of several elements that affect farmers' decisions to embrace sustainable farming practices.

A non-significant relationship between subjective norm on farmers' intentions was found in the study of Hypothesis 2, which claimed that subjective norm would favorably influence farmers' intentions. This resulted in Hypothesis 2 not being supported (Cofe = 0.239, $p = 0.106$). This result is in line with a number of research that have found conflicting effects of SN on behavioral intention. In the case of families' readiness to adopt gray water treatment technology, Oteng-Peprah et al. (2020) discovered that subjective norm contributed to influencing intention, but its influence was not equivalent to other components of the TPB. Similar to this, Rezaei et al. (2019) observed that subjective norm did not affect farmers' intention to utilize integrated pest management in a statistically meaningful way. Nguyen and Drakou (2021) also noted that farmers' intentions to adopt sustainable agriculture were not significantly influenced by subjective norm. On the other hand, several research studies emphasize how important subjective norm is in determining intentions. For instance, Castillo et al. (2021) showed that farmers' adoption of pressurized irrigation technology was significantly influenced by subjective norm, while Borges and Lansink (2016) found that farmers' intention to use improved natural grassland was significantly influenced by subjective norm. In addition, according to Cakirli Akyüz and Theuvsen (2020), SN was a major driver for the uptake and maintenance of organic agriculture. Chen (2016) shown that SNs had a profound impact on public intention to use bikes.

A study by Venkatesh et al. (2003) conducts the impacts of SN on intention by applying four different models which includes the theory of reasoned action (TRA), technology acceptance model 2 (TAM2), theory of planned behavior (TPB), and combined model of technology

acceptance model and theory of planned behavior (C-TAM-TPB). The outcome shows that none of the social influence constructs are important when used in a voluntary environment, but they all become important when used in a mandatory one. This might be the reason in this research where the influence of SN on farmers' adaption to excreta compost as a fertilizer in Arba Minch City becomes non-influential. However, social impact tends to be crucial only in the early phases of an individual's encounter with technology, with its significance fading over time and eventually becoming non-substantial with continuous usage, as shown by Venkatesh and Davis (2000) in forced situations. Social influence has an effect on a person's behavior through three methods, according to Venkatesh and Davis (2000): compliance, internalization, and identification. Although internalization and identification have an impact on how people behave, compliance just leads to a person changing their intention in response to social pressure.

The conflicting findings on the relationship between SN on behavioral intention can be linked to a number of sociocultural elements and the unique environments in which farmers work. For instance, past research has revealed that sociocultural elements including taboos, religion, and conventions serve as obstacles to the use of human excrement as fertilizer (Gwara et al., 2022b). According to Mariwah and Drangert (2011), farmers' resistance to using excrement as fertilizer can be due to normative ideas that cause them to feel under social pressure. These ideas might have their roots in worries about odor, health dangers, and how dirty excreta are thought to be. To overcome these sociocultural hurdles and alter farmers' attitudes and views toward employing excreta fertilizers, significant effort and scientific proof are needed to convince farmers of the benefits and safety of such techniques. The impact of subjective norm on behavioral intention can be context-specific and influenced by a variety of sociocultural elements, even if it did not prove to be a major predictor in our study. Future studies should examine the complex dynamics of subjective norm in the use of organic fertilizers and take into account the sociocultural setting in which farmers operates. As a result, we will have a deeper comprehension of the variables affecting farmers' intentions and be better equipped to implement targeted interventions and policies to advance sustainable farming practices.

Hypothesis 3 suggested that perceived behavioral control (PBC) would positively influence farmers' intentions. This hypothesis was supported by the analysis findings, which showed that PBC significantly affects farmers' intentions (= 0.136, $p = 0.000$). The result implies that the perception of urban farmers' ability to control their behavior determines their intention to use organic fertilizer. The relationship between PBC and intention in the agricultural sector has been studied by many scholars. According to Borges and Lansink (2016), PBC is the major determinant of farmers' intentions to adapt improved natural grassland. On the contrary, a study by Castillo et al. (2021) identified PBC as not a major determinant for farmer's use of pressurized irrigation systems. Additionally, Gwara et al. (2022b) highlighted negative perceptions of PBC among farmers in relation to using human excreta as fertilizer. However, Daxini et al. (2019) identified that PBC was the major determinant of farmers' intentions to follow a nutrient management plan. Overall, these findings underscore the complex nature of PBC and its context-dependent influence on farmers' intentions. It is crucial to consider factors such as farmers' perceived self-efficacy, skills, and evaluation of control when designing interventions to promote the adoption of excreta-based organic fertilizers.

The findings of the study approved both hypothesis 4 and hypothesis 5, which posited that PU and PEOU positively affect the attitude of farmers toward the adaptation of excreta-based organic fertilizers, with the results of PU = 0.462, p 0.001, and PEOU = 0.795, p 0.001, respectively. These results are in line with other studies by Folorunso and Ogunseye (2008) and Verma and Sinha (2018), which emphasize the significance of farmers' perceptions of a technology or practice's advantages and simplicity of use in determining their attitudes toward adopting it. On the other hand, the results of hypothesis 6 support that farmers' PU has a significant positive impact on their intention to adopt excreta-based organic fertilizer. The findings are consistent with a previous study by Legris et al. (2003) that examined the role of PU in affecting farmers' opinions of and plans to utilize organic compost.

Hypothesis 7 assesses the relationship between PEOU and PU, and the results confirm that there is a strong positive relationship between PEOU and PU, with Coef = 0.182, $p = 0.001$. The results of the study confirm that farmers tend to be convinced of the benefits of excreta compost if it is easy to apply. This suggests that farmers were more inclined to consider the fertilizers beneficial if they thought they were simple to use. These findings support Davis et al.'s (1989) theory where PU has a directly correlation with ease of use, as being able to engage with a system easily can improve overall work performance. Although perceived usefulness might affect perceived ease of use, it is vital to remember that both constructs are crucial in determining farmers' attitudes and intentions about use organic fertilizers.

The synthesis of existing literature on the mediating role of attitude in farmer intentions, particularly concerning perceived usefulness (PU) and perceived ease of use (PEOU) as independent variables, lays a robust foundation for understanding the dynamics of technology adoption. Suprawan (2017) and Osman et al. (2016) contribute to this understanding by emphasizing the direct influence of attitude on behavioral intention, with Suprawan (2017) proposing that attitude mediates the complex relationship between perceived usefulness, perceived ease of use, and behavioral intention. Verma and Sinha's (2018) insights further enrich this narrative, highlighting the significant impact of intrinsic factors, particularly ease of use, on shaping farmer attitudes and subsequent behavioral outcomes. Translating these theoretical underpinnings into the empirical context of the study, the results affirm and extend these theoretical foundations. Hypotheses 8 (H8), 9 (H9), and 10 (H10) delve into the nuanced interplay of PU and PEOU on farmers' intentions through the lens of attitude as a mediating factor. The findings substantiate these hypotheses, revealing a positive indirect influence of both PU and PEOU on intention, skillfully mediated by attitude.

For H8, intention is positively influenced indirectly by PU, with mediation by attitude (= 0.140, $p = 0.003$), aligning with the empirical insights from Dong et al. (2022) concerning the adoption of ecological farming technology in China. In parallel, H9's exploration of PEOU's impact on intention unveils a favorable indirect effect (= 0.469, $p = 0.001$), skillfully mediated by attitude. H10, which posits the collaborative mediation of PU and attitude in the link between PEOU and intention, receives empirical validation, with PEOU exerting a positive indirect influence on intention (= 0.385, $p = 0.001$) through the interconnected mediation of PU and attitude. This extended discussion underscores the richness of the interplay between psychological factors, particularly attitudes, and farmers' intentions to adopt excreta-based organic fertilizer. It accentuates the necessity for

interventions and strategies geared toward technology adoption in agriculture to holistically address both perceived usefulness and ease of use, thereby shaping positive attitudes among farmers. The study's empirical findings contribute nuanced insights into the intricate psychological dynamics steering technology adoption in the agricultural landscape, offering practical implications for researchers, policymakers, and industry stakeholders alike.

6 Conclusion

This study looked into how urban farmers in Arba Minch City, Ethiopia, felt and intended to use organic fertilizers as part of their sustainable farming methods. To thoroughly examine all of the variables impacting farmers' intentions, the research used a combined model of the theory of planned behavior and technology acceptance model (C-TPB-TAM) as its theoretical framework. The study's conclusion sheds important light on the factors that influence farmers' desire to use organic fertilizers. Farmers' overall positive attitudes toward using excreta-based organic fertilizers strongly influenced their intentions to adopt such practices. Perceived behavioral control was significantly influencing farmers' intentions, which reflected how they believed they could manage their behavior in adopting the fertilizers. Farmers' attitudes and intentions were greatly influenced by perceived usefulness and perceived ease of use. Organic fertilizers were more likely to be adopted by farmers who believed they were advantageous and simple to use. Additionally, the study identified three significant indirect effects through the mediating role of attitude. The perceived ease of use of organic fertilizers had a substantial indirect impact on farmers' intentions through attitude, as did perceived usefulness.

In Arba Minch City, Ethiopia, the effect of subjective norm, which stands for societal influences, on farmers' intents to embrace organic fertilizers, was not substantial. This finding implies that farmers' decisions to embrace sustainable farming practices may be relatively unaffected by social pressures and other people's opinions. This result implies that farmers' adoption decisions about organic fertilizers may not be much influenced by social pressures and significant others' approval. The lack of a correlation between SN and farmers' intentions to adopt organic fertilizer may be attributed to the farmers' level of excreta compost knowledge and awareness, their perception of the risks and hazards associated with excreta application, and the dynamics of the neighboring farming community. A study that examines the causes of SN and seeks to quantify its effects should be created at a specific period. Addressing information gaps, enhancing risk communication, encouraging peer learning, and farmer-to-farmer communication are some potential methods to enhance the function of subjective norm and encourage widespread adoption.

The research adds to the rising collection of scholarly works on the role of attitude in shaping farmers' intentions to adopt sustainable agricultural practices and highlights the need for strategies that foster positive attitudes. However, it is essential to acknowledge the complexity of the relationship between attitudes and intentions as some research results challenge attitudes as the primary determinants of intention. The findings underscore the importance of considering farmers' perceived behavioral control, perceived usefulness, and ease of use when promoting the adoption of organic fertilizers. Policymakers, agricultural extension workers, and practitioners can utilize these insights to design evidence-based interventions that effectively address barriers and facilitate widespread adoption of sustainable agricultural practices. Promoting the use of organic fertilizers can help sustain agriculture, protect the environment, and advance the socioeconomic status of urban agricultural communities in developing nations. Future studies should investigate additional contextual variables and obstacles that could affect farmers' attitudes and evaluate the long-term effects of using organic fertilizers on agricultural productivity and environmental sustainability. Advancing our understanding of the variables influencing farmers' decisions to adopt sustainable agricultural methods can be done by looking into the complex dynamics of subjective norms in the adoption of organic fertilizers.

6.1 Implications and policy considerations

The theoretical implications of this study are significant in advancing the understanding of urban farmers' intention to adopt excreta-based organic fertilizers in the specific context of Arba Minch City, Ethiopia. By combining the theory of planned behavior (TPB) and the technology acceptance model (TAM) into a comprehensive framework (C-TPB-TAM), the research contributes a unique perspective on the interplay between psycho-behavioral elements and technology acceptance factors in shaping farmers' intentions. This integrative model offers a nuanced analysis, going beyond the conventional silos of psychological and technological determinants, thereby enhancing the explanatory power of the study. The theoretical framework successfully demonstrates that individual behavioral factors (attitude, perceived behavioral control, and subjective norm) and technology acceptance factors (perceived usefulness and perceived ease of use) collectively influence urban farmers' intentions to adopt excreta-based organic fertilizers. Furthermore, the study's theoretical implications extend to the confirmation of the direct and indirect effects of TAM and TPB constructs on farmers' intentions. The direct impacts, where attitude, perceived behavioral control, and perceived usefulness directly affect intention, emphasize the central role of individual and technological factors in shaping farmers' behavioral intentions. Importantly, the study reveals the mediation role of attitude in the indirect relationships, indicating that perceived ease of use and perceived usefulness indirectly affect intention through the farmers' overall favorable or unfavorable appraisal of adopting excreta-based organic fertilizers. This nuanced understanding of the interrelations among these constructs provides a solid theoretical foundation for future research endeavors in the realm of sustainable agricultural practices, particularly in urban settings, offering insights that can guide interventions and policy formulations tailored to the specific needs of Arba Minch City and similar contexts.

The study's discussion outcomes and practical insights highlight crucial implications for steering urban farmers in Arba Minch City toward adopting excreta-based organic fertilizers. The observed positive impact of attitude on farmers' intentions emphasizes the necessity for targeted interventions aimed at fostering a favorable perception of organic fertilizers. Addressing cultural taboos, health concerns, and odor-related reservations calls for robust educational initiatives providing scientific evidence. Utilizing existing cooperative structures, akin to the rural 1-to-5 group model, presents a practical

framework for organizing and supporting urban farmers in a collective effort to overcome challenges linked to organic fertilizer adoption. On the policy front, the revealed practical issues stress the urgency of reform to encourage sustainable urban agriculture. The absence of explicit support for urban farming in national agricultural policies necessitates a re-evaluation, urging policymakers to integrate urban agriculture into broader frameworks. Essential support mechanisms, including financial incentives, certification standards, and government-led promotions, are pivotal to empower urban farmers. Collaborative governance and partnerships among stakeholders emerge as crucial for surmounting supply-side challenges, promoting a holistic strategy for a sustainable shift toward organic farming in Arba Minch City.

Based on the discussion and conclusion, a key policy recommendation emerges for fostering the adoption of excreta-based organic fertilizers among urban farmers in Arba Minch City. The study underscores the pivotal role of attitude in influencing farmers' intentions, emphasizing the need for targeted interventions to cultivate a positive perception of organic fertilizers. In this context, a comprehensive educational campaign should be developed to dispel cultural taboos, address health concerns, and counter odor-related reservations associated with excreta-based fertilizers. This campaign should not only provide scientific evidence but also leverage existing cooperative structures, mirroring the successful rural 1-to-5 group model. These structures can be adapted for urban settings to facilitate collective efforts in overcoming challenges linked to the adoption of organic fertilizers. Moreover, the study highlights the limited policy support for urban farming in national agricultural policies. To catalyze sustainable urban agriculture, policymakers should consider revising existing agricultural frameworks to explicitly incorporate and support urban farming initiatives. This reform should encompass financial incentives, certification standards, and government-led promotions tailored to the unique challenges faced by urban farmers. Collaborative governance and partnerships among diverse stakeholders, including city administrations, NGOs, and micro- and small-scale enterprises, are identified as critical components for addressing supply-side challenges. Therefore, the policy recommendation emphasizes the need for a comprehensive, multi-stakeholder approach to create an enabling environment that encourages the adoption of excreta-based organic fertilizers in Arba Minch City.

6.2 Limitation and future research direction

The present study makes important contributions to our understanding of urban farmers' perceptions and intentions toward adopting organic fertilizers. However, certain limitations should be acknowledged. First, the study's sample was largely confined to Arba Minch City, Ethiopia, which would limit the applicability of the results to the whole nation. To increase the representativeness of the findings, future study should try to include other cities and towns in Ethiopian in addition to exploring experiences from other African nations. Furthermore, to increase the findings' regional scope, it is essential to expand this research to additional growing and developing economies. Comparative research involving different nations, such as ongoing twin projects in South Africa, the Democratic Republic of the Congo, and Rwanda, offers the chance for a more thorough comprehension of the elements affecting the uptake of organic fertilizer in the African region. These studies can offer more generalizable insights by involving a diverse set of producers.

The study's emphasis on farmers' intentions rather than their actual adoption behavior should also be noted. While intentions are known to strongly influence future actions, future research should aim to examine the actual adoption levels of excreta-based organic fertilizers among farmers. This would provide a more robust understanding of the effectiveness of interventions promoting organic fertilizer adoption. Moreover, although this study offers valuable insights, limitations exist in terms of sample representativeness, the need to broaden the geographical scope, and the focus on intentions rather than actual adoption behavior. Future studies could expand on these drawbacks by looking at real adoption rates in a wider variety of settings. Researchers and decision-makers can then acquire a more thorough understanding of the elements affecting the adoption of organic fertilizer and use that expertise to support sustainable farming practices in emerging and developing countries.

Data availability statement

The raw data supporting the conclusions 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 participants 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 & editing. KY: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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