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Understanding receptivity to recycled water: mitigating risks and overcoming social reticence for sustainable adoption

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Abstract

Purpose – This study investigates university campus affiliates' perceptions and acceptance of recycled wastewater. It examines the impact of regulation availability, water quality, service and psychological risks, trust in recycled water and the moderating effect of social reticence on receptivity across different applications.

Design/methodology/approach – The research employed a concurrent mixed-methods design including a focus group and cross-sectional survey. Data from 14 focus group interviews and 550 questionnaires were collected and analyzed.

Findings – The qualitative findings show that participants recognized that recycled water sources affect perceptions of quality and reuse potential. Students are often confused about recycling, mistaking it for natural sources like rain or seawater, whereas staff correctly link it to previously used water. However, the quantitative findings reveal that the availability of regulations significantly enhances receptivity toward recycled water across all uses.

Research limitations/implications – The findings imply that on university campuses, perceived risk, trust, regularity clarity, and social hesitation play a role in shaping acceptance of recycled water across different usages.

Practical implications – The findings provide insights for universities and policymakers to design awareness initiatives and communication strategies that encourage the acceptance and use of recycled wastewater in university campuses.

Originality/value – This study offers original insights into the acceptance of recycled water within Arab university communities, emphasizing cultural and informational influences that are rarely examined in sustainability research. It identifies perceived water source and knowledge of the recycling process as key determinants shaping acceptance and use.

Keywords Recycled water, Wastewater, Social reticence, Higher education institutions, Circular economy, PROCESS macro

Paper type Research article

1. Introduction

Water scarcity poses an increasing threat to global sustainability, as climate change and rapid population growth have increased pressure on finite freshwater resources. Recycled water, which is the intended reuse of treated wastewater for drinking and non-drinking purposes, has emerged as a vital strategy to improve water security and support the transition toward circular water economies (e.g. Moesker *et al.*, 2024; Nkhoma *et al.*, 2021). Although it has environmental and economic benefits, societal acceptance remains one of the most stubborn barriers to its large-scale implementation (Ross *et al.*, 2014).

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Public receptivity to recycled water is influenced by a composite interaction of cognitive, emotional, and functional considerations. Perceived service and psychological risks, concerns about water quality, and distrust in authorities often weaken confidence and hinder behavioral adoption (Hou *et al*., 2020; Goodwin *et al*., 2018). Furthermore, in collectivist societies, social reticence often leads individuals to suppress support for recycled-water s initiatives because of fearing that vocal endorsement could mark them as socially unconventional, even when they privately acknowledge water scarcity or even their cultural norms emphasize purity or propriety (Liu *et al*., 2022; Wester *et al*., 2016). In addition, because water reuse carries a primitive "yuck factor," many individuals in culturally conservative settings remain socially reticent to endorse it openly, worried that their neighbors will interpret their acceptance as a breach of purity norms (Kecinski *et al*., 2018). Prior research suggests that when social norms strongly favor caution regarding reclaimed water, people often remain reticent to express acceptance, even in contexts where they privately acknowledge its necessity (Ganguly *et al*., 2025). Therefore, understanding the drivers and inhibitors is critical for developing effective sustainability strategies and policy interventions.

To address these issues, three research questions are formulated: (1) how do individuals perceive and interpret the concept of water recycling? (2) What factors influence their awareness, attitudes, and associations with it? (3) What concerns, conditions, and contextual factors (such as hygiene, health, and acceptable uses) affect individuals' acceptance and behavioral intentions toward recycled water?

The current research uses a mixed-methods design, combining both qualitative and quantitative insights to gain a comprehensive understanding of receptivity to recycled water. This approach enables triangulation between personal experiences and measurable constructs—enhancing the reliability and relevance of the findings (Creswell and Plano-Clark, 2018). Specifically, the study examines public perceptions and acceptance of recycled water. It investigates how people interpret and relate to the concept of water recycling, as well as the factors that influence their awareness, concerns, and attitudes toward its use. The research also explores how awareness, regulatory availability, perceptions of water quality, and perceived risks interact with trust in recycled water services to shape public receptivity across various application domains. Additionally, it evaluates the moderating effect of social reticence, emphasizing how cultural and social factors impact sustainable behavioral outcomes. Framing this analysis within higher education institutions—key environments for fostering sustainability literacy and behavioral change—this study contributes both theoretically and practically to advancing sustainable water management in Arab contexts. The research focuses on the higher education sector, specifically Egyptian universities. The synthesis of the two study sections occurred during the interpretation of the results (Creswell and Plano-Clark, 2018). The study comprised two parts: a focus group study with university students and interviews with academic and non-academic staff, which provided qualitative data; and a cross-sectional survey, which provided quantitative data.

In the following, we discuss the literature review and hypotheses development. Then, the triangulation design methodology is outlined. Next, the qualitative and quantitative analysis and results are presented. Finally, we discuss the study findings and their theoretical and managerial implications.

2. Literature review

The literature on recycled water acceptance can be broadly organized into three complementary perspectives: perceived risk, institutional governance, and affective-social responses. The first perspective emphasizes the role of service risk and psychological risk as key barriers to public acceptance of recycled water, as individuals often evaluate water reuse technologies through concerns about safety, reliability, and potential health implications. The second perspective highlights the importance of institutional governance mechanisms, particularly the availability of regulatory frameworks and assurances regarding water quality, which shape public confidence in recycled water systems. The third perspective focuses on affective and social responses, emphasizing the role of trust in recycled water systems and social dynamics—such as social reticence—in translating risk perceptions into behavioral receptivity. By integrating these perspectives, the present study explains how institutional signals influence recycled water acceptance both directly and indirectly through perceived service risk (PSR), psychological risk (PPR), and trust in recycled water systems.

2.1 Regulations availability as a determinant of PSR and PPR

Various national and international organizations have established regulatory frameworks and standards intended to ensure the safe use of recycled water. Nevertheless, existing regulatory systems often vary considerably across jurisdictions, and some studies suggest that current regulations—many of which focus primarily on human health—may still be insufficient to address emerging contaminants and other potentially harmful pollutants (Shoushtarian and Negahban-Azar, 2020). Despite these limitations, the literature consistently highlights regulatory availability and clarity as key institutional signals shaping public perceptions of recycled water safety. In particular, the absence of credible and transparent regulatory frameworks can increase PSR, as individuals may question the reliability, monitoring capacity, and operational safety of recycled water systems (Massoud *et al.*, 2018).

Beyond operational concerns, regulatory frameworks also influence PPR, which refers to emotional discomfort or fear associated with using recycled water even when objective safety standards are met (Nkhoma *et al*., 2021; Ross *et al*., 2014). In contexts involving unfamiliar technologies such as water reuse systems, individuals frequently rely on institutional cues when evaluating safety. The visibility and credibility of regulatory frameworks therefore play an important role in reducing psychological uncertainty. Clear and enforceable regulations provide reassurance that treatment processes are subject to oversight, monitoring, and safety verification, particularly when recycled water may involve direct contact or potential consumption (Smith *et al.*, 2018). Empirical evidence further suggests that transparent governance structures, continuous monitoring systems, and effective public communication strategies can substantially reduce psychological barriers toward recycled water adoption (Moesker *et al.*, 2024).

Trust in regulatory authorities, treatment technologies, and governance frameworks has also been identified as a key mechanism linking risk perception to behavioral intention (Leong and Lebel, 2020; Fielding *et al*., 2019). When individuals perceive that water reuse systems operate under strong regulatory oversight and effective monitoring mechanisms, their psychological discomfort tends to decrease and their openness toward recycled water increases—even in contexts involving higher perceived risk (Moesker *et al.*, 2024). Similarly, Leong and Lebel (2020) demonstrate that strong regulatory trust can significantly reduce psychological resistance toward recycled water applications involving direct contact. Moesker *et al.* (2024) further argue that regulatory clarity and transparency can transform emotional discomfort into cautious acceptance, even in more sensitive contexts.

Communication strategies also influence how regulatory frameworks shape risk perceptions. McClaran *et al*. (2020) show that terminology used to describe treated water—such as “recycled” versus “reclaimed”—can trigger different emotional and cognitive responses, thereby influencing perceived safety and trust. These findings suggest that effective communication strategies emphasizing regulatory rigor, safety standards, and environmental benefits are essential complements to formal regulatory frameworks. Therefore,

H1. Regulations availability decreases (a) PSR and (b) PPR associated with recycled water.

2.2 Water quality as a determinant of PSR and psychological risk

Water quality represents a critical determinant of the perceived safety and acceptability of recycled water systems. Ensuring that recycled water meets appropriate treatment standards is essential for maintaining safe water reuse practices (Helmecke *et al.*, 2020). Governments and water authorities increasingly emphasize the importance of maintaining high-quality treatment processes to satisfy the requirements of different end users.

Perceptions of water quality can significantly influence PSR. Individuals often evaluate recycled water based on whether its quality meets the standards required for specific applications, such as irrigation, domestic use, or potable consumption. When water quality is perceived as meeting the necessary treatment standards, users are less likely to perceive risks associated with system reliability, treatment effectiveness, or safety (Rebelo *et al.*, 2020). Consequently,

H2a. Water quality negatively affects PSR.

In addition to operational concerns, perceived water quality also influences PPR. PPR reflects emotional reactions such as discomfort, disgust, or anxiety associated with recycled water use. Even when recycled water is technically safe, individuals may rely on subjective cues—such as the water's appearance, odor, and perceived cleanliness—to assess its safety (Dolnicar and Hurlimann, 2010). When recycled water is perceived as clear, odorless, and properly treated, emotional resistance—commonly associated with the "yuck factor"—tends to decline (Menegaki *et al.*, 2009). Individuals frequently rely on indirect cues, such as the origin of wastewater and the perceived effectiveness of treatment technologies, to evaluate safety in the absence of direct technical knowledge (Fielding *et al.*, 2019; Rozin *et al.*, 2015). Research also shows that familiarity with the source of wastewater may influence psychological responses. For instance, Fielding *et al.* (2019) found that individuals were more accepting of recycled water from their own domestic sources, whereas water from communal systems elicited greater psychological discomfort. Similarly, treatment methods perceived as natural or involving multiple purification barriers—such as aquifer recharge or distillation processes—are often associated with higher perceptions of safety (Ellis *et al.*, 2022; Rozin *et al.*, 2015). These perceptions contribute to the formation of quality heuristics, where visible or well-communicated treatment processes serve as signals of safety. Such heuristics help mitigate instinctive emotional reactions, including the "yuck factor," which can otherwise act as a barrier to acceptance of recycled water (Pathiranage *et al.*, 2024).

H2b. Water quality negatively affects PPR.

2.3 PSR and trust in recycled water

PSR represents a critical barrier to public acceptance of recycled water systems. Individuals often evaluate recycled water through the lens of potential health risks, treatment reliability, and uncertainty about the water's source and processing (Wester *et al.*, 2016). When individuals perceive recycled water as unsafe, contaminated, or poorly monitored, their trust in the system is likely to decline. These concerns frequently relate to questions regarding water quality, treatment processes, and the potential presence of harmful contaminants or pathogens. Previous research suggests that these perceptions are not solely based on technical information but are also shaped by the language and framing used when communicating about recycled water systems. For example, Massoud *et al.* (2018) note that some water reuse projects intentionally avoid terms such as "treated wastewater" or "recycled wastewater" because such terminology may amplify public perceptions of risk and reduce trust in the water's safety. Consequently,

H3. Higher PSR decreases trust in recycled water.

2.4 PPR and trust in recycled water

PPR extends beyond operational concerns and reflects emotional reactions such as discomfort, disgust, or anxiety associated with recycled water use. These emotional responses can significantly undermine trust in treatment technologies, regulatory authorities, and water governance systems (Fielding *et al.*, 2019; Ross *et al.*, 2014). Individuals experiencing heightened PPR may question the effectiveness of treatment processes and the competence of institutions responsible for water safety, thereby reducing their openness to recycled water adoption even when objective safety standards are met.

As highlighted by Ding and Liu (2024), trust becomes particularly important when recycled water is proposed for potable or direct-contact applications. In such contexts, psychological concerns can outweigh technical assurances unless institutions successfully address underlying emotional responses and perceptions of risk. Without mitigating these psychological barriers, public confidence in recycled water systems may remain limited despite robust technological and regulatory safeguards.

H4. Higher PPR decreases trust in recycled water.

2.5 Trust in recycled water and receptivity toward recycled water use

Public receptivity toward recycled water is widely recognized as a critical determinant of the success of water reuse initiatives (Abdelradi *et al.*, 2017). However, receptivity varies across countries and populations, as demographic characteristics such as age, gender, and educational level may influence individuals' perceptions of recycled water safety (Mohamed *et al.*, 2024). Although recycled water has become increasingly important within water policy frameworks, many stakeholders still view water reuse projects as risky investments because consumers may reject recycled water and prefer alternative sources, such as bottled or freshwater supplies (Moya-Fernández *et al.*, 2021). Emotional reactions also play a significant role in shaping public attitudes toward recycled water. Negative emotions—such as disgust or discomfort—can arise from perceptions related to the appearance, smell, or perceived contamination of recycled water (e.g. Moya-Fernández *et al.*, 2021). Nevertheless, empirical evidence suggests that these attitudes may evolve over time as public familiarity with recycled water increases. For instance, Diodosio *et al.* (2025) report that communities exposed to water reuse programs over extended periods often develop more positive perceptions once initial concerns regarding safety and quality are addressed.

Trust therefore emerges as a central mechanism through which individuals evaluate recycled water systems. Previous studies consistently show that trust in water authorities, treatment technologies, and regulatory frameworks significantly increases the likelihood of public acceptance of recycled water (Gul *et al.*, 2024; Smith *et al.*, 2018). However, receptivity toward recycled water may vary depending on the intended application. Research suggests that individuals tend to exhibit higher acceptance for non-potable uses compared to potable applications, as perceived risks differ across usage contexts (Goodwin *et al.*, 2018).

Moreover, perceptions of contamination and health risks can also influence receptivity. When individuals believe that recycled water may contain harmful substances, they may experience discomfort or concern when using the water or consuming agricultural products irrigated with recycled water (Ricart *et al.*, 2019). In contrast, trust tends to increase when recycled water is used indirectly rather than through direct consumption, as individuals may perceive indirect exposure as less risky (Saurí and Arahuetes, 2019). Nevertheless, skepticism may still persist when individuals believe that water sources—such as lakes or rivers—are supplied by recycled water, highlighting the importance of trust in shaping acceptance across different reuse contexts.

H5a. Trust in recycled water positively affects receptivity toward the use of recycled water for domestic purposes.

H5b. Trust in recycled water positively affects receptivity toward the use of recycled water for public services.

H5c. Trust in recycled water positively affects receptivity toward the use of recycled water for supplementary water uses.

2.6 Regulations availability and receptivity toward the use of recycled water

Regulatory frameworks have been widely identified as a key institutional mechanism influencing public acceptance of recycled water. The availability and clarity of water reuse regulations play a particularly important role in shaping receptivity toward non-potable domestic applications such as toilet flushing, clothes washing, and garden irrigation. Mukherjee and Jensen (2020) demonstrate that clearly defined regulatory standards significantly enhance public confidence in treated recycled water systems. Despite technological advances in water treatment, the adoption of water reuse technologies—particularly for potable uses—has often been constrained by limited public acceptance. In this context, the presence of transparent and enforceable regulatory frameworks functions as an institutional assurance mechanism that can alleviate safety concerns and foster broader acceptance of recycled water initiatives.

Beyond providing technical guidelines, regulatory frameworks also operate as signals of institutional credibility and governance capacity. Moesker *et al.* (2024) argue that overcoming public hesitancy toward direct potable reuse requires governance approaches that go beyond disseminating technical information and instead emphasize inclusive, transparent, and socially responsive decision-making processes consistent with Responsible Research and Innovation (RRI) principles. Similarly, Santos (2024) illustrate how strong regulatory oversight combined with strategic public engagement has supported high levels of receptivity toward recycled water in Singapore's non-potable reuse programme. Together, these findings suggest that regulatory clarity, transparency, and institutional legitimacy can significantly influence public willingness to adopt recycled water, particularly when the water is intended for domestic uses that involve closer human interaction.

Regulations also influence receptivity toward recycled water used for public services. The reuse of treated wastewater for applications such as street cleaning, park irrigation, fire suppression, and public sanitation systems has gained increasing attention as a sustainable strategy to reduce pressure on freshwater resources. Compared to potable uses, these applications are generally perceived as lower risk and therefore represent an important entry point for the expansion of water reuse initiatives (Fielding *et al.*, 2019; Pathiranage *et al.*, 2024). Nevertheless, public acceptance of these applications remains strongly influenced by the presence of credible regulatory frameworks that ensure the safety, quality, and governance of recycled water systems.

Institutional governance capacity also plays an important role in shaping public confidence in water management systems. Benito *et al.* (2019) show that strong local government leadership improves the efficiency and performance of drinking water services in small municipalities, indicating that governance quality can indirectly enhance public trust in treated water initiatives. Similarly, Benito *et al.* (2019) demonstrate that municipalities managing their own water supply services tend to perform better than those relying on outsourced management. This institutional proximity and operational control can strengthen public confidence in municipal-level recycled water systems.

H6a. Regulations availability positively affects receptivity toward the use of recycled water for domestic purposes.

H6b. Regulations availability positively affects receptivity toward the use of recycled water for public services.

H6c. Regulations availability positively affects receptivity toward the use of recycled water for supplementary water uses.

2.7 Water quality and receptivity toward the use of recycled water

In addition to regulatory frameworks, perceptions of water quality represent another important institutional signal influencing public acceptance of recycled water. Although awareness of the environmental benefits of recycled water has increased in recent years, many individuals continue to perceive recycled water as being of lower quality than freshwater sources. Some members of the public still associate recycled water with potential health risks or contamination concerns (Bass *et al.*, 2022). While developed countries often have access to advanced treatment technologies that produce high-quality recycled water, populations in disadvantaged urban areas may still experience concerns regarding polluted water sources and inadequate treatment systems. Consequently, governments and water authorities have increasingly focused on improving water quality through advanced treatment technologies and enhanced monitoring systems. Effective monitoring and auditing of recycled water quality can significantly increase public confidence in water reuse initiatives by demonstrating that the water is safe and free from harmful pathogens, bacteria, chemicals, and other contaminants (Tortajada, 2020). In domestic contexts, such assurances are particularly important because recycled water applications often involve closer proximity to household activities and human contact.

Perceptions of water quality also shape acceptance of recycled water used in public services. Although some individuals are comfortable with using recycled water in applications such as road dust suppression or public fountains (Goodwin *et al.*, 2018), others remain concerned that recycled water may contribute to environmental degradation, including soil contamination or ecosystem damage. At the same time, the use of recycled water for irrigation and other public purposes may reduce water waste and enhance water resource efficiency (Bass *et al.*, 2022). In such situations, receptivity toward recycled water depends strongly on perceptions that the water has been treated to a sufficiently high standard and will not cause environmental harm (Tortajada, 2020).

Similarly, perceptions of water quality influence receptiveness to recycled water used for supplementary applications such as groundwater recharge or the replenishment of rivers and lakes. Many cities have developed multi-supply spreading basin systems that provide communities with affordable groundwater resources through local water supplies, including recycled water (Bradshaw *et al.*, 2019; Manisha *et al.*, 2024). However, the use of inadequately treated wastewater for supplementary purposes can generate concerns regarding soil degradation or ecological damage. In contrast, previous studies show that advanced wastewater treatment technologies can significantly improve water quality and contribute to groundwater recharge without causing adverse environmental effects. For example, Verma *et al.* (2023) report that the use of treated wastewater for supplementary purposes increased groundwater levels in monitored boreholes, while soil properties and microbial diversity remained largely unchanged in most of the studied areas.

H7a. Water quality positively affects receptivity toward the use of recycled water for domestic purposes.

H7b. Water quality positively affects receptivity toward the use of recycled water for public services.

H7c. Water quality positively affects receptivity toward the use of recycled water for supplementary water uses.

2.8 The mediating role of PSR, PPR and trust

Growing water scarcity and climate change have intensified global interest in water reuse systems; however, public resistance remains one of the major barriers to the implementation of recycled water initiatives. Previous research consistently shows that public attitudes toward recycled water are strongly shaped by perceptions of risk and institutional trust. In particular, PSRs—such as concerns regarding system reliability, treatment effectiveness, and potential health implications—play a critical role in shaping public willingness to adopt recycled water technologies (Nkhoma *et al.*, 2021).

Risk perceptions often operate as barriers to trust in water reuse systems. When individuals believe that water treatment processes may fail or that monitoring mechanisms are insufficient, their confidence in recycled water systems declines. In contrast, trust in water authorities and transparent communication regarding treatment standards and safety protocols can significantly increase public receptivity toward recycled water across various applications, including domestic uses, public services, and supplementary water uses (Nkhoma *et al.*, 2021).

Earlier studies similarly indicate that individuals' concerns regarding water safety and quality strongly influence their behavioral intentions toward water reuse (Leviston *et al.*, 2006). Within this context, perceived health risks represent a central determinant of acceptance, while trust functions as a critical mediator between risk perception and behavioral adoption (Ross *et al.*, 2014). Effective regulatory frameworks and transparent monitoring systems can therefore reduce perceived risks and increase public confidence in water authorities. Through this mechanism, trust operates as a bridge linking institutional assurances provided by regulations to the behavioral acceptance of recycled water technologies.

The importance of regulatory assurance becomes particularly evident in contexts where uncertainty regarding treatment processes exists. Ong (2018) shows that public receptivity toward recycled water—especially for potable and domestic uses—is strongly influenced by perceptions of water safety and treatment reliability. When regulatory guidelines are inconsistent or insufficiently communicated, PSRs increase and willingness to adopt recycled water declines. Similarly, the absence of clear regulatory assurance in public infrastructure applications—such as parks, fountains, and cleaning systems—can increase public hesitation toward recycled water use (Tortajada and Ong, 2016).

Evidence from the Windhoek water reuse programme further illustrates the role of governance structures in shaping public acceptance. Van Rensburg (2018) demonstrates that strong regulatory oversight combined with effective health-risk management and advanced treatment technologies significantly increases public trust and receptivity toward recycled water initiatives. Similar patterns have been observed in supplementary applications such as irrigation and industrial water reuse, where higher perceptions of health risk are generally associated with lower acceptance rates (Dolnicar and Hurlimann, 2010). However, when regulatory frameworks are supported by advanced treatment technologies and transparent monitoring systems, perceived risks decline and adoption becomes more feasible even in large-scale agricultural and industrial contexts (van Rensburg, 2018). Thus,

H8a. PSR and trust in recycled water mediate the relationship between regulations availability and receptivity toward the use of recycled water for domestic purposes.

H8b. PSR and trust in recycled water mediate the relationship between regulations availability and receptivity toward the use of recycled water for public services.

H8c. PSR and trust in recycled water mediate the relationship between regulations availability and receptivity toward the use of recycled water for supplementary water uses.

Beyond operational concerns, emotional and psychological reactions toward recycled water also influence public acceptance. PPR reflects feelings of discomfort, uncertainty, or disgust associated with recycled water use, even when objective safety standards are met. Previous research suggests that regulatory transparency plays an important role in mitigating such psychological concerns. Ross *et al.* (2014) demonstrate through structural equation modeling that when communities perceive regulatory frameworks as transparent and procedurally fair—through mechanisms such as stakeholder engagement, open communication, and reliable information sharing—citizens develop stronger institutional alignment with water authorities.

This institutional alignment strengthens trust in regulatory institutions and treatment technologies, thereby reducing PPR associated with recycled water use.

Similarly, studies highlight that trust in regulatory institutions is a key determinant of public acceptance of recycled water programmes (Leong and Lebel, 2020; Mukherjee and Jensen, 2020). When citizens believe that authorities enforce stringent safety standards and operate under transparent governance frameworks, their psychological resistance to recycled water declines, enabling greater receptiveness to reuse initiatives.

Recent evidence also emphasizes the role of broader psychological and moral factors in shaping trust in water reuse systems. Recent findings further emphasize the importance of socioeconomic, psychological, and moral dimensions in shaping trust in water recycling systems. For instance, loyalty values—emphasizing collective welfare and alignment with institutional objectives—tend to increase trust in water recycling programmes. In contrast, concerns about purity and contamination heighten psychological discomfort and reduce trust in recycled water systems (Bedle, 2024).

The survey also reveals that trust in climate scientists positively influences trust in water recycling programmes, suggesting that individuals' broader environmental belief systems may shape their willingness to adopt recycled water technologies. Interestingly, generalized fears about environmental disasters or climate change do not appear to directly influence trust levels, indicating that confidence in institutions and expertise plays a more decisive role than generalized environmental anxiety (Bedle, 2024). In domestic contexts in particular, strong regulatory oversight and monitoring systems are essential for overcoming the psychological "yuck factor" associated with direct human interaction with recycled water (Dolnicar and Hurlimann, 2010).

These findings suggest that regulatory availability may influence receptivity toward recycled water indirectly by reducing PPR PPR and strengthening institutional trust.

H9a. PPR and trust in recycled water mediate the relationship between regulations availability and receptivity toward the use of recycled water for domestic purposes.

H9b. PPR and trust in recycled water mediate the relationship between regulations availability and receptivity toward the use of recycled water for public services.

H9c. PPR and trust in recycled water mediate the relationship between regulations availability and receptivity toward the use of recycled water for supplementary water uses.

Perceptions of water quality represent another important determinant of public acceptance of recycled water. Previous studies consistently show that trust in recycled water systems is strongly influenced by individuals' perceptions of water safety and treatment quality (Hoang *et al*., 2025). Public confidence in recycled water therefore depends not only on technical performance but also on the information individuals receive regarding water quality from government authorities and service providers (Brouwer *et al*., 2020). When individuals perceive that recycled water meets high safety standards, their trust in water management institutions increases, which in turn enhances receptivity toward water reuse technologies. Maintaining high water quality standards is also essential for reducing PSRs associated with recycled water systems. Effective monitoring and treatment processes can alleviate concerns regarding contamination or system failures, thereby encouraging acceptance of recycled water for domestic and public uses (Dery *et al*., 2019). Water quality perceptions also influence acceptance of supplementary water applications such as groundwater recharge or the replenishment of rivers and lakes. These applications often represent indirect potable reuse systems in which recycled water eventually reenters broader water supply systems (Distler and Scruggs, 2020). Although such indirect applications may be perceived as less risky than direct domestic use, perceptions of water quality and trust in treatment technologies continue to shape public acceptance of these practices.

Taken together, these findings indicate that water quality perceptions influence receptivity toward recycled water primarily through their effects on PSR and institutional trust.

H10a. PSR and trust in recycled water mediate the relationship between water quality and receptivity toward the use of recycled water for domestic purposes.

H10b. PSR and trust in recycled water mediate the relationship between water quality and receptivity toward the use of recycled water for public services.

H10c. PSR and trust in recycled water mediate the relationship between water quality and receptivity toward the use of recycled water for supplementary water uses.

In addition to service-related concerns, psychological perceptions also influence public acceptance of recycled water systems. Individuals may experience discomfort when using recycled water not necessarily because of objective safety concerns but because of perceived social judgments or emotional reactions associated with recycled water use. Previous studies indicate that social norms and shared cultural values play an important role in shaping these perceptions, particularly in collectivist societies where individuals may be strongly influenced by the opinions of others (Bedle, 2024). Emotional reactions such as disgust or discomfort are frequently associated with sensory cues related to recycled water, including perceptions of taste, colour, or smell (Moya-Fernández *et al.*, 2021). Consequently, researchers increasingly emphasize the importance of understanding emotional responses when evaluating public acceptance of recycled water technologies (Ding and Liu, 2021). In many cases, individuals' reactions are shaped not only by personal perceptions but also by concerns about how others might evaluate their behaviour (Liu *et al.*, 2024; Ormerod and Scott, 2013). Improving perceived water quality can therefore play an important role in reducing psychological barriers associated with recycled water use. When recycled water is perceived as clean, odorless, and safely treated, social and cultural concerns may diminish, enabling individuals to develop greater trust in water reuse systems. This mechanism is also relevant to supplementary applications, such as groundwater recharge or river replenishment, in which recycled water is integrated into broader water supply systems. In such contexts, addressing psychological perceptions of risk can help align public attitudes with expert assessments regarding water safety (Ormerod and Scott, 2013). These findings suggest that water quality perceptions influence public receptivity toward recycled water indirectly through their effects on PPR and institutional trust.

H11a. PPR and trust in recycled water mediate the relationship between water quality and receptivity toward the use of recycled water for domestic purposes.

H11b. PPR and trust in recycled water mediate the relationship between water quality and receptivity toward the use of recycled water for public services.

H11c. PPR and trust in recycled water mediate the relationship between water quality and receptivity toward the use of recycled water for supplementary water uses.

2.9 The moderating role of social reticence

Social reticence refers to a form of social anxiety or shyness that limits an individual's ability to actively participate in social interactions or adapt to unfamiliar situations (Robinson *et al.*, 2013). It is related to the person feeling difficulty meeting new people, making new friends, communicating with others, frequently feeling depressed and sad, being sensitive and feeling lonely. In other words, it refers to individuals with high levels of social reticence who often experience discomfort when encountering new environments, technologies, or social practices. This tendency can generate hesitation or suspicion toward unfamiliar innovations (Smith *et al.*, 2019). In the context of water reuse, social reticence may therefore influence how individuals interpret information about regulatory assurances and water quality, shaping their perceptions of the risks associated with recycled water use. Whether from a health perspective (physical risk) or the risk of being blamed by people (PPR).

Previous studies indicate that consumer perceptions and attitudes play a central role in determining the success of recycled water initiatives. Public discussions surrounding water reuse can either strengthen trust or intensify resistance depending on how risks are communicated and socially interpreted (Drechsel *et al*., 2015; Fielding *et al*., 2019; Ross *et al*., 2014). Individuals with higher levels of social reticence may rely more heavily on personal beliefs or socially transmitted concerns than on institutional information, which may amplify perceived risks associated with recycled water systems. As a result, the effectiveness of regulatory frameworks and water quality assurances in reducing perceived risks may vary depending on individuals' levels of social reticence.

The presence of transparent regulatory frameworks and effective institutional communication mechanisms can significantly influence public perceptions of recycled water safety. Regulatory transparency, stakeholder engagement, and risk communication initiatives have been shown to reduce PPRs associated with recycled water use (Drechsel *et al*., 2015; Ross *et al*., 2014). However, when regulatory visibility is limited or technical guidelines remain unclear, communities may exhibit stronger resistance toward recycled water systems, as perceived risks may outweigh scientific evidence regarding safety (Fielding *et al*., 2019). In such contexts, socially reticent individuals may be particularly sensitive to uncertainty, which can strengthen the relationship between regulatory ambiguity and perceived service or PPRs.

Similarly, perceptions of water quality play an important role in shaping risk evaluations, and these effects may be amplified when moderated by social reticence. Even when recycled water undergoes advanced purification and complies with established safety standards, individuals frequently rely on subjective cues—such as color, smell, or culturally embedded perceptions—to assess its safety. Cultural norms and social narratives may further intensify these reactions. For example, previous studies show that recycled water may face resistance because of perceived contamination or moral disgust, even when scientific evidence confirms its safety (Syme *et al.*, 2004; Dolnicar and Hurlimann, 2010). Research also indicates that desalinated water may be perceived as more acceptable for close-to-person uses, while rainwater is sometimes preferred over highly treated recycled water despite potentially higher health risks (Syme *et al.*, 2004). These findings suggest that psychological perceptions and social dynamics may overshadow objective indicators of water quality, particularly when individuals rely on social cues rather than institutional information. In this context, social reticence may act as an important moderating factor influencing how individuals interpret both regulatory signals and water quality information. Socially reticent individuals tend to exhibit greater sensitivity to social judgments and may experience stronger concerns regarding cleanliness, contamination, and the perceived reactions of others (Butler, 2016). Such behavioural tendencies have also been described as onlooking or socially withdrawn behaviour, reflecting an internal conflict between the desire to engage socially and hesitation to initiate interaction (Wu, 2024). Consequently, individuals with higher levels of social reticence may exhibit stronger perceptions of risk when evaluating recycled water systems, particularly in situations where regulatory information or water quality signals are ambiguous.

Taken together, these findings suggest that social reticence may influence the strength of the relationships between regulatory availability, water quality perceptions, and perceived risks associated with recycled water systems.

H12a. Social reticence moderates the relationship between regulation availability and (a) PSR and (b) PPR.

H12c. Social reticence moderates the relationship between water quality and (a) PPR, and (b) PSR.

Figure 1 shows the research framework.

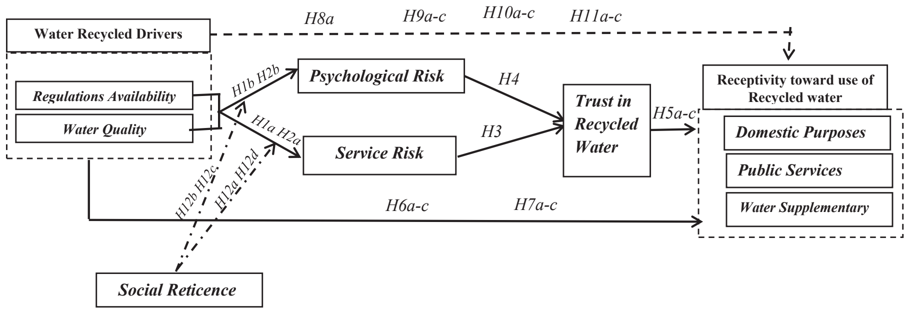

Figure 1. The research framework. Source: Authors' own work

3. Methodology

This section describes the triangulation design adopted. First, the qualitative methodology (focus group and in-depth interviews) adopted is explained, followed by the quantitative methodology (cross-sectional survey).

3.1 Focus group and in-depth interviews

A focus group session was conducted with 8 undergraduate final year students, 7 females and 1 male, ages ranging from 20–21. Participants were introduced to the aims of the study and provided their consent to participate and for the session to be audio recorded. The focus group was conducted in Arabic and was moderated by a member of academic staff with extensive experience in qualitative query and interviewing techniques. A semi-structured format was adopted to target key aspects relevant to the research questions and objective, as well as allow for flexibility for other unforeseen aspects to emerge. The session lasted approximately 50 min. It included a set of open-ended questions to explore participants' awareness, understanding, and attitudes towards water recycling and reuse. Topics covered included, for instance, prior knowledge of water recycling, personal interpretation and associations with the concept, acceptable and unacceptable uses of recycled water, concerns around hygiene and health, potential reassurance factors, acceptable price range, and finally, a vignette scenario to gauge behavioral intentions related to water waste and value perception.

Findings from focus groups were followed by in-depth interviews to explore the applicability of the identified themes beyond the student's sample. Findings were shared with members of academic and non-academic staff to gain more understanding on the perspectives of the broader university community. This aims to expand and refine the findings to a more diverse group of stakeholders. This goal aligns with Lincoln and Guba's (1985) notion of "transferability check" to enhance rigor of qualitative research and the notion of "analytic expansion" endorsed by Charmaz (2014). Furthermore, this would help assess whether findings "ring true" to other members/sample units and acknowledges "resonance" as a quality criterion in qualitative research (Tracy, 2010). Six semi-structured in-depth interviews were conducted with four academic and two non-academic staff. The interview guide was built around the four themes identified previously. Interview questions covered each theme to capture participants' perceptions and the extent to which they align with students' perceptions. Interviews were conducted online and lasted between 25 to 45 min.

3.2 Cross-sectional survey

This research employed cross-sectional survey design to investigate the influence of regulations availability and water quality of recycled water on user's outcomes in the higher education institutions sector, specifically in the Egyptian universities in Egypt.

Sampling and data collection: The target population consisted of all people working in the universities, and the universities' students. We follow the principles of the back-translation method to ensure the linguistic equivalence of the questionnaire (Brislin, 1970; Elalfy *et al.*, 2025). The questionnaire was administered by the researchers face-to-face (using electronic version of survey via a tablet). We adopt a convenience sampling approach because of the accessibility constraints. We asked the participants to respond to all statements in the questionnaire. 550 valid responses were collected. Table 1 shows the sample characteristics. Ethical considerations were observed throughout the data collection process. All participants provided informed consent, and anonymity was maintained by not collecting any personally identifying information.

Construct Measures: Following Jones and Russell (1982), we operationalized social reticence, using 22-items. We measured regulations availability using six-item, five-point Likert scale adopted from Liu *et al.* (2024) study. In addition, we used six items to measure water quality, five-point Likert scale based on the work of Figueiredo *et al.* (2024). We measured individuals' trust in recycled water using five-items developed by Nancarrow *et al.* (2009). We captured both perceived psychological risk and service risk using a six-item and ten-item scales respectively, based on the work of Liu *et al.* (2024). Finally, for the dependent variable, an eight-item scale measured person-organization fit developed by Gu *et al.* (2015).

4. Data analysis and results

This section includes two subsections, which discuss the data analysis and results of the qualitative and quantitative studies, respectively.

4.1 Qualitative study

An in-depth qualitative data analysis was conducted over two stages -as explained below-to identify the general themes discussed in Table 2 about factors influencing receptivity to recycled wastewater.

Table 1. Sample characteristics

Characteristics	Category	No.	%
Gender	Male	315	57.3
	Female	235	42.7
Age	18–24 years old	205	37.3
	25–34 years old	164	29.8
	35–44 years old	89	16.2
	45–54 years old	61	11.1
	Greater than 54 years old	31	5.6
Position	Student	316	57.5
	Employee	115	20.9
	Manager	27	4.9
	Teaching Assistants	43	7.8
	Staff (Academics)	49	8.9
Income	LES7,000	246	44.7
	7,000–9,999	101	18.4
	10,000–14,999	76	13.8
	15,000–24,999	66	12.0
	25,000–34,999	40	7.3
	35,000 OR above	21	3.8

Source(s): Authors' own work

Table 2. Cross-case analysis key differences

Themes	Students	Staff
Theme 1: Source matters	Confusion over the type/source of water that undergoes recycling	More understanding of the fact that recycled water comes from water that "has been used before"
Theme 2: The further the better	Refuse direct and indirect consumption of recycled water	More acceptance of indirect consumption (eating fruits/vegetables) and awareness of the "benefits" of the recycled water to plants and the organic nutrients it might provide
Theme 3: Knowledge can change perceptions	Attention to detail and interest to learn more about technical aspects	More attention to general "evidence" in terms of "research" and "reports" on the quality of the treatment process
Theme 4: Conditional acceptance	Negative feelings and perceiving water recycling as an "extreme" measure	More awareness of the importance of water recycling as a "water efficiency" tool to conserve fresh water sources

Source(s): Authors' own work

4.1.1 Stage 1: student check. An in-depth qualitative data analysis was conducted. A thematic analysis approach was adopted following principles of Braun and Clarke (2013) which are widely adopted and endorsed in qualitative data analysis literature (e.g. Campbell *et al*., 2021). Preliminary coding of the data set was carried out in English, then emerging sub-themes and four key themes were identified.

Discussions in the focus groups have provided rich data that uncovers key perceptions related to water recycling and reuse. Thematic analysis identified 4 key themes namely: source matters, the further the better, knowledge can change perceptions and finally, conditional acceptance. Theme 1 "source matters" indicates that participants rely on their perceptions about the source of recycled water to shape their attitudes towards water recycling and its potential uses. Domestic and municipal waste water (grey/black) was perceived as "not clean" and not suitable for personal consumption. Theme 2 "the further the better" highlights how participants' perceptions of potential uses of recycled water varies depending on the personal proximity to the water. They expressed more acceptance of indirect usage (e.g. garden irrigation, car wash) than direct consumption (e.g. laundry, showering, cooking). Theme 3 "knowledge can change perceptions" uncovered that negative perceptions are mainly rooted in lack of knowledge about the recycled water and the recycling process. Analysis identified four main questions/concerns that represent important knowledge aspects required by participants: where the water is coming from? How is it recycled? What tools/technologies are used and governance in place? Who is managing/operating the process? Finally Theme 4 "conditional acceptance" concludes that achieving public acceptance is a challenging goal. While participants' perceptions might slightly change, there is a high level of resistance to completely embrace recycled water as a substitute for fresh water, especially in personal direct uses.

4.1.2 Stage 2: stakeholders check. Cross-case analysis (Miles *et al*., 2014) was used in this stage to compare data across staff and students' cases. It is widely used in qualitative research to enhance transferability, theoretical generalizability, and contextual understanding across different cases (Yin, 2014; Stake, 2006; Ayres *et al*., 2003). Data analysis indicated that generally, the same themes are relevant across cases. Nonetheless, staff perspectives on some of the themes differ from students. The key differences under each theme are illustrated in Table 2.

4.2 Quantitative study

A summary of the model fit for the current constructs under investigation is shown in Table 3.

The model had a good fit (x^2 (1574) = 1641.908 p = 0.114; GFI = 0.910; NFI = 0.97; CFI = 0.999; TLI = 0.999; RMSEA = 0.010; SRMR = 0.013). All factor loadings' estimates

Table 3. Means, standard deviations, CR, AVE, Standardized factor loadings and *t*-value

Constructs and items	Mean	Stand devia	Standzd loadings	*t*-value	AVE(1)	CR(2)
Regulations availability						
REAv1	2.36	0.943	0.953	51.193	0.904	0.983
REAv2			0.943	48.543		
REAv3			0.954	51.394		
REAv4			0.952	50.987		
REAv5			0.950	50.377		
REAv6			0.952			
Water quality						
WQu1	4.35	0.745	0.946	48.845	0.892	0.980
WQu2			0.951			
WQu3			0.936	46.411		
WQu4			0.948	49.354		
WQu5			0.949	49.650		
WQu6			0.938	47.025		
Perceived psychological risk						
PSR1	2.28	0.978	0.950		0.918	0.982
PSR2			0.964	53.884		
PSR3			0.954	50.861		
PSR4			0.959	52.297		
PSR5			0.964	53.677		
Perceived service risk						
SERI1	2.67	1.03	0.964	56.842	0.928	0.991
SERI2			0.957			
SERI3			0.965	57.115		
SERI4			0.963	56.363		
SERI5			0.963	56.624		
SERI6			0.965	57.417		
SERI7			0.958	54.858		
SERI8			0.970	59.445		
SERI9			0.963	56.502		
Trust in recycled water						
TRWa1	2.49	0.964	0.967		0.923	0.979
TRWa2			0.963	59.630		
TRWa3			0.959	57.944		
TRWa4			0.953	55.774		
Receptivity toward use of recycled water	2.11	0.891				
Domestic purposes					0.906	0.993
RTURWa1	2.11	0.906	0.948	47.687		
RTURWa2			0.948	47.658		
RTURWa3			0.962	51.153		
RTURWa4			0.950	48.215		
Public services						
RTURWa5	2.12	0.902	0.956	49.606		
RTURWa6			0.953	48.951		
RTURWa7			0.942			
RTURWa8			0.948	47.694		
Water supplementary						
RTURWa9	2.12	0.899	0.952	48.544		
RTURWa10			0.946	47.096		
RTURWa11			0.954	49.221		

(*continued*)

Table 3. Continued

Constructs and items	Mean	Stand devia	Standzd loadings	*t*-value	AVE(1)	CR(2)
Social reticence						
SORi1	3.69	0.912	0.989	117.290	0.919	0.993
SORi2			0.992	126.070		
SORi3			0.996	144.843		
SORi4			0.993	130.682		
SORi5			0.994	137.614		
SORi6			0.991			
SORi7			0.992	128.684		
SORi8			0.994	133.929		
SORi9			0.998	157.043		
SORi10			0.993	133.650		
SORi11			0.989	116.406		
SORi12			0.995	139.833		
SORi13			0.995	139.631		

Note(s): (1) Average variance extracted (2) Composite reliability

Source(s): Authors' own work

were above 0.5, and all of t-values were greater than 1.96; loadings ranged from 46.411 to 157.034. Furthermore, as shown in Table 3, all composite reliability scores exceeded the recommended threshold of 0.7. Regarding the AVE scores, all these scores were above the recommended level of 0.5. Thus, all four criteria provided support of the constructs' convergent validity (Fornell and Larcker, 1981; Janssens *et al*., 2008). Table 4 shows the assessment of discriminant validity, providing evidence of discriminant validity for all these constructs.

4.2.1 Direct effect of regulations availability and water quality. Empirical results in Table 5 also show that regulations availability construct influences PSR ($\beta = 0.246$, $p < 0.001$) but does not influence PPR employee's turnover intention ($\beta = -0.068$, $p > 0.05$). Thus, Hypotheses 1a, is supported, but 1b is not supported.

Empirical results in Table 5 also show that while water quality influences PSR ($\beta = 0.215$, $p < 0.001$), it does not influence PPR ($\beta = -0.046$, $p > 0.05$). Thus, Hypothesis 2a is supported, while Hypothesis 2b is not supported.

Table 4. Correlations and square root of the average variance extracted

	SORi	REAv	WQu	TRWa	PSR	RTURWa	SERI
SORi	*0.959*						
REAv	−0.070	*0.951*					
WQu	0.015	0.075	*0.945*				
TRWa	−0.028	−0.029	−0.020	*0.961*			
PSR	0.060	−0.064	−0.035	0.664	*0.958*		
RTURWa	−0.054	0.694	0.112	−0.053	−0.044	*0.952*	
SERI	−0.089	0.233	0.160	−0.043	−0.080	0.245	0.963

Note(s): Social reticence (SORi) Regulations availability (REAv) Water quality (WQu) Trust in recycled water (TRWa) Perceived psychological risk (PSR) Receptivity toward use of recycled water (RTURWa) Perceived service risk (SERI)

Source(s): Authors' own work

Table 5. Direct effect results

Hypotheses	Path coefficient	t-value
H1a: Regulations Availability → Perceived Service Risk	0.246	(5.402)***
H1b: Regulations Availability → Perceived Psychological Risk	−0.068	(−1.55)†
H2a: Water Quality → Perceived Service Risk	0.215	(3.693)***
H2b: Water Quality → Perceived Psychological Risk	−0.046	(−1.83)†
H3: Perceived Service Risk → Trust in Recycled Water	0.007	(1.218)†
H4: Perceived Psychological Risk → Trust in Recycled Water	0.644	(20.032)***
H5a: Trust in Recycled Water → Receptivity toward use of Recycled Water (Domestic Purposes)	−0.050	(-1.306)†
H5b: Trust in Recycled Water → Receptivity toward use of Recycled Water (Public Services)	−0.056	(−1.444)†
H5c: Trust in Recycled Water → Receptivity toward use of Recycled Water (Water Supplementary)	−0.045	(−1.296)†
H6a: Regulations Availability → Receptivity toward use of Recycled Water (Domestic Purposes)	0.639	(20.842)***
H6b: Regulations Availability → Receptivity toward use of Recycled Water (Public Services)	0.622	(19.942)***
H6c: Regulations Availability → Receptivity toward use of Recycled Water (Water Supplementary)	0.625	(20.370)***
H7a: Water Quality → Receptivity toward use of Recycled Water (Domestic Purposes)	0.086	(1.688)†
H7b: Water Quality → Receptivity toward use of Recycled Water (Public Services)	0.082	(1.604)†
H7c: Water Quality → Receptivity toward use of Recycled Water (Water Supplementary)	0.097	(1.923)*
R^2		
Perceived service risk	0.057a (0.030)b	
Perceived psychological risk	0.004a (0.001)b	
Trust in recycled water	0.425a (0.425)b	
Receptivity toward use of recycled water (Domestic Purposes)	0.477a (0.065)b	
Receptivity toward use of recycled water (Public Services)	0.454a (0.060)b	
Receptivity toward use of recycled water (Water Supplementary)	0.467a (0.067)b	

Note(s): ***$p < 0.01$.**$p < 0.05$.*$p < 0.10$.†Not significant (a) regulations availability (b) cases of water quality
Source(s): Authors' own work

4.2.2 Direct effect of PPR and PSR constructs on trust in recycled water. The empirical results also show that while PPR construct influences trust in recycled water (β = 0.644, $p < 0.001$), PSR does not influence it (β = 0.007, $p > 0.05$). Thus, Hypothesis 4 is supported, but Hypothesis 3 is not supported.

4.2.3 Direct effect of trust in recycled water on receptivity toward use of recycled water. The empirical results also show that trust in recycled water construct does not influence all dimensions of receptivity toward use of recycled water, namely domestic purposes (β = −0.050, $p > 0.05$), public services (β = - 0.056, $p > 0.05$), and water supplementary (β = −0.045, $p > 0.05$). Thus, Hypotheses 5a, 5b, and 5c are not supported.

4.2.4 Direct effect of regulations availability on receptivity toward use of recycled water. The empirical results also show that the availability of regulations construct influences all dimensions of receptivity toward the use of recycled water, namely domestic purposes (β = 0.639, $p < 0.001$), public services (β = 0.622, $p < 0.001$), and water supplementary (β = 0.625, $p < 0.001$). Thus, Hypotheses 6a, 6b, and 6c are supported.

4.2.5 Direct effect of water quality on receptivity toward use of recycled water. The empirical results also show that water quality construct does not influence all dimensions of receptivity toward use of recycled water, namely domestic purposes (β = 0.086, $p > 0.05$), public services ($\beta = 0.082$, $p > 0.05$), and water supplementary ($\beta = 0.097$, $p > 0.05$). Thus, Hypotheses 7a, 7b and 7c are not supported.

4.2.6 The serial mediation effect. We used PROCESS macro, specifically model 6 was used. Regarding the indirect relationships between regulations availability and receptivity toward use of recycled water dimensions, H8a-c and H9a-c test these relationships. The bootstrap procedure generated a 95% bias-corrected confidence interval that included zero for the indirect effect of regulations availability on receptivity toward the use of recycled water dimensions, through PSR and trust in recycled water. but rather - 0.001–0.001, for all three dimensions, as shown in Table 6. Thus, hypotheses 8a, b, and c are not supported. In addition, the bootstrap procedure also generated a 95% bias-corrected confidence interval that included zero in the indirect effect for regulations availability on receptivity toward use of recycled water dimensions, through PPR, and trust in recycled water. but rather - 0.001–0.008, for all three dimensions, as shown in Table 6. Thus, Hypotheses 9a, b, and c are not supported.

Regarding the indirect relationships between water quality and receptivity toward use of recycled water dimensions, H10a-c and H11a-c test these relationships. The bootstrap procedure generated a 95% bias-corrected confidence interval that included zero in the indirect effect for water quality on receptivity toward use of recycled water dimensions, through PSR, and trust in recycled water. but rather – 0.001–0.001, for all three dimensions, as shown in Table 6. Thus, Hypotheses 10a, b, and c are not supported. In addition, the bootstrap procedure generated a 95% bias-corrected confidence interval that included zero for the indirect effect of water quality on receptivity toward the use of recycled water dimensions, through PPR and trust in recycled water. but rather – 0.003–0.009, – 0.004–0.009, – 0.003–0.006, respectively, as shown in Table 6. Thus, Hypotheses 11a, b, and c are not supported.

4.2.7 The moderation effects of social reticence. PROCESS macro (model 1) was used to measure the statistical significance of the direct effects of regulations availability (H12a-b) and water quality (H12c-d) on PSR and perceived psychological risk in the presence of the moderation effect of social reticence. Regarding regulations availability, we can deduce that the moderation of social reticence had a significant effect on PSR ($\beta = -0.083$, $p < 0.1$), as shown in Table 7. However, we cannot deduce that the moderation of social reticence had a significant effect on perceived psychological risk ($\beta = -0.005$, $p > 0.1$). Thus, H12a is supported and H12b is not supported.

Regarding water quality, we can deduce that the moderation of social reticence had a significant effect on perceived psychological risk ($\beta = -0.130$, $p < 0.05$), as shown in Table 8. However, we cannot deduce that the moderation of social reticence had a significant effect on risk PSR ($\beta = -0.078$, $p > 0.1$), as shown in Table 8. Thus, H12c is supported and H12d is not supported.

5. Discussion and implications

The study examined the impact of regulatory availability, water quality, service risk, psychological risk, and trust in recycled water on receptivity across various uses, and the moderating effect of social reticence. The results show that regulatory availability reduces PSR and that trust in recycled water is strongly influenced by perceived water quality and the source of the water (Chen *et al.*, 2013; Nkhoma *et al.*, 2021). Participants emphasized the importance of transparency, governance, and clear communication in shaping perceptions, highlighting the theme “knowledge can change perceptions,” which reflected concerns about water origin, treatment technologies, monitoring systems, and responsible institutions. These findings suggest that clear regulatory frameworks and effective communication reduce uncertainty and enhance trust in recycled water systems.

Perceptions of water origin significantly affected receptivity, as shown by the theme “source matters.” Many students associated recycled water with domestic wastewater, contamination, and health risks, while staff members demonstrated a clearer understanding that recycled water is derived from previously used water that has undergone advanced

Table 6. Indirect effect results

Hypotheses	Direct effects	Bootstrap LLCI	ULCI	Indirect effects	Bootstrap LLCI	ULCI
H8a: Regulations availability → Perceived service risk → Trust in recycled water → Receptivity toward use of recycled water (Domestic Purposes)	0.639**	0.758	0.699	−0.001†	−0.001	0.001
H8b: Regulations availability → Perceived service risk → Trust in recycled water → Receptivity toward use of recycled water (Public Services)	0.615**	0.560	0.683	0.001†	−0.001	0.001
H8c: Regulations availability → Perceived service risk → Trust in recycled water → Receptivity toward use of recycled water (Water Supplementary)	0.625**	0.565	0.685	0.001†	−0.001	0.001
H9a: Regulations availability → Perceived psychological risk → Trust in recycled water → Receptivity toward use of recycled water (domestic purposes)	0.639**	0.758	0.699	0.002†	−0.001	0.008
H9b: Regulations availability → Perceived psychological risk → Trust in recycled water → Receptivity toward use of recycled water (public services)	0.615**	0.560	0.683	0.002†	−0.001	0.008
H9c: Regulations availability → Perceived psychological risk → Trust in recycled water → Receptivity toward use of recycled water (Water Supplementary)	0.625**	0.565	0.685	0.002†	−0.001	0.008
H10a: Water quality → Perceived service risk → Trust in recycled water → Receptivity toward use of recycled water (Domestic Purposes)	0.086†	−0.014	0.187	−0.001†	−0.001	0.001
H10b: Water quality → Perceived service risk → Trust in recycled water → Receptivity toward use of recycled water (Public Services)	0.082†	−0.018	0.182	−0.001†	−0.001	0.001
H10c: Water quality → Perceived service risk → Trust in recycled water → Receptivity toward use of recycled water (Water Supplementary)	0.097†	−0.002	0.197	0.001†	−0.001	0.001
H11a: Water quality → Perceived psychological risk → Trust in recycled water → Receptivity toward use of recycled water (Domestic Purposes)	0.086†	−0.014	0.187	0.001†	−0.003	0.009
H11b: Water quality → Perceived psychological risk → Trust in recycled water → Receptivity toward use of recycled water (Public Services)	0.082†	−0.018	0.182	0.001†	−0.004	0.009
H11c: Water quality → Perceived psychological risk → Trust in recycled water → Receptivity toward use of recycled water (Water Supplementary)	0.097†	−0.002	0.197	0.001†	−0.003	0.006

Note(s): ***$p < 0.01$. **$p < 0.05$. †Not significant
Source(s): Authors' own work

treatment. This difference suggests that increased awareness and technical knowledge can improve PPRs and trust. Variations in acceptance across different uses were highlighted by the theme "the further the better," with participants showing greater receptivity to indirect applications, such as irrigation or car washing, and strong resistance to direct personal uses,

Table 7. Conditional process analysis (regulations availability)

Conditional direct effect analysis of regulations availability, and social reticence on perceived service risk	β	Boot SE	LLCI	ULCI
3.0000	0.294**	0.054	0.205	0.382
4.0000	0.211**	0.049	0.130	0.292
5.0000	0.128†	0.081	−0.005	0.262

Note(s): ** $p < 0.05$. †Not significant
Source(s): Authors' own work

Table 8. Conditional process analysis (water quality)

Conditional direct effect analysis of water quality, and social reticence on perceived psychological risk	β	Boot SE	LLCI	ULCI
3.0000	0.039†	0.069	−0.075	0.153
4.0000	−0.091†	0.059	−0.189	0.007
5.0000	−0.221**	0.099	−0.385	−0.058

Note(s): ** $p < 0.05$. †Not significant
Source(s): Authors' own work

including cooking, showering, or drinking. These findings align with previous research showing that perceived proximity to personal consumption increases perceived health and PPRs (Gul *et al.*, 2024).

The theme "conditional acceptance" further illustrates that public receptivity remains highly context-dependent. Although participants recognized the environmental benefits of water recycling and its contribution to water conservation, many viewed it as an extreme solution and were hesitant to adopt it for direct personal uses. Contrary to initial expectations (Degnan *et al.*, 2014), social reticence did not moderate the relationships among regulation availability, water quality, and service risk.

Overall, acceptance of water recycling and reuse is shaped by two main factors. First, the source of water fundamentally influences perceptions, with municipal, agricultural, and industrial effluents frequently associated with contamination and health risks (Fielding *et al.*, 2019; Smith *et al.*, 2018). Participants rejected direct potable reuse and sometimes produce irrigated with recycled water, reflecting the "yuck factor" in the water reuse literature (Rozin *et al.*, 2015; Russell and Lux, 2009). Nevertheless, all participants accepted the use of recycled water for irrigating green spaces and non-edible plants, consistent with prior studies (Fielding *et al.*, 2019; Hurlimann and Dolnicar, 2016), suggesting that initiatives like campus water treatment plants may be well received if initially limited to non-potable uses.

Second, knowledge and understanding of the recycling process play a crucial role in shaping perceptions and acceptance. Participants emphasized the importance of understanding treatment technologies, quality assurance mechanisms, governance structures, and regulatory oversight. Prior research shows that increased awareness and transparency regarding treatment processes significantly improve trust and public acceptance of recycled water systems (Dolnicar *et al.*, 2011). These findings underscore the importance of communication, education, and public awareness campaigns in improving knowledge and reducing negative perceptions associated with recycled water reuse.

Theoretically, these findings contribute to the literature on water reuse acceptance in several respects. First, the study extends risk perception theory by demonstrating that perceived contamination risk is strongly influenced by the symbolic meaning attributed to the water source, rather than solely by objective water quality. This finding supports previous arguments that both emotional and cognitive responses shape public attitudes toward recycled water (Fielding *et al.*, 2019; Russell and Lux, 2009). Second, the study advances trust-based models of environmental technology adoption by illustrating that knowledge of treatment processes, governance, and regulation can reduce PPR and strengthen trust in recycled water systems. This underscores the importance of institutional transparency and regulatory credibility in fostering acceptance of sustainable water solutions. The quantitative findings further reinforce these theoretical insights. Results indicate that regulatory availability and water quality are key determinants of public receptivity toward recycled water, confirming that institutional governance structures play a central role in reducing PSR and increasing trust. These findings are consistent with prior research demonstrating that regulatory frameworks and quality assurance mechanisms enhance confidence in recycled water systems (Dolnicar *et al.*, 2011; Smith *et al.*, 2018). Although PPR significantly influenced attitudes toward recycled water, the expected moderating role of social reticence was not supported. This suggests that structural factors such as governance and perceived quality may exert a stronger influence on acceptance than individual social behavioral traits.

This study offers several practical and policy recommendations to enhance public acceptance of recycled water in Egypt and other water-scarce regions. First, targeted awareness and education initiatives should address prevalent misconceptions regarding the origins of recycled water, particularly among students who may confuse it with natural sources such as rainwater or seawater. Universities and water authorities are encouraged to implement programs including guided tours of wastewater treatment facilities, seminars led by water engineers, and concise educational modules within sustainability or environmental curricula. Interactive demonstrations and digital simulations that illustrate treatment processes can further improve understanding of recycling technologies and associated safety protocols. Second, risk communication strategies should prioritize transparent dissemination of water quality data. Water authorities and universities should regularly publish laboratory test results and compliance reports that align with international standards, such as those set by the WHO, on their official websites or through campus communication channels. Simplified infographics and dashboards that clarify water quality indicators can make technical information more accessible and foster public trust. Third, policymakers are advised to establish governance frameworks that reinforce institutional trust. As the findings indicate variability in trust among stakeholder groups, collaborative management involving universities, government water authorities, and respected international organizations may enhance the credibility of recycled water initiatives. Fourth, a phased implementation strategy is recommended. Given that both staff and students expressed greater acceptance of non-potable uses, initial projects should prioritize low-risk applications, such as irrigating campus landscapes, public parks, and non-edible plants. As familiarity and trust grow, the scope of recycled water applications can be expanded incrementally, contingent upon demonstrated safety and community endorsement. Finally, awareness campaigns should contextualize water scarcity and sustainability imperatives. Communication efforts can underscore Egypt's increasing water demand and the critical role of recycling in preserving freshwater resources. Universities may facilitate public lectures, sustainability campaigns, and student-led environmental projects to encourage collective responsibility for water conservation.

The generalizability of the study's findings should be considered, given that it was drawn from a university campus in an Arab country; therefore, future research is encouraged to replicate the study in other countries. In addition, the differences between students' and staff's perceptions about knowledge of water treatment and receptivity of recycled water warrant further investigation. Furthermore, examine the effect of awareness campaigns through social media platforms (Fathy *et al.*, 2025) on the reliability of recycled water, trust, and receptivity to recycled water. Finally, the moderating effect of socio-economic factors such as education level, field of specialization and income on perceptions of recycled water should be investigated.

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Further reading

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