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Pathways to Sustainable Consumption Apps Adoption: Extending UTAUT2 With Personal Values and Behaviors

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ABSTRACT

Sustainable consumption apps (SCAs) support consumer transitions toward responsible purchasing decisions. This study advances understanding of SCAs adoption pathways by developing a comprehensive framework that integrates the Unified Theory of Acceptance and Use of Technology (UTAUT2) with dimensions from the value-belief-norm (VBN) theory. Specifically, it examines how different UTAUT2 configurations—enriched with consumer values (green values), contextual beliefs (intrapersonal religious commitment), and behaviors (sustainable consumer behaviors)—shape adoption patterns. An online survey of 1360 Gen Y and Gen Z participants was analyzed using fuzzy-set qualitative comparative analysis (fsQCA) and necessary condition analysis (NCA). This dual-method approach reveals generational differences: Gen Z prioritizes usability and engagement, while Gen Y is more influenced by sustainability values and behavioral norms. From a practical perspective, SCAs targeting Gen Z should emphasize user experience, gamification, and affordability through personalized recommendations and rewards. For Gen Y, adoption strategies should focus on facilitating conditions, technical support, and reinforcing environmental values to strengthen engagement. These insights inform targeted SCAs strategies, aligning them with generational preferences to maximize sustainable impact.

1 | Introduction

Sustainable consumption, as defined in Sustainable Development Goal (SDG) 12 of the 2030 Agenda, encourages consumers to minimize waste, make informed purchasing decisions throughout a product's lifecycle, and consider ecological and social well-being for future generations (UN.org 2023; Lim et al. 2025). However, despite growing awareness (Nielsen 2023), many consumers struggle to integrate sustainable practices into their daily lives (Adams et al. 2024; Lim 2024). The SHIFT framework (White et al. 2019) highlights the need to make sustainable choices more accessible and intuitive (McNamee and Fernandez 2021) fostering greater consumer engagement in sustainability.

Sustainable consumption applications (SCAs)—also referred to as green or ethical consumption apps (Watts and Wyner 2011; Brauer et al. 2016; Fuentes and Sorum 2019; Guillen Mandujano et al. 2022)—have emerged as digital tools that support consumers in making more sustainable purchasing decisions. These apps offer sustainability ratings, ethical product certifications, second-hand marketplaces, and gamified incentives (Brauer et al. 2016; Humphery and Jordan 2018; Guillen Mandujano et al. 2022), enabling users to align their consumption choices with environmental and ethical considerations. Their adoption has accelerated in response to Agenda 2030's emphasis on information and communication technologies (ICTs) in sustainability efforts (Hilty and Aebischer 2015; Humphery and Jordan 2018). Leading platforms such as Vinted and Too Good To Go have surpassed 80 million users and downloads, respectively (Statista 2024a; Vo-Thanh et al. 2021; Too Good To Go 2024). Market projections indicate that the global green technology sector will grow to $58.7 billion by 2030 (Research and Markets 2024; Twinr 2024). Despite this expansion, SCAs usage remains inconsistent—some consumers actively integrate

them into their daily routines, while others abandon them after initial adoption (Fuentes 2019; Fuentes et al. 2021; D'Arco and Marino 2022).

While SCAs help overcome key barriers to pro-environmental behaviors (Gifford 2011), such as knowledge gaps and perceived risks (Guillen Mandujano et al. 2022), their adoption patterns across consumer segments remain insufficiently understood. Despite increasing academic attention (Nghiem and Carrasco 2016; D'Arco and Marino 2022; Douglas and Brauer 2021; Alloghani 2024), existing research offers a fragmented view, often emphasizing usability, functionalities, or gamification (Guillen Mandujano et al. 2022; Krath et al. 2022) while overlooking the motivational and normative factors that influence adoption (Fuentes and Sorum 2019; Sorum 2020). As Guillen Mandujano et al. (2022) observe, gamified SCAs tend to prioritize resource efficiency but frequently neglect social and attitudinal dynamics that could foster more lasting behavioral change.

As a result, this study examines the decision-making pathways that drive the adoption of SCAs by integrating technological and ethical dimensions into a comprehensive framework. Specifically, it extends the technology acceptance factors of Unified Theory of Acceptance and Use of Technology (UTAUT2—Venkatesh et al. 2012) with the moral and normative dimensions of value-belief-norm (VBN) theory (Stern et al. 1999). Green values (GVs—Haws et al. 2014; Pegan et al. 2023) serve as a primary value system, while religiosity (Minton et al. 2022; Kaplan and Iyer 2021) functions as a contextual belief system. Additionally, sustainable consumption behaviors (SCBs) are incorporated to bridge the functional and motivational drivers of UTAUT2 and VBN, offering a more holistic perspective on SCAs adoption.

UTAUT2 identifies key adoption drivers, including performance expectancy (PE), effort expectancy (EE), social influence (SI), and hedonic motivation (HM), which have been widely applied in mobile technology adoption research (Hew et al. 2015; Venkatesh et al. 2016; Tang 2019; Chopdar et al. 2018; Duarte and Pinho 2019; Akdim et al. 2022; Alalwan 2020; Hsu and Chen 2021; Tamilmani et al. 2021). However, while UTAUT2 captures the functional and experiential aspects of technology adoption, it overlooks moral and normative motivations that are central to sustainable consumption (Minton et al. 2022; Orlandi et al. 2022).

Conversely, research in sustainability science has employed the VBN theory (Stern et al. 1999) to explain how personal values and beliefs shape a sense of responsibility toward sustainable actions, influencing consumer decision-making (Steg and Vlek 2009). While some scholars emphasize biospheric and altruistic values as key antecedents of pro-environmental behaviors (De Groot and Steg 2009; Nguyen et al. 2016), others focus on GVs within consumption contexts, highlighting their role in shaping green purchasing behavior and intentions (Haws et al. 2014; Kautish and Sharma 2019). This study adopts the latter conceptualization, framing GVs as an individual's commitment to environmental protection through purchasing decisions, directly linking sustainability concerns to consumption choices (Haws et al. 2014; Pegan et al. 2023).

Additionally, belief systems such as religion influence worldviews and behavioral norms (Minton et al. 2018) and may serve as contextual factors shaping sustainability-related beliefs and norms (Saroglou 2011; Roccas and Elster 2013; Kaplan and Iyer 2021; Minton et al. 2022). While religiosity is not a core component of the VBN model, it can influence perceptions of sustainable consumption as part of faith-driven daily choices (Orellano et al. 2020; Pegan et al. 2023). Conceptualized here as intrapersonal religious commitment (IaRC) (Martin and Bateman 2014), religiosity may also impact the acceptance of technological innovations (Minton et al. 2022; Orlandi et al. 2022), potentially shaping SCAs adoption.

Beyond values and beliefs, SCAs adoption may also be shaped by preexisting SCBs (UN.org 2023; Kalamas et al. 2014; Sudbury-Riley and Kohlbacher 2016). For consumers already engaged in sustainability, SCAs can reinforce performance and EE, enhancing their ability to achieve sustainability goals (Guillen Mandujano et al. 2022; Douglas and Brauer 2021). For less engaged consumers, SCAs may facilitate behavioral change by simplifying decision-making and providing incentives, bridging the gap between sustainable intentions and actual behavior (White et al. 2019). While SCBs are influenced by individual habits (Hs) and external factors, they may also reflect deeper value-driven motivations, aligning with VBN theory (Stern et al. 1999). In this context, GVs and religiosity (IaRC) (Haws et al. 2014; Kalamas et al. 2014; Minton et al. 2022) may shape sustainable behaviors over time, influencing the extent to which consumers perceive SCAs as valuable tools for sustainability.

Against this backdrop, this study addresses the following research question:

RQ: How do different UTAUT2 configurations, extended with consumer values (GVs), beliefs (IaRC), and behaviors (SCBs), explain SCAs adoption?

To explore this question, we conducted a quantitative study surveying 1370 potential SCAs users from two digitally fluent and sustainability-oriented generational cohorts (Kotler et al. 2021): Generation Y (Gen Y or Millennials, born 1980–1996) and Generation Z (Gen Z, born 1997–2010) (Ahluwalia et al. 2023; Meet et al. 2024). These groups were analyzed separately to examine generational differences in digital adoption patterns. Gen Y demonstrates strong digital engagement and social responsibility, while Gen Z prioritizes environmental and social concerns (Casalegno et al. 2022; Johnstone and Lindh 2022; Meet et al. 2024).

Using fuzzy-set qualitative comparative analysis (fsQCA) and necessary condition analysis (NCA), we identify sufficient pathways driving adoption and necessary conditions constraining it. This dual-method approach offers a multidimensional perspective on how UTAUT2, GVs, IaRC, and SCBs interact to shape SCAs adoption in Gen Z and Gen Y. Findings highlight the need for tailored engagement strategies, recognizing that while some consumers are intrinsically motivated toward sustainability, others require external incentives and behavioral nudges. Marketers and policymakers should leverage adaptive digital strategies, gamification, and ethical positioning to enhance SCAs' effectiveness as tools for promoting sustainable consumption.

2 | Theoretical Foundations and Research Propositions

2.1 | Mobile Apps and Sustainable Consumption Decisions

SCAs have reshaped consumer engagement with sustainability by offering digital tools that streamline responsible decision-making and promote sustainable consumption practices (Fuentes and Sorum 2019; Mulcahy et al. 2020; Hawkins and Horst 2020; Douglas and Brauer 2021; Guillen Mandujano et al. 2022). Functioning as intermediaries between consumers and sustainability information, SCAs enhance market transparency, lower search costs, and implement behavioral nudges that encourage sustainable choices (Humphery and Jordan 2018; White et al. 2019).

SCAs can be categorized into three main types based on their core functionalities (Humphery and Jordan 2018). Information-based SCAs digitize sustainability labels and certifications, providing real-time insights into product sustainability (Brauer et al. 2016; Beetroot 2024). Market-based SCAs facilitate ethical transactions through platforms like Vinted, Wallapop, and Good On You, supporting responsible purchasing decisions. Engagement-based SCAs integrate gamification and social incentives to encourage sustainable behaviors, as seen in apps such as Forest, Ecosia, and Too Good To Go (Douglas and Brauer 2021; Guillen Mandujano et al. 2022). With the widespread adoption of smartphones, daily use of SCAs—offering sustainability ratings, ethical recommendations, and impact assessments—enhances consumer awareness and decision-making, potentially driving sustainable behavior more effectively than traditional communication campaigns (Brauer et al. 2016).

As mobile apps become embedded in shopping routines (Gong et al. 2018; Tang 2019; Liu and Sese 2022), SCAs have experienced significant growth, drawing increasing academic interest in sustainable consumption research (Fuentes and Sorum 2019; Sorum 2020; Mulcahy et al. 2020; Fuentes et al. 2021; Douglas and Brauer 2021; D'Arco and Marino 2022; Guillen Mandujano et al. 2022; Alloghani 2024). However, despite their potential to facilitate sustainable decision-making, adoption patterns remain inconsistent across consumer groups. Some studies highlight usability and engagement challenges, particularly related to gamification (Sorum 2020; Douglas and Brauer 2021; Fuentes et al. 2021; Krath et al. 2022; Guillen Mandujano et al. 2022), while others emphasize their role in fostering ethical consumption lifestyles (Fuentes and Sorum 2019). As Guillen Mandujano et al. (2022) observe, gamified SCAs prioritize resource efficiency but often overlook social and attitudinal dimensions crucial for sustained behavioral change.

This study builds on these insights by moving beyond fragmented perspectives, investigating the combined influence of technological, psychological, and behavioral factors on SCAs adoption.

2.2 | UTAUT2 and SCAs

To examine SCAs adoption from a technological perspective, this study applies the UTAUT2 theory (Venkatesh et al. 2012), a widely used framework in digital consumer behavior research. Compared with the technology acceptance model (TAM), which primarily focuses on perceived ease of use and usefulness (Davis 1989; Davis et al. 1989; Davis et al. 1992), UTAUT2 offers a more comprehensive perspective by incorporating both utilitarian and hedonistic factors (Hsu and Chen 2021; Akdim et al. 2022; Tang 2019). This framework has been extensively applied in studies on mobile technology adoption (Hew et al. 2015; Peng et al. 2018; Chopdar et al. 2018; Duarte and Pinho 2019; Alalwan et al. 2017; Tamilmani et al. 2021) and consists of seven key dimensions influencing consumer adoption decisions.

A central component of UTAUT2 is PE, which reflects the perceived usefulness of SCAs in facilitating sustainable consumption (Fuentes and Sorum 2019). Apps that provide accurate sustainability assessments or personalized recommendations enhance their perceived utility. EE captures the ease of learning and using SCAs (Venkatesh et al. 2012). Because consumers favor technologies that integrate seamlessly into daily routines, usability plays a crucial role in adoption (Fuentes and Sorum 2019; Fuentes et al. 2021). SI refers to the impact of peer norms and societal expectations on adoption decisions (Venkatesh et al. 2012; Kulviwat et al. 2009). While research suggests that social norms shape sustainable behaviors (Ajzen 1991; White et al. 2019), their influence on private technology use remains less explored (Ahn et al. 2016; Herrero and San Martín 2017).

Facilitating conditions (FC) encompass the resources and external support available to consumers, such as access to technical assistance, compatibility with other digital platforms, and overall digital literacy (Venkatesh et al. 2012; Duarte and Pinho 2019). HM highlights the role of enjoyment in technology adoption (Venkatesh and Brown 2001). Gamification features, including reward systems and interactive elements, can increase engagement and sustained use (Guillen Mandujano et al. 2022; Douglas and Brauer 2021). Price value (PV) reflects the financial benefits consumers associate with SCAs in promoting sustainable purchasing decisions (Douglas and Brauer 2021). Although SCAs are often free to download, their value lies in increasing price transparency, guiding cost-effective yet ethical choices, and reducing skepticism toward sustainable products (Sivapalan et al. 2024). Finally, H refers to the extent to which SCAs have become an integral part of consumer behavior (Duarte and Pinho 2019). H formation may stem from a preexisting tendency to use digital tools for sustainability or be reinforced through gamification strategies that encourage consistent engagement (Douglas and Brauer 2021; Guillen Mandujano et al. 2022). Given these theoretical foundations, we propose the following proposition:

Proposition 1. *The dimensions of UTAUT2 offer a path for understanding the consumer decision-making process regarding adopting SCAs.*

2.3 | Extending the UTAUT2 Model With Consumer Values and Belief

While UTAUT2 provides a robust framework for understanding technology adoption, it does not fully account for the moral and normative motivations that drive sustainability-related

technology use. To address this gap, this study integrates the VBN theory (Stern et al. 1999), which explains how personal values (Kautish and Sharma 2019; Nguyen et al. 2016; Sharma and Jha 2017) and ethical obligations shape pro-environmental behaviors (Steg et al. 2014; Liu and Wu 2020; Lim 2024). Within the VBN framework, values function as trans-situational goals that influence behavior by shaping the perceived importance of environmental consequences, activating norms, and reinforcing environmental self-identity, ultimately leading to SCBs (Schwartz and Bardi 2001; De Groot and Steg 2009; Steg et al. 2014; Gifford 2014).

This study focuses on GVs—a consumer's commitment to sustainability through purchasing decisions (Haws et al. 2014). GVs drive individuals to prioritize sustainability in their consumption choices, making them particularly relevant in decision contexts such as green purchasing (Pegan et al. 2023). While research highlights their role in shaping consumer preferences for sustainable products, their influence on adoption of digital sustainability remains underexplored. In the context of SCAs, GVs may serve as distal but influential antecedents, fostering the perceived utility of these tools in supporting sustainable practices and reinforcing an individual's sustainable consumer self-identity.

Beyond personal values, religiosity functions as a contextual belief system that can moderate sustainability-related moral obligations (Minton et al. 2022; Orlandi et al. 2022). Although not a core component of VBN (Stern et al. 1999), religious commitment influences values and personal norms, shaping sustainable behaviors (Minton et al. 2016, 2018). A key dimension of religiosity is IaRC, defined as the extent to which individuals integrate religious beliefs into daily life (Worthington et al. 2003; Martin and Bateman 2014). IaRC plays a complex role in sustainability, as it can either strengthen or weaken moral obligations toward responsible consumption, depending on how religious teachings align with sustainability values (Felix and Braunsberger 2016; Bhuian et al. 2018; Pegan et al. 2023).

While some studies suggest that individuals with higher IaRC engage more in sustainable consumption and exhibit greater trust in AI-driven sustainable brands (Minton et al. 2015, 2022), others indicate that strong religious commitment may foster resistance to product and technological innovations (Essoo and Dibb 2004; Mansori et al. 2015). Given these divergent findings, this study examines whether IaRC reinforces or diminishes moral norms related to SCAs adoption, reflecting the broader complexities of religiosity, sustainability, and technology (Minton et al. 2022; Pegan et al. 2023). Thus, we propose the following proposition:

Proposition 2. *GVs and IaRC, in combination with UTAUT2, can offer additional insights into how consumer values and beliefs shape SCAs adoption pathways.*

2.4 | Extending the UTAUT2 Model With Sustainable Behaviors Pattern

SCBs reflect the extent to which consumers actively choose products that minimize environmental harm, avoid unethical options, prioritize recyclable or reusable packaging, and demonstrate a willingness to pay a premium for sustainable alternatives (Sudbury-Riley and Kohlbacher 2016; UN.org 2023; Lim 2024; Lim et al. 2025). This study incorporates SCBs into UTAUT2 (Venkatesh et al. 2012; Meet et al. 2022) to examine whether prior engagement in sustainability facilitates adoption or whether SCAs serve as behavioral catalysts for less engaged consumers.

For individuals with established SCBs, SCAs may enhance PE and EE by reinforcing the perceived utility and ease of integrating these apps into existing consumption routines (Guillen Mandujano et al. 2022; Douglas and Brauer 2021). Over time, SCAs could also strengthen sustainable Hs, contributing to the H dimension by embedding sustainability practices into daily decision-making. However, for consumers with lower SCBs, adoption may require stronger hedonic or economic incentives (Fuentes and Sorum 2019; White et al. 2019). SCAs could act as enablers (Humphery and Jordan 2016; Fuentes and Sorum 2019), helping bridge the gap between ethical intentions and actual behaviors (Pinna 2020). By simplifying complex decisions, providing reliable sustainability information, and addressing inconsistencies between declared attitudes and practiced behaviors, SCAs may facilitate sustainable consumption (White et al. 2019; Douglas and Brauer 2021), thus encouraging adoption.

HM may play a dual role, as enjoyment is a key driver of technology adoption across consumer segments (Venkatesh et al. 2012; Akdim et al. 2022). For consumers already engaged in sustainable consumption, pleasure may stem from reinforcing their ecological identity and commitment to sustainability. Conversely, for those without prior sustainable behaviors, enjoyment may arise from the novelty and ease of engaging in sustainable practices through user-friendly digital tools. This dual function—reinforcing engagement for sustainability-conscious consumers while encouraging behavioral change among less engaged users—remains an underexplored area in digital sustainability research.

From a VBN theory perspective (Stern et al. 1999), SCBs represent the observable outcome of interactions between values, beliefs, and norms. They reflect the internalization of ethical and sustainability principles and influence how consumers perceive and adopt tools like SCAs, which align with their sustainability goals. These behaviors can be interpreted as expressions of personal norms activated by sustainability-oriented values and beliefs. GVs (Haws et al. 2014) serve as a fundamental driver for prioritizing sustainable choices in daily life, as they represent the consumer value system most relevant in sustainable consumption contexts, particularly green purchasing decisions (Pegan et al. 2023).

Furthermore, IaRC, as a contextual factor, may shape consumers' sense of responsibility to act sustainably (Minton et al. 2016, 2018), either reinforcing or, in some cases, constraining the development of SCBs (Orellano et al. 2020). While VBN theory suggests that moral obligations drive SCBs, SCAs adoption may also depend on the alignment between personal norms and technological trust (Orlandi et al. 2022; Minton et al. 2022).

Given the diverse ways SCBs interact with UTAUT2 and its extended dimensions in shaping SCAs adoption, this study proposes the following:

Proposition 3. *SCBs, alongside UTAUT2, GVs, and IaRC, may offer additional pathways for understanding SCAs adoption by reflecting preexisting sustainable conduct and potential behavioral shifts.*

2.5 | The Role of Generational Differences

Given the increasing relevance of generational differences in sustainable consumption research but their limited exploration (Casalegno et al. 2022), this study examines whether the configurations of drivers for adopting SCAs differ between Gen Y and Gen Z. These two cohorts represent the largest markets for mobile app usage and online shopping, both demonstrating strong environmental concerns and engagement in sustainable consumption (Turner 2015; Kotler et al. 2021; World Economic Forum 2022).

To investigate these generational distinctions, this study draws on two independent samples of Gen Z and Gen Y consumers, recognizing that these cohorts exhibit distinct attitudes toward technology and sustainability. Gen Z, born between 1995 and the early 2010s (Meet et al. 2022), are digital natives who have grown up with advanced technology and social media, shaping their consumption behaviors and sustainability preferences (Seemiller and Grace 2016; Meet et al. 2024). This generation prioritizes environmental sustainability and ethical consumption, often leveraging digital platforms to make informed and conscientious purchasing decisions (Seemiller and Grace 2016). While academic research on Gen Z's GVs system remains limited, global data indicate that they are more ethically driven in their consumption choices, demanding greater sustainability commitments from brands (Smith 2020; Djafarova and Bowes 2021; Statista 2024b). Moreover, research suggests that Gen Z's relationship with religiosity is complex and multifaceted. Economic hardships have led to divergent reactions, with some segments increasing religious engagement as a coping mechanism, while others distance themselves from religious practices (Stavrianea and Kamenidou 2017).

In contrast, Gen Y, also known as Millennials, born between the early 1980s and mid-1990s, experienced the rise of the internet and digital transformation during their formative years, shaping their adoption behaviors differently (Bolton et al. 2013). As early adopters of technology, Millennials tend to approach sustainability with a more pragmatic perspective, often weighing cost-effectiveness and practicality alongside environmental concerns (Smith 2020). Their experiences with the early stages of social media and e-commerce have influenced their expectations and interactions with digital platforms (Bolton et al. 2013). While Millennials are often labeled as "green consumers" (Young 2018), empirical findings on their actual green consumption values (Haws et al. 2014) present mixed results. Some studies highlight skepticism toward green products, driven by concerns about trade-offs between cost and perceived benefits compared with conventional alternatives (Bonera et al. 2020). Additionally, Millennials tend to be less religious (Sirgy et al. 2006) and more materialistic than previous generations, often using brands as a means of self-expression rather than adhering to traditional religious or ethical frameworks.

By distinguishing between these two generational groups, this study seeks to uncover nuanced insights into how differences in technology engagement, sustainability priorities, and personal values (Meet et al. 2022; Smith 2020; Fromm and Read 2018) influence SCAs adoption. This generational perspective allows for a more targeted analysis of motivational drivers and barriers, leading to the following expectation:

Baseline expectation. SCAs adoption is anticipated to differ between generation Y and generation Z

As such, several scholars (Pappas and Woodside 2021) have emphasized the importance of methodologies that account for multiple, non-linear pathways leading to the same outcome. Traditional symmetric approaches often assume uniform effects across all consumers, overlooking the possibility that different configurations of factors may drive adoption for different consumer segments. In response, this study adopts an asymmetric approach to uncover the nuanced adoption patterns of SCAs, recognizing that consumer decision-making is shaped by a combination of technological, psychological, and behavioral factors that interact in complex ways.

Figure 1 presents the proposed theoretical model, illustrating how SCAs adoption is not driven by single factors in isolation but by the confluence of multiple conditions. Rather than focusing on direct, additive effects, this study examines how different configurations of UTAUT2 dimensions, GVs, IaRC, and SCBs collectively shape consumer engagement with SCAs. This perspective aligns with configurational theorizing, which suggests that consumer adoption behaviors emerge from distinct combinations of enabling and constraining factors rather than from isolated causal relationships (Fiss 2011).

3 | Data and Method

3.1 | Sample and Data Collection

This study focuses on Generations Z and Y, who demonstrate the highest levels of engagement with mobile shopping applications and sustainability-oriented digital tools (Merkel and Hess 2020). Eligibility criteria required respondents to be either current or prospective users of SCAs and to indicate an interest in sustainable consumption practices. Generation X (born 1965–1979) was excluded because of distinct digital consumption patterns (Kotler et al. 2021), which may have introduced confounding variance linked to differing levels of familiarity with mobile technologies (Venkatesh et al. 2012). Given the absence of a predefined sampling frame for Gen Z and Gen Y SCAs users, a non-probability sampling strategy was employed, combining convenience, snowball, and purposive sampling (Koenig-Lewis et al. 2014; Johnstone and Lindh 2022). The final sample consisted of 1370 Italian participants, evenly distributed between Gen Y and Gen Z (50% each) to enable generational comparisons. Participants were recruited through a two-stage process. First, 50 master's students from a northeastern Italian university were instructed to recruit individuals meeting the inclusion criteria. Second, an anonymous online survey was distributed via social media and personal networks, ensuring a diverse yet demographically relevant respondent pool. The online format

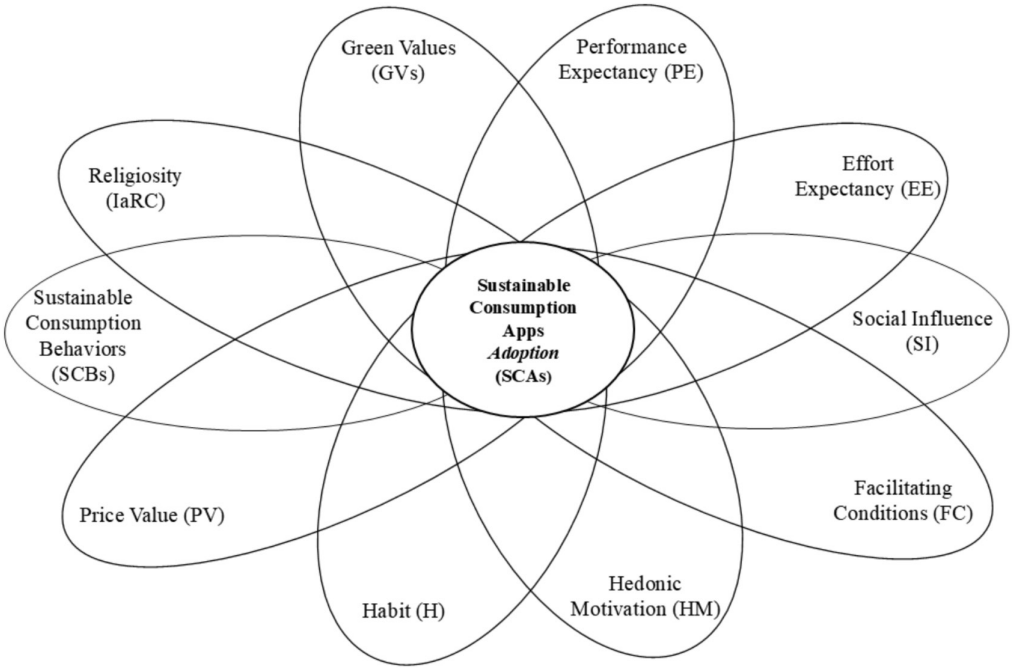

FIGURE 1 | Theoretical model.

facilitated broad geographic coverage while reducing social desirability bias (Alzubaidi et al. 2021). These methods are widely applied in behavioral research, particularly when investigating the relationship between values and behaviors rather than aiming for full population representativeness (Bruine de Bruin and Bostrom 2013).

To enhance data quality, the survey included three attention checks, and respondents failing at least two were excluded, leaving 1360 valid responses. While the sample is not fully representative of national demographics, it aligns with the profile of early SCAs adopters—digitally engaged and sustainability-conscious consumers. The main sample characteristics are summarized in Table 1.

Some deviations from national benchmarks are methodologically justified. Education levels exceed national averages (55.2% of Gen Z and 53.6% of Gen Y hold a university degree, compared with 30%–45% nationally), reflecting research linking higher education to sustainability awareness and digital adoption (Pegan et al. 2023). Student status is overrepresented among Gen Z (82.9% vs. ~60% nationally), consistent with global trends indicating higher mobile app adoption for sustainable consumption among younger consumers (Statista 2024b; Douglas and Brauer 2021). Income levels suggest greater financial stability than national averages, with 73.4% of Gen Y reporting average or above-average income (Eurostat 2023), likely influenced by student financial support and the self-selection of digitally active individuals.

This study adhered to the ethical guidelines of the Declaration of Helsinki, ensuring anonymity and data protection. No incentives were provided, as monetary rewards could have compromised the study's focus on intrinsic motivations, such as sustainability and prosocial values (Kamenica 2012; Pegan et al. 2023).

3.2 | Measures and Reliability

The complete set of items used in this study, along with their factor loadings and reliability checks, is detailed in Table 2. The reliability of the constructs ranged from good to excellent, with Cronbach's alpha values exceeding 0.8, confirming the robustness of the measurement scales. To capture the nuances of consumer engagement with SCAs, participants were asked to indicate their level of agreement with various statements or rate the frequency of their consumption behaviors using a 7-point Likert scale, ranging from *never* to *very often*. This approach ensures consistency in measurement while allowing for a fine-grained analysis of behavioral patterns.

Before completing the questionnaire, participants were presented with a general definition of SCAs, which described their sustainability objectives, key functionalities, and domains of use (e.g., food, fashion, mobility), supplemented by illustrative examples. This approach aimed to establish a shared conceptual reference and reduce potential bias associated with familiarity or preference for specific applications.

The dependent variable, SCAs adoption, was assessed using six items derived from Duarte and Pinho (2019). These items were adapted to reflect consumer engagement with sustainability-focused mobile applications, specifically in the context of monitoring and improving consumption-related environmental and social impacts. This formulation captures both intentionality and commitment, allowing for a meaningful assessment of how consumers integrate SCAs into their daily routines.

To better understand the technological drivers of SCAs adoption, this study incorporated the seven UTAUT2 constructs, measured using 36 items drawn from Venkatesh et al. (2012)

TABLE 1 | Sample characteristics.

Gen Z			Gen Y		
Gender			Gender		
Male	313	44.5%	Male	342	52.1%
Female	390	55.5%	Female	315	47.9%
Total	703	100%	Total	657	100%
Age			Age		
18–24	703	100%	18–24	0	0%
25–30	0	0%	25–30	355	54%
31–36	0	0%	31–36	151	23%
37–40	0	0%	37–40	151	23%
Total	703	100%	Total	657	100%
Education level			Education level		
Lower school	7	1%	Lower school	13	2%
High school	295	42%	High school	201	30.6%
Bachelor/master degree	388	55.2%	Bachelor/master degree	352	53.6%
PhD	6	0.9%	PhD	82	12.5%
Other	7	1%	Other	9	1.4%
Total	703	100%	Total	657	100%
Profession			Profession		
Student	583	82.9%	Student	166	25.3%
Employee	45	6.4%	Employee	244	37.1%
Skilled laborer	14	2%	Skilled laborer	38	5.8%
High skilled laborer	2	0.3%	High skilled laborer	21	3.2%
Freelance	18	2.6%	Freelance	77	11.7%
Entrepreneur	1	0.1%	Entrepreneur	19	2.9%
House worker	0	0%	House worker	8	1.2%
Unemployed	8	1.1%	Unemployed	13	2%
Other	32	4.6%	Other	71	10.8%
Total	703	100%	Total	657	100%
Income level			Income level		
On the average	501	71.3%	On the average	482	73.4%
Below the average	92	13.1%	Below the average	61	9.3%
Above the average	110	15.6%	Above the average	114	17.4%
Total	703	100%	Total	657	100%
Marital status			Marital status		
Single	322	45.8%	Single	188	28.6%
Engaged	286	40.7%	Engaged	181	27.5%
Live together	35	5%	Live together	143	21.8%
Married	36	5.1%	Married	116	17.7%

(Continues)

TABLE 1 | (Continued)

Gen Z			Gen Y		
Divorced	8	1.1%	Divorced	13	2%
Other	15	2.1%	Other	16	2.4%
Total	703	100%	Total	657	100%
Household components			Household components		
1	79	11.2%	1	82	12.5%
2	69	9.8%	2	192	29.2%
3	190	27%	3	164	25%
4	266	37.8%	4	153	23.3%
5	81	11.5%	5	51	7.8%
More than 5	18	2.6%	More than 5	17	2.3%
Total	703	100%	Total	657	100%
Religious belief			Religious belief		
Christian	383	54.3%	Christian	401	61%
Jewish	2	0.3%	Jewish	2	0.3%
Atheist	204	29%	Atheist	141	21.5%
Buddhist	6	0.9%	Buddhist	9	1.4%
Hinduist	1	0.1%	Hinduist	1	0.2%
Muslim	2	0.3%	Muslim	5	0.8%
Other	106	15.1%	Other	98	14.9%
Total	703	100%	Total	657	100%

and Duarte and Pinho (2019). These constructs were adapted to reflect the mobile sustainability app context, ensuring that the wording aligned with the specific functionalities and user experiences of SCAs.

For example, PE—which captures perceived usefulness. By considering both utilitarian and hedonic motivations, this study accounts for the multiple ways in which consumers engage with SCAs, from a goal-oriented perspective (seeking sustainability benefits) to a more experiential one (enjoying the interactive and gamified features of these apps).

Because one of the key aims of this research is to understand whether preexisting sustainability behaviors influence SCAs adoption, Sudbury-Riley and Kohlbacher's (2016) scale for SCBs was employed. This widely used scale captures five distinct aspects of SCB: Eco-buy (purchasing environmentally friendly products), Recycle (engaging in waste-reduction behaviors), Eco-boycott (avoiding products that harm the environment), CSR-boycott (avoiding brands with unethical corporate practices), and Willingness to Pay More (financial commitment to sustainability). By capturing these dimensions, the study aimed to assess whether individuals who are already engaged in sustainable behaviors are more likely to adopt SCAs or whether these apps serve as an entry point for less engaged consumers.

Because values shape consumer decision-making, this study incorporated the 6-item scale developed by Haws et al. (2014) to assess GVs—that is, the degree to which individuals consider environmental and social consequences in their purchasing decisions. GVs serve as a fundamental motivational factor, reinforcing the idea that consumers with strong sustainability values are more likely to perceive SCAs as useful tools in their daily decision-making.

As this study also explores the role of religiosity as a contextual belief system, we employed the intrapersonal subscale of the Religious Commitment Scale (Worthington et al. 2003; Martin and Bateman 2014; Minton et al. 2022). This 6-item measure captures the extent to which religious beliefs influence daily behavior, making it particularly relevant in assessing whether religious commitment reinforces or hinders engagement with sustainability-related technology. This dimension provides insights into whether personal moral frameworks, shaped by religious values, align with sustainability motivations and contribute to SCAs adoption.

3.3 | fsQCA

fsQCA examines the relationships between an outcome and all possible configurations of independent variables (Ragin 2009).

TABLE 2 | Items, loadings, and reliability checks.

Constructs and items		α	CR	AVE
Sustainable consumption apps adoption (SCAA)				
SCAA1	I am determined to use SCAs to monitor the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions	0.924	0.944	0.739
SCAA2	I intend to use SCAs to monitor the environmental impact (“) of my daily purchasing and consumption decisions			
SCAA3	I plan to use SCAs to monitor the environmental impact (“) of my daily purchasing and consumption decisions in the future.			
SCAA4	I am curious about using SCAs to monitor the environmental impact (“) of my daily purchasing and consumption decisions			
SCAA5	I find that it would be nice to use SCAs to monitor the environmental impact (“) of my daily purchasing and consumption decisions			
SCAA6	I rate as positive the use of SCAs to monitor the environmental impact (“) of my daily purchasing and consumption decisions			
Performance expectancy (PE)				
PE1	I find SCAs to monitor the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions useful in my daily life.	0.928	0.944	0.737
PE2	Using SCAs to monitor ... increases my chances of achieving things that are important to me.			
PE3	Using SCAs to monitor ... helps me to control activities more quickly.			
PE4	Using SCAs to monitor ... increases my effectiveness in sustainable consumption decisions			
PE5	Using SCAs to monitor ... increases my performance in sustainable consumption decisions.			
PE6	Using SCAs to monitor ... increases my facility in sustainable consumption decisions.			
Effort expectancy (EE)				
EE1	Learning how to use mobile app to monitor the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions is easy for me.	0.921	0.941	0.762
EE2	My interaction with SCAs to monitor... is clear and understandable.			
EE3	I find SCAs to monitor ... easy to use.			
EE4	It is easy for me to monitor ... skillful at using SCAs for ...			
EE5	Using SCAs to monitor ... does not require me much effort			

(Continues)

TABLE 2 | (Continued)

Constructs and items		α	CR	AVE
Social influence (SI)				
SI1	People who are important to me think that I should use mobile app to monitor the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions	0.910	0.933	0.736
SI2	People who influence my behavior think that I should use SCAs for monitoring ...			
SI3	People whose opinions that I value prefer that I use SCAs for monitoring...			
SI4	People who are important to me agree with the use of SCAs for monitoring ...			
SI5	People I trust believe that I should use SCAs for monitoring...			
Facilitating conditions (FCs)				
FC1	I have the necessary resources to use SCAs for monitoring the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions	0.829	0.877	0.545
FC2	I have the knowledge necessary to use SCAs for monitoring			
FC3	SCAs for monitoring ... I use is compatible with other technologies for monitoring...			
FC4	I can get help from others when I have difficulties using SCAs for monitoring ...			
FC5	I feel comfortable using SCAs for monitoring ...			
FC6	I have no problems using SCAs for monitoring ...			
Hedonic motivation (HM)				
HM1	Using a SCAs for monitoring the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions is fun.	0.936	0.949	0.725
HM2	Using SCAs for monitoring ... is enjoyable.			
HM3	Using SCAs for monitoring ... is very entertaining.			
HM4	Using SCAs for monitoring ... gives me pleasure.			
HM5	Using SCAs for monitoring ... is exciting.			
HM6	Using SCAs for monitoring ... is thrilling.			
HM7	Using SCAs for monitoring ... is delightful.			
Habit (H)				
H1	The use of SCAs for monitoring the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions has become a habit for me.	0.897	0.936	0.831
H2	I am addicted to using SCAs for monitoring ...			
H3	Using SCAs for monitoring ... has become natural to me			

(Continues)

TABLE 2 | (Continued)

Constructs and items		α	CR	AVE
Price value (PV)				
PV1	SCAs for monitoring the environmental impact (*read as natural and social*) of my daily purchasing and consumption decisions enable me to make cost-effective purchase/consumption decisions	0.858	0.905	0.705
PV2	SCAs for monitoring ... offer an amount that corresponds to the money you pay			
PV3	I find it convenient to use SCAs for monitoring ...			
PV4	Regardless of the price, SCAs for monitoring ... are always a good deal			
Sustainable consumer behaviors (SCBs)				
EB1	When there is a choice, I always choose the product that contributes to the least amount of environmental damage.	0.930	0.941	0.615
EB2	I have switched products for environmental reasons.			
EB3	If I understand the potential damage to the environment that some products can cause, I do not purchase those products.			
EB4	I do not buy household products that harm the environment.			
EB5	Whenever possible, I buy products packaged in reusable or recyclable containers.			
EB6	I make every effort to buy paper products (toilet paper, tissues, etc.) made from recycled paper.			
EB7	I will not buy a product if I know that the company that sells it is socially irresponsible.			
EB8	I do not buy products from companies that I know use sweatshop labor, child labor, or other poor working conditions.			
EB9	I have paid more for environmentally friendly products when there is a cheaper alternative.			
EB10	I have paid more for socially responsible products when there is a cheaper alternative.			
Religiosity (IaRC)				
IaRC1	My religious beliefs lie behind my whole approach to life.	0.956	0.965	0.821
IaRC2	I spend time trying to grow in understanding of my faith.			
IaRC3	It is important to me to spend periods of time in private religious thought and reflection.			
IaRC4	Religious beliefs influence all my dealings in life.			
IaRC5	Religion is especially important to me.			
IaRC6	I often read about my faith.			

(Continues)

TABLE 2 | (Continued)

Constructs and items		α	CR	AVE
Green values (GVs)				
GV1	It is important to me that the products I use do not harm the environment.	0.907	0.928	0.684
GV2	I consider the potential Environmental impact of my actions when making many of my decisions.			
GV3	My purchase habits are affected by my concern for our environment.			
GV4	I am concerned about wasting the resources of our planet.			
GV5	I would describe myself as environmentally responsible.			
GV6	I am willing to be inconvenienced in order to take actions that are more environmentally friendly.			

Unlike traditional methods that assess the individual importance of each factor in isolation, fsQCA emphasizes how different conditions interact and combine to shape consumer behavior. This holistic approach is particularly well-suited for capturing the causal complexity inherent in social phenomena, where multiple pathways may lead to the same outcome (Ragin 2009).

By identifying configurations of conditions that are consistently associated with high (or low) levels of SCAs adoption, fsQCA allows researchers to go beyond linear relationships and uncover alternative, yet equally valid, explanatory pathways. This is particularly valuable for exploring nonlinear and asymmetric effects, where factors that drive adoption in one group may not be relevant in another. Moreover, fsQCA enables the identification of necessary and sufficient conditions, providing a more nuanced understanding of the structural patterns underlying SCAs adoption.

Applying fsQCA in this study allowed us to systematically address the multidimensional nature of SCAs adoption by considering how technological, psychological, and behavioral factors interact. This method is particularly insightful in uncovering configurations that may be overlooked in more traditional research designs, where variable-by-variable analyses may fail to capture the complexity of real-world decision-making. By adopting fsQCA, we provide a rigorous, systematic, and context-sensitive examination of the factors driving SCAs adoption across different consumer segments.

Given the study's focus on generational differences, fsQCA was preferred over partial-least square (PLS-SEM) or covariance-based (CB-SEM) methodologies, which would require strong a priori assumptions about linearity and homogeneity. This approach enables the identification of alternative adoption pathways, offering deeper insights into how different consumer segments engage with SCAs.

3.4 | Calibration

Multi-item scales were utilized to measure the causal conditions in this study, and the scores were averaged to determine each measure. Thus, we converted the initial 7-point Likert scale values into a fuzzy set scale for calibration. We adhered to the calibration methodology presented by Ragin (2009), which entails scaling the membership of each causal condition from 0 to 1. Here, 0 denotes "non-membership," and 1 denotes "full membership." In line with Ragin's recommendations, we identified three cutoff points for the fuzzy set calibration on the condition using the direct method. This approach requires defining the parameters for full membership, the crossover point, and non-membership (Ragin 2009). We adopted the percentile method to delineate these three parameters, as suggested by the best practices in fsQCA research (Marzi et al. 2023).

Consequently, the non-membership threshold was designated at the original value, accounting for 5% of the data values (fuzzy score = 0.05). The crossover points threshold was designated at the original value, representing 50% of the data values (fuzzy score = 0.50). Finally, the total membership threshold was established at the original value corresponding to 95% of the data values (fuzzy score = 0.95). All calibration values for the conditions are depicted in Table 3.

3.5 | NCA

The fsQCA analysis is then complemented with the NCA analysis. NCA aims to explore the relationship between two variables regarding the necessary level of one variable, X, to predict a specific effect on the desired outcome variable, Y (Dul 2016). As such, NCA can indicate specific bottlenecks and the minimum level of a condition (X) required to produce a specific effect on an outcome (Y) (Dul 2022), also showing the intensity of such an effect and the statistical significance of it. The bottleneck analysis determines the thresholds below which a factor becomes a significant barrier to the outcome (Y). By quantifying these bottlenecks, NCA highlights absolute necessities and provides insights into the intensity and statistical significance of these constraints. This approach is grounded by calculating ceiling lines, which define the critical limits that must be met for the outcome to materialize. Although such calculations can be performed differently, the most robust approach rests on the

TABLE 3 | fsQCA calibration.

Constructs	Mean	SD	Minimum	Maximum	Calibration (fuzzy score)		
					0.05	0.50	0.95
GenZ							
PE	4.714	1.352	1.000	7.000	2.000	4.833	6.667
EE	5.481	1.183	1.000	7.000	3.240	5.800	7.000
SI	4.011	1.407	1.000	7.000	1.600	4.200	6.200
FC	5.522	1.029	1.833	7.000	3.533	5.667	7.000
HM	4.410	1.380	1.000	7.000	1.857	4.429	6.571
H	2.618	1.525	1.000	7.000	1.000	2.333	5.333
PV	4.413	1.311	1.000	7.000	2.000	4.500	6.500
SCB	4.750	1.319	1.000	7.000	2.400	4.900	6.680
IaRC	1.992	1.343	1.000	7.000	1.000	1.333	4.833
GVs	5.244	1.147	1.000	7.000	2.833	5.500	6.833
SCAA	5.382	1.303	1.000	7.000	2.667	5.667	7.000
GenY							
PE	4.697	1.413	1.000	7.000	1.667	4.833	6.667
EE	5.394	1.262	1.000	7.000	3.000	5.600	7.000
SI	4.071	1.423	1.000	7.000	1.600	4.000	6.400
FC	5.415	1.114	1.000	7.000	3.333	5.667	7.000
HM	4.254	1.421	1.000	7.000	1.571	4.286	6.429
H	2.849	1.625	1.000	7.000	1.000	2.667	6.000
PV	4.420	1.370	1.000	7.000	1.500	4.500	6.500
EB	4.895	1.278	1.000	7.000	2.400	5.000	6.700
IaRC	2.421	1.633	1.000	7.000	1.000	1.833	5.683
GVs	5.371	1.172	1.000	7.000	2.817	5.667	6.833
SCAA	5.286	1.350	1.000	7.000	2.500	5.500	7.000

"ceiling envelope with free disposal hull" (CE-FDH). The result of CE-FDH is a graphical representation where the size of the empty space on the upper left corner of the graph shows the level of necessity requested from predictor X for generating outcome Y (Dul 2016; Dul et al. 2020). Next, the bottleneck table summarizes the CE-FDH results for each predictor X level in generating the desired outcome Y. As a result, the bottleneck analysis can show the relation between X and Y at different degrees of X.

4 | Results

4.1 | Results of the fsQCA Analysis

In performing the truth table, we first set a frequency threshold of four and a consistency threshold of 0.90 for both GenZ and GenY consumers (Ragin 2009), allowing us to reach the recommended value of 80% of the included cases (Ragin 2009). The fsQCA results for the target variables indicate the presence of multiple configurations, each representing distinct pathways through which consumers express their willingness to adopt SCAs (Table 4). This approach allows us to capture the complexity and heterogeneity of consumer decision-making, recognizing that different profiles of users may follow diverse but equally valid paths to the same outcome.

To ensure the robustness of the identified solutions, we followed Fiss's (2011) methodological recommendations for sensitivity analysis, testing different calibration crossover points (±25%). The results remained stable across permutations, with only minor and statistically insignificant changes observed, confirming the reliability and robustness of our fsQCA findings (Fiss 2011). Table 4 presents the results of the fsQCA analysis, identifying five valid configurations for GenZ consumers (GZ1, GZ2, GZ3, GZ4, and GZ5) and five for GenY consumers (GY1, GY2, GY3, GY4, and GY5). The solution coverage—which reflects the proportion of cases explained by the configurations—indicates that the identified pathways explain 64.9% of the sample for GenZ (0.649) and 79.1% for GenY (0.791), demonstrating a strong explanatory power.

TABLE 4 | Configurations leading to the adoption of SCAs.

	Solutions									
	GenZ					GenY				
Configuration	**GZ1**	**GZ2**	**GZ3**	**GZ4**	**GZ5**	**GY1**	**GY2**	**GY3**	**GY4**	**GY5**
UTAUT2 model										
Performance expectancy (PE)	●			•		•		•		
Effort expectancy (EE)	●	•	•	•	•			•	•	●
Social influence (SI)										
Facilitating conditions (FCs)		•	•	•	●			•	•	
Hedonic motivation (HM)	●	●		●		●	●	●		
Habit (H)	•							•		
Price value (PV)	●		●	•				•	●	
Consumer behavior										
Sustainable consumption behaviors (SCBs)	•			•	●	•				●
Values										
Religiosity (IaRC)		⊗	⊗		⊗		⊗		⊗	⊗
Green values (GVs)	•			•	•	•				•
Consistency	0.958	0.926	0.906	0.970	0.939	0.954	0.855	0.967	0.892	0.895
Raw coverage	0.464	0.451	0.449	0.444	0.396	0.595	0.547	0.482	0.439	0.418
Unique coverage	0.066	0.012	0.013	0.009	0.006	0.064	0.058	0.030	0.012	0.001
Overall solution consistency			0.889					0.848		
Overall solution coverage			0.649					0.791		

Note: Black circles (●) indicate the presence of a condition and circles with "x" (⊗) indicate its absence. Large circle; core condition, small circle; peripheral condition; blank space; "do not care" condition.

Regarding the UTAUT2 model, the fsQCA results indicate that all model variables are included in acceptable solutions (Duarte and Pinho 2019; Marzi et al. 2023). However, out of the seven dimensions, six influence consumers' adoption of SCAs: SI, understood as the perception that the consumer has of the pressure that "others" who matter push the use of SCAs, not being present in any configurations, constitutes the "do not care" across all configurations. This result suggests that SI does not play a determining role in SCAs adoption, as users follow adoption pathways independent of social pressure.

Other conditions play varying roles, central or peripheral, across configurations. HM, measured as the SCAs capacity to deliver a fun and enjoyable consumer experience, as a core condition in three out of five decision profiles for Gen Z and Y, represents the most relevant condition that drives the intention to adopt SCAs. This finding suggests that the ability of SCAs to provide an engaging and enjoyable experience is a critical driver of adoption. EE, measuring perceived ease of use, appears in eight out of 10 configurations, assuming a core role in two cases. This result underscores the importance of usability in shaping SCAs adoption decisions. FCs, representing the consumer's confidence and comfort in using SCAs, are present in six configurations, with a core role in one. PV, considered the consumer-perceived "good value for money" that SCAs enable in sustainable purchases, guides five adoption paths out of 10, representing critical drivers in three configurations, highlighting consumers' sensitivity to the economic benefits of using SCAs. PE, reflecting whether SCAs are perceived as practical enablers of sustainable consumption, appears in four configurations, playing a decisive role in one. Finally, H, representing the habitual use of SCAs, is a factor in only two out of 10 configurations, suggesting that prior experience with SCAs does not universally predict adoption.

Focusing on the findings beyond the UTAUT2 model to incorporate the three extended dimensions, Table 4 shows, first of all, the significant and positive role of GVs, measured as a consumer value system related to the specific sphere of green purchases, in five out of 10 configurations, indicating the influence of green consumption value in adopting SCAs for specific segments of consumers. Considering religiosity as a belief system that can shape how norms and values influence SCAs adoption, and here measured as IaRC, fsQCA results show that in six out of 10 SCAs adoption pathways, IaRC is an absent condition, with

four cases where its absence is peripheral and two where it constitutes a core absent condition. This finding suggests that religious commitment does not play a significant role in shaping SCAs adoption.

Considering the behavioral dimension, SCB patterns positively impact five out of 10 and serve as a core condition in two, highlighting the link between pre-existing behaviors and SCAs adoption. Further, the results highlight that SCBs are strongly associated with GVs (both present in the same five adoption paths), reinforcing the connection between green consumption values and behavioral choices.

Figure 2 summarizes the main configurations (GY1, GY2, GY3, GZ1, GZ2, and GZ3) lead to an SCAs adoption.

4.1.1 | Main Configurations: The Difference Between Gen Z and Y

While fsQCA identifies multiple pathways to adoption, some configurations stand out due to their higher consistency and coverage, making them the most reliable consumer SCAs adoption representations. These key configurations are especially relevant as they represent the most stable and frequently observed adoption patterns.

In GZ1, PE, EE, HM, and PV display a core presence. This configuration represents a context where users' expectations of performance, ease of use, desire for pleasure, and cost-effectiveness are the dominant drivers. However, SI plays no role, indicating a possible individualistic or autonomous decision-making process. Though not core, the presence of H and SCBs could suggest some degree of habituation and ethical considerations in users' behaviors. In GZ2, only HM shows a core presence, implying that users in this context are primarily driven by the enjoyment and pleasure derived from the product or service. Other factors, including EE and FC, indicate some relevance, although not core. The non-core absence of IaRC could suggest that religious norms or values might not directly impact consumer decisions in this context. GZ3 is mainly defined by PV as a core condition, suggesting the primary role of economic accessibility in influencing consumer decisions. This class of users mainly uses SCAs to improve their spending decisions.

A core presence of HM characterizes configuration GY1. Additionally, PE, SCBs, and GVs are present as conditions, though not core. This suggests that consumer behavior in GY1 is primarily driven by the enjoyment derived from the behavior. Meanwhile, expectations regarding its performance, sustainability-oriented behaviors, and GVs are relevant but do not hold central importance in shaping consumer decisions. A core presence of HM characterizes configuration GY2. All other conditions show a "do not care" status, suggesting their impact is inconsequential, except IaRC, which shows a non-core absence. This indicates that, in GY2, consumer behavior is primarily influenced by HM, and religious beliefs may not be a significant driver. Configuration GY3 reveals a core presence of HM, with PE, EE, FC, H, and PV also showing non-core presence. This finding suggests a multi-faceted context where pleasure-seeking is central, and factors like performance (PE) and effort expectations (EEs), FC, Hs, and PV also play a role, although their influence is not paramount.

As a result, the fsQCA analysis highlighted distinct adoption patterns between GZ and GY, with notable differences in key drivers. HM is core across all the main GY configurations, whereas in GZ, it is central in GZ1 and GZ2 but absent in GZ3;

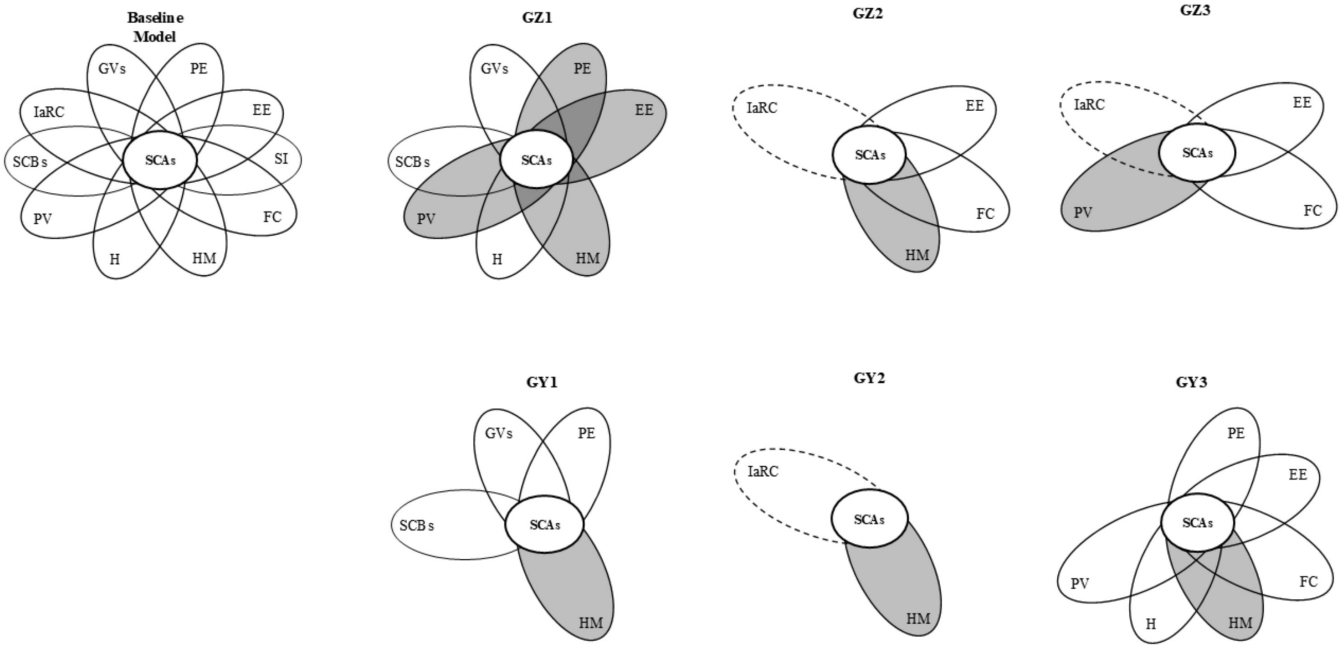

FIGURE 2 | Graphical representation of the fsQCA results. *Note:* Bold lines indicate the presence of a condition; dashed lines indicate its absence. Solid-filled circles indicate the presence of a core condition; dashed-filled circles indicate the absence of a core condition. The absence of circles indicates a "do not care" condition.

for this last configuration, PV emerges as the primary driver. PE and EE are core in GZ1, indicating a more substantial influence of functionality and ease of use. In contrast, in GY, PE appears only as a non-core condition in GY1 and GY3, suggesting a more limited role. SCBs and GVs are present in GY1 but absent in all GZ configurations, implying a stronger environmental consciousness among GY users. SI plays no role in GZ1, and its absence across GY suggests a relatively autonomous decision-making process in both groups. PV is core in GZ3, reflecting a greater sensitivity to financial considerations in GZ, whereas in GY, it remains a non-core condition in GY3, indicating a lesser emphasis on budget. Finally, IaRC is consistently absent as a relevant factor in both groups, reinforcing its lack of influence on adoption decisions.

4.2 | Results of the NCA Analysis

The NCA analysis complements the fsQCA analysis, shedding additional light on the predictors that act as bottlenecks in app adoption across Gen Z and Gen Y. These findings emphasize the varying significance of specific predictors, highlighting the thresholds required to overcome barriers to SCAs adoption, offering a nuanced understanding of generational differences in app adoption. The results of the NCA analysis are presented in Tables 5 and 6. As suggested by Dul (2016), we used the identical latent scores calculated for the multiple regression presented above, using standardized values. The CE-FDH showed that, among the three constructs that extended UTAUT2 in the present study, only two have statistical significance (SCBs and GVs).

4.3 | Key Predictors and Bottlenecks for Gen Z and Gen Y

Tables 5 and 6 provide insights into the necessary conditions for the adoption of SCAs among Gen Z and Gen Y, using NCA. These analyses identify the bottlenecks, or the minimum thresholds that must be met for adoption to occur. The higher the effect size is, the more critical the factor is in determining adoption. Also, the value percentage of CE-FDH X on Y depicts the level every variable should reach.

For Gen Z, several variables emerged as statistically significant in influencing app adoption. Predictors such as PE, EE, HM, FC, SCBs, and GVs were critical, suggesting a multifaceted interplay between utilitarian, hedonic, and values-driven motivations. Notably, H and IaRC appeared non-significant, indicating a limited role in shaping SCAs adoption for this cohort. Among the significant predictors, PE emerged as the most pronounced bottleneck. The analysis revealed a steep threshold, with PE reaching a bottleneck level of 44.4% at the 100% ceiling. This underscores the necessity for apps to demonstrate clear and compelling utility to drive adoption among Gen Z. Other predictors, such as HM and GVs, also presented notable bottlenecks. For HM, the threshold reached 38.1% at the 100% ceiling level, reinforcing the importance of creating an enjoyable user experience. Apps that align with the hedonic preferences of Gen Z—through features that are engaging or gamified—are more likely to achieve widespread adoption. Similarly, GVs exhibited a threshold of 19.4% at the 100% ceiling, suggesting that sustainability-conscious values play a meaningful, albeit secondary, role in motivating app adoption. Moderate bottlenecks were observed for EE and FC. While these factors contribute to app adoption, their influence is less pronounced compared with predictors such as PE and HM. The moderate thresholds for EE and FC suggest that while ease of use and support mechanisms are valued by Gen Z, they alone are unlikely to drive adoption without stronger hedonic or performance-related incentives.

For Gen Y, several variables are statistically significant in driving app adoption. Among these, PE, EE, SI, FC, SCBs, and GVs emerge as critical predictors. Interestingly, HM and PV exhibit smaller effects, suggesting they play a secondary role in decision-making for this cohort. As with Gen Z, IaRC appears non-significant, highlighting its minimal influence in this context. A standout finding is the bottleneck associated with FC, which demonstrates a steep threshold at the 100% ceiling level (27.8%). This underscores the necessity for a supportive environment—such as reliable infrastructure and accessible resources—for achieving higher app adoption rates among Gen Y. Apps that fail to address these facilitation needs are less likely to gain traction in this cohort. Additionally, GVs exhibit a significant threshold, reaching 36.1% at the 100% ceiling. This indicates that aligning app features with sustainability concerns is increasingly important for Gen Y, reflecting their growing commitment to environmentally conscious behaviors. Moderate bottlenecks are observed for PE and EE. While both are statistically significant, their thresholds are lower compared with FC and GVs, suggesting that although functionality and ease of use matter, they are not as critical as facilitation and sustainability in driving app adoption for Gen Y. The smaller effects of HM further delineate the adoption patterns of this cohort. Unlike Gen Z, for whom enjoyment and perceived economic value play a stronger role, Gen Y appears to prioritize utility and alignment with its broader values over hedonic or cost-related considerations.

5 | Discussions and Implications

Our findings confirm the robustness of the UTAUT2 model in explaining SCAs adoption (Duarte and Pinho 2019; Tamilmani et al. 2021; Meet et al. 2022), with six of its seven dimensions significantly predicting adoption. However, their influence varies across generational cohorts, revealing distinct adoption patterns.

A key generational contrast emerges in the role of PE. For Gen Z, PE is a cornerstone of adoption, consistently interacting with other drivers in configurations like GZ1 and GZ4. This is reinforced by NCA results, where PE presents the steepest bottleneck (44.4% at the 100% ceiling), indicating that Gen Z consumers adopt SCAs primarily for their perceived utility in achieving sustainability goals. In Gen Y, however, PE plays a more peripheral role. While it appears in specific configurations (GY1, GY5), its effect is less pronounced, with NCA showing a more moderate threshold, suggesting that Gen Y's adoption decisions are less utility-driven. Instead, FC emerge as a core driver in configurations like GY4 and GY5, with a steep NCA bottleneck (27.8% at the 100% ceiling), emphasizing Gen Y's reliance on external enablers—such as infrastructure, usability, and technical support—rather than intrinsic app utility. This aligns with broader

TABLE 5 | Necessary condition analysis (NCA) for GenZ.

Bottlenecks CE-FDH X on Y										
App adoption (Y)	**Performance expectancy (PE)**	**Effort expectancy (EE)**	**Social influence (SI)**	**Facilitating conditions (FCs)**	**Hedonic motivation (HM)**	**Habit (H)**	**Price value (PV)**	**Sustainable consumer behaviors (SCBs)**	**Religiosity (IaRC)**	**Green values (GVs)**
0%	—	—	—	—	—	—	—	—	—	—
10%	—	—	—	—	—	—	—	—	—	—
20%	—	—	—	—	—	—	—	1.7%	—	—
30%	—	—	—	—	—	—	—	1.7%	—	—
40%	5.5%	—	—	—	—	—	—	5%	—	—
50%	5.5%	—	—	—	—	—	—	5%	—	—
60%	16.7%	6.7%	—	6.5%	—	—	—	8.3%	—	11.1%
70%	16.7%	6.7%	—	6.5%	7.2%	—	—	8.3%	—	11.1%
80%	19.4%	13.3%	—	6.5%	7.2%	—	4.2%	8.3%	—	19.4%
90%	19.4%	20%	10%	22.6%	28.6%	—	4.2%	20%	—	19.4%
100%	44.4%	53.3%	20%	32.3%	38.1%	—	29.2%	20%	—	19.4%
Effect size	0.109***	0.067**	0.023***	0.055*	0.060***	n.s.	0.023***	0.074***	n.s.	0.071**

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

TABLE 6 | Necessary condition analysis (NCA) for GenY.

Bottlenecks CE-FDH X on Y										
App adoption (Y)	**Performance expectancy (PE)**	**Effort expectancy (EE)**	**Social influence (SI)**	**Facilitating conditions (FCs)**	**Hedonic motivation (HM)**	**Habit (H)**	**Price value (PV)**	**Sustainable consumer behaviors (SCBs)**	**Religiosity (IaRC)**	**Green values (GVs)**
0%	—	—	—	—	—	—	—	—	—	—
10%	—	—	—	—	—	—	—	—	—	8.3%
20%	—	—	—	—	—	—	—	—	—	13.9%
30%	—	—	—	13.9%	—	—	—	—	—	13.9%
40%	—	—	—	19.4%	—	—	—	5%	—	13.9%
50%	—	—	—	19.4%	—	—	—	11.7%	—	16.7%
60%	—	—	—	19.4%	—	—	—	11.7%	—	16.7%
70%	2.8%	16.7%	—	25%	—	—	—	11.7%	—	16.7%
80%	2.8%	20%	—	27.8%	7.2%	—	—	11.7%	—	16.7%
90%	41.7%	40%	16.7%	27.8%	7.2%	—	—	11.7%	—	16.7%
100%	41.7%	43.3%	20%	27.8%	7.2%	—	—	21.7%	—	36.1%
Effect size	0.072***	0.088***	0.029***	0.164***	0.018***	n.s.	n.s.	0.075***	n.s.	0.147***

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

generational differences: Gen Z, as digital natives, expects seamless value from apps, whereas Gen Y prioritizes external conditions that simplify integration into daily routines.

Notably, SI is the only non-significant UTAUT2 dimension, suggesting that the private nature of SCAs use minimizes the impact of external pressures. This aligns with prior research on mobile app adoption (Ahn et al. 2016; Kulviwat et al. 2009), reinforcing the need to contextualize UTAUT2's applicability when SI is less relevant.

Another generational distinction emerges in HM. For Gen Z, HM is a key driver, as seen in configurations like GZ4, with NCA showing significant thresholds (38.1% at the 100% ceiling). Gamification, interactive interfaces, and reward-based engagement enhance appeal (Guillen Mandujano et al. 2022; Douglas and Brauer 2021), demonstrating that Gen Z seeks both utility and enjoyment in SCAs. In contrast, Gen Y exhibits a more pragmatic approach, with HM playing a secondary role. While enjoyment enhances user experience, it does not significantly drive adoption, as confirmed by its weaker NCA effect. This reflects a generational divide: Gen Z expects apps to be both engaging and functional, while Gen Y prioritizes practical benefits over entertainment.

5.1 | Theoretical Implications: Beyond UTAUT2—Integrating VBN Theory

Our findings indicate that SCAs adoption is better explained by integrating technological (UTAUT2) and normative (VBN) factors, particularly consumer values (GVs) (Haws et al. 2014), beliefs (IaRC) (Martin and Bateman 2014; Felix and Braunsberger 2016; Minton et al. 2022; Pegan et al. 2023), and preexisting behaviors (SCBs) (Sudbury-Riley and Kohlbacher 2016). This UTAUT2–VBN integration bridges technological acceptance with personal and normative adoption drivers, offering a comprehensive framework for sustainability-related technology adoption.

For Gen Z, fsQCA identifies GVs as a complementary factor, interacting with hedonic (HM) and functional (EE) drivers (e.g., GZ1, GZ4). However, NCA reveals a modest bottleneck (19.4% at the 100% ceiling), suggesting that sustainability concerns compete with other priorities like engagement and ease of use. In contrast, GVs play a more central role in Gen Y, with configurations like GY1 and GY5 linking GVs to enabling factors (FC). NCA confirms a higher GVs threshold (36.1% at the 100% ceiling), indicating that Gen Y consumers integrate sustainability within structured, practical adoption processes rather than as an independent motivator. This distinction underscores how GVs bridge UTAUT2 and VBN theory, aligning with experiential factors in Gen Z and functional enablers in Gen Y.

Regarding IaRC, expected to act as both a value-based motivator and a moderating factor, our findings indicate minimal influence on SCAs adoption. Neither fsQCA nor NCA identifies IaRC as a core or peripheral condition, with thresholds confirming a negligible effect. While previous research linked religiosity to SCBs (Minton et al. 2015; Orlandi et al. 2022) and trust in AI-driven sustainability tools (Minton et al. 2022), our results align with studies reporting only marginal associations between IaRC and green purchasing (Pegan et al. 2023) or even negative effects (Essoo and Dibb 2004; Orellano et al. 2020). This suggests that faith-based obligations do not significantly shape SCAs adoption, with GVs emerging as the primary normative driver across both cohorts.

Our findings also extend UTAUT2 (Venkatesh et al. 2012) and VBN theory (Stern et al. 1999; Lim 2024) by demonstrating how SCBs shape SCAs adoption differently across generational cohorts. Within UTAUT2, SCBs were expected to enhance PE and EE, yet this varies by generation.

In Gen Z, SCBs frequently interact with HM and GVs (as seen in configurations GZ1 and GZ5), suggesting that sustainability concerns function as part of a broader set of adoption drivers rather than a standalone factor. This indicates that younger consumers integrate sustainability goals with both functional and experiential motives, balancing ethical responsibility with engagement and enjoyment.

For Gen Y, SCBs play a less central role, appearing as a peripheral condition in configurations like GY4. This suggests that SCBs complement rather than drive adoption, typically aligning with FC and GVs. Thus, for Gen Y, SCAs adoption is embedded in broader enabling mechanisms, where sustainability considerations are relevant but not primary motivators.

These results refine UTAUT2 by demonstrating that SCBs shape adoption only when embedded within other relevant drivers, rather than serving as a direct predictor across all users. From a VBN perspective, this reinforces the idea that SCBs reflect the internalization of ethical values (GVs), influencing adoption patterns (Stern et al. 1999). However, their interaction with other drivers differs across generations.

5.2 | Practical Implications

This study offers valuable strategic insights for practitioners, institutions, and marketers seeking to promote sustainable consumption technologies by aligning them with consumer adoption drivers (Brauer et al. 2016; Guillen Mandujano et al. 2022). As Zhao and Balagué (2015) emphasize, a deep understanding of these drivers is essential for effectively designing and positioning SCAs to meet the expectations of diverse consumer segments. Our findings underscore the need for tailored engagement strategies, ensuring that SCAs resonate with both shared motivations and generation-specific adoption patterns among consumers.

5.2.1 | Addressing Generational Differences

The results highlight that SCAs adoption preferences vary across generations, requiring distinct engagement approaches.

For Gen Z, SCAs adoption is heavily influenced by user experience, gamification, and affordability. Given their preference for interactive and engaging digital environments, SCAs should incorporate personalized recommendations, reward-based incentives, and dynamic content to sustain user interest. Additionally,

cost-effectiveness is a key concern for this segment. Pricing strategies that emphasize affordability and perceived value may further boost adoption rates.

For Gen Y, adoption is primarily driven by technical support, ease of access, and reinforced environmental values. This cohort benefits from SCAs that offer educational content, seamless usability, and efficient support systems, allowing effortless integration into daily routines. Transparency in sustainability claims and functional efficiency are critical to appeal to Gen Y's pragmatic and purpose-driven approach to sustainability.

5.2.2 | Targeting Consumers Based on Sustainability Orientations, Social, and Religious Motivations

Beyond generational differences, sustainability orientations—particularly GVs (Haws et al. 2014) and SCBs (Sudbury-Riley and Kohlbacher 2016)—shape adoption likelihood.

For consumers with strong GVs or established SCBs, SCAs should offer multi-dimensional integration, combining functional efficiency, hedonic appeal, and economic value. These users demand transparency, sustainability-driven solutions, and high-quality functionality that aligns with their pre-existing sustainability commitments. For Gen Z consumers in this segment, demand remains high for engaging yet practical SCAs that merge entertainment with utility.

For consumers with lower GVs and limited SCBs, SCAs adoption is contingent on perceived enjoyment and financial benefits rather than intrinsic sustainability motivations. Hedonic and economic incentives serve as entry points, introducing sustainable behaviors through interactive and cost-saving features. By framing sustainability as a byproduct of enjoyable and financially beneficial engagement, SCAs can expand their appeal to a broader audience and act as a behavioral bridge toward ethical consumption over time.

For highly engaged consumers who already exhibit strong SCBs or GVs, SCAs should focus on enhancing functionality to further support sustainable practices. Improving usability, transparency, and efficiency will likely resonate with this group, as they seek seamless digital tools that reinforce their commitment to sustainability. Offering tailored solutions that optimize existing behaviors can help SCAs deepen their long-term impact among these users.

Findings also suggest that SI does not significantly drive SCAs adoption, indicating that SCAs should be framed as personal empowerment tools rather than peer-driven sustainability solutions. However, because SI remains influential in broader sustainable behaviors (White et al. 2019; Fuentes and Sorum 2019), SCAs can still leverage social engagement through alternative means, such as user-generated content, gamification elements (Krath et al. 2022; Guillen Mandujano et al. 2022), or partnerships with green influencers to foster normative support (Pegan and Balzano 2025).

Similarly, the negligible impact of IaRC on SCAs adoption suggests that marketing strategies should emphasize universal ethical and environmental values rather than explicitly religious narratives. However, because moral considerations remain central to faith-based decision-making (Minton et al. 2022; Orlandi et al. 2022), sustainability could still be framed as a shared ethical responsibility, aligning with principles of stewardship and social justice to broaden consumer appeal.

6 | Limitations and Future Research Directions

While this study offers theoretical and managerial insights, it also presents limitations that suggest future research avenues.

First, HM emerged as a key driver of SCAs adoption, particularly for Gen Z, yet the specific elements that drive engagement remain unexplored. Future studies could extend the current research by exploring design-related factors such as aesthetic appeal, app atmosphere, and sensory engagement that contribute to enhancing user experience and fostering mobile app stickiness (Akdim et al. 2022; Chang et al. 2014; Pegan and Balzano 2024). A more nuanced understanding of these elements could assist developers in optimizing the emotional resonance of SCAs, thereby promoting greater adoption, particularly among younger users. Additionally, future research may investigate how specific characteristics of SCAs—such as their functional focus, duration on the market, and whether they are developed domestically or internationally—affect user engagement. Examining these dimensions could uncover important correlations between app provenance and adoption behavior across varied cultural and regulatory environments.

Second, this study focused on Italian Gen Z and Gen Y consumers, ensuring homogeneity in mobile familiarity and digital engagement. However, expanding the analysis to other generational cohorts (e.g., Gen X, Gen Alpha) and European markets could reveal broader SCAs adoption patterns. While Gen X was excluded to maintain consistency in digital expertise, their growing digital literacy warrants further investigation into sustainability adoption in later life stages. Additionally, cross-cultural research (Minton et al. 2015) could explore how variations in national sustainability policies, digital infrastructures, and cultural norms influence SCAs adoption, thereby informing the development of branded applications that promote sustainable consumption (Zhao and Balagué 2015). Future studies are encouraged to investigate adoption patterns across diverse global regions—such as North America, Latin America, and Southeast Asia—where differing levels of sustainability awareness, regulatory frameworks, and e-commerce maturity may yield valuable comparative insights.

Furthermore, the use of a non-probability sampling strategy introduces potential limitations regarding representativeness. However, the sample composition reflects key characteristics of early adopters and is therefore methodologically justified. Given the absence of a defined population frame for SCAs users, future research could address this limitation by employing complementary strategies such as multi-sample replication across varied user segments or cross-national comparisons. These approaches would enhance the robustness and generalizability of SCAs adoption findings.

Although SI was non-significant, prior research underscores its relevance in sustainable behaviors (White et al. 2019; Fuentes and Sorum 2019). The private nature of SCAs may limit peer pressure effects (Kulviwat et al. 2009), but SI could still operate indirectly by shaping perceived social norms (Ajzen 1991). Future research should investigate SI's role in digital sustainability adoption, particularly through peer networks, online communities, and influencer-driven sustainability campaigns (Pegan and Balzano 2025). Additionally, examining how SI affects different types of SCAs—such as eco-labeling apps versus second-hand marketplaces—could clarify its contextual impact.

Findings suggest that pragmatic and value-driven considerations, rather than religiosity (IaRC), shape sustainability-related technology choices. However, this does not negate the role of faith but suggests that its influence may be context-dependent. Future research should examine how specific religious doctrines shape SCAs adoption (Minton et al. 2016, 2022) Additionally, spirituality—distinct from religiosity—may be a more relevant driver, as its emphasis on authenticity and self-evolution aligns with consumer trends (Orlandi et al. 2022; Minton et al. 2022). Cross-cultural research could further explore spirituality's role in SCAs adoption across different cultural contexts (Hofstede 1991).

Lastly, while this study focused on mobile apps, consumers engage with multiple digital platforms—including websites, social media, blogs, and AI-driven tools like chatbots (Ozuem et al. 2024). Future research could examine how SCAs function within broader digital ecosystems, assessing whether multi-platform engagement enhances sustainable behaviors. Understanding these dynamics would help firms design integrated digital strategies that maximize SCAs adoption.

Another possible limitation of this study is the use of fsQCA and NCA, without employing PLS-SEM or CB-SEM to test causal relationships and statistical significance. While fsQCA effectively captures causal complexity and identifies multiple, equally valid adoption pathways, it does not measure the magnitude of effects or assess direct and mediating influences. Future research could address this limitation by combining fsQCA with PLS-SEM or CB-SEM to validate configurational pathways, examine direct, mediating, and moderating effects, or compare asymmetric vs. linear models.

7 | Conclusions

To conclude, by integrating UTAUT2 and VBN theory, this study highlights how performance-related, experiential, and enabling drivers interact with ethical and normative influences in shaping sustainability-related technology adoption. While UTAUT2 explains usability and behavioral determinants, VBN theory captures intrinsic values and sustainability norms, showing that neither model alone fully explains adoption patterns. Instead, their integration provides a more nuanced understanding of generational differences, reinforcing the need for multi-faceted engagement strategies. Some consumers are intrinsically motivated by sustainability, while others require external incentives and behavioral nudges—a critical distinction for practitioners designing and promoting SCAs.

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