This is a preprint version of the article: Ismail, E., Awad, B.K. and Mahrous, A.A. (xxxx) 'Unlocking green app adoption in Egypt: the role of eco-innovation, tech-savviness and environmental consciousness', EuroMed J. Management, Vol. X, No. Y, pp.xxx–xxx.

Unlocking Green App Adoption in Egypt: The Role of Eco-Innovation, Tech-Savviness, and Environmental Consciousness

Esraa Ismail
Basmah K. Awad
Abeer A. Mahrous

Abstract

The United Nations Sustainable Development Goals (SDGs), particularly Goals 11, 12, and 13, emphasize environmental sustainability and innovative solutions to reduce waste and carbon emissions. Despite rising global awareness, green mobile applications that promote recycling, reuse, and responsible consumption remain underutilized, especially in emerging economies. Prior studies mainly examine green products and general pro-environmental behaviors, offering limited insight into green application adoption in daily life. Addressing this gap, this study investigates how perceived eco-innovation, perceived tech-savviness, and environmental consciousness influence green application use among Egyptian consumers. Survey data from 158 smartphone users were analyzed using SPSS and SmartPLS. Results show that perceived eco-innovation and perceived tech-savviness significantly and positively affect green application use, while environmental consciousness significantly influences perceived eco-innovation. However, the moderating role of environmental consciousness between tech-savviness and green application use is not supported. The study contributes an integrated explanation of green application underuse and provides practical guidance.

Keywords: Eco-innovation, Green Applications, Tech-Savviness, Environmental Consciousness.

1. Introduction

Ecological innovations and sustainability have gained significant attention across various disciplines as urgent global concerns. According to recent statistics, information technology (IT) accounts for approximately 4% of total global greenhouse gas (GHG) emissions (World Bank and ITU 2024). This environmental impact has increased alongside growing consumer awareness and concern regarding the ecological footprint of daily products and services (Teniola et al. 2025; Uz Zaman et al. 2024).

The urgency of this issue stems from the severe threats posed by GHG emissions, energy waste, and pollution. These factors collectively contribute to climate change and environmental degradation (Song et al. 2024). As part of the solution, green information technology (GIT) has emerged as a framework aimed at mitigating these negative environmental effects (Abdullah and Lim 2023; Sharma et al. 2025).

Although global efforts have historically focused on establishing policies to restrict GHG emissions, the growing economies of developing nations have only recently been incorporated into this discourse (Kaplinsky et al. 2009; Clark, 2024; Kanuri et al. 2025). Prior sustainability research has investigated customer adoption of green innovations (e.g. Kapoor et al. 2014; Walia et al. 2020; Nadeemi et al. 2025). However, the majority of studies predominantly focus on green products (Walia et al. 2020), green assets (Taneja et al. 2023), and green behaviours (Dokmai 2018), rather than the daily living patterns adopted by consumers.

These consumer behaviors are strongly influenced by technology and habitual reliance on smartphones (Asongu & Odhiambo 2023).

The rapid expansion of smartphone usage presents a unique opportunity for sustainable digital solutions. Global smartphone ownership has surged by approximately 200% from 2019 to 2024, reaching nearly 4.5 billion users worldwide (Degenhard 2024). In Egypt, reports from NAOS (2024) and Statista (2024) indicate a 180% increase in smartphone users since 2022, with over 70% of the population now owning or using a smartphone.

This widespread digital adoption has fueled exponential growth in the mobile application market, with over 8.9 million applications available to consumers (Degenhard 2024). However, this expansion has also led to fragmented influences on consumer behavior and attitudes (Huang and Benyoucef 2023; Zolkepli et al. 2021; Hoti 2025)

To address the environmental impact of IT, GIT practices have been classified into two key dimensions (Jenkin et al. 2011):

1. Direct impact (Green IT-in): Reducing the negative environmental footprint of IT itself.

2. Indirect impact (Green IT-for): Using IT to support broader sustainability initiatives across industries (Hasan et al. 2024; Naim 2021).

Within this framework, green mobile applications play a critical role in driving sustainable practices. Brauer et al. (2016) define green mobile applications as digital solutions that actively promote environmental sustainability, operational efficiency, and strategic eco-friendly processes. These applications must either directly reduce environmental harm, such as lowering waste or emissions, or indirectly support sustainability efforts by enhancing decision-making and management efficiency (Haraty and Bitar, 2019; Hasan et al. 2024; Melville 2010).

Although the concept of **green mobile applications** is well documented, it remains underutilized in many sustainability studies (Brauer et al. 2016; Haraty and Bitar 2019; Huang and Benyoucef 2023). For instance, while the term is frequently applied in research on **food waste reduction applications** (Balińska et al. 2024; Bolwig et al. 2021; Haas et al. 2022a, 2022b), its broader applications in environmental sustainability are less explored.

This study therefore adopts an inclusive perspective, whereby **any mobile application that contributes to waste reduction or fosters sustainable consumer behavior is considered a "green app."**

Egypt presents a unique context for green app adoption due to rapid urbanization. This process has led to a significant decline in green spaces and associated environmental challenges, including heat islands, air pollution, and high energy consumption (Desouki et al. 2024; Mason 2023; Hegazy et al. 2017). In response, initiatives such as rooftop greening have emerged, offering both environmental and social benefits (Desouki et al. 2024).

The country's Sustainable Development Strategy, Egypt Vision 2030, emphasizes green economy policies and sustainable planning. This strategy particularly focuses on enhancing green infrastructure through spatial planning in regions such as the River Nile and Maadi (El Dessouky 2023; Mahmoud & Selman 2011). In the building sector, high energy use and CO_2 emissions are being addressed through green and solar technologies. However, adoption remains constrained by high initial costs (Marzouk et al. 2022).

Similarly, the agricultural sector is adopting solar-powered drip irrigation systems aligned with the water–energy–food–ecosystems (WEFE) nexus. These systems improve sustainability and resource-use efficiency (Karnib et al. 2025). Public support for renewable energy, particularly in regions such as the Suez Canal Economic Zone, is driven by anticipated economic benefits (Ali 2020). Accordingly, policy efforts increasingly emphasize infrastructure development, subsidies, and training programs to promote sustainable technologies (Karnib et al. 2025).

In the context of Egypt as an emerging economy, there have been few investigations into sustainable application usage. For example, Tarek and Ibrahim Nasreldin (2023) examined green applications that support sustainable transportation practices, while Abed et al. (2024) referred to green applications that promote energy efficiency and energy saving. Other types of applications have also become a focal point for sustainability scholars, such as recycling applications (Seif et al. 2023), which are likewise an area of interest in the present research.

To this end, the present study aims to address the following research question: "What factors are associated with consumers' adoption of green mobile applications in Egypt, and how can these applications effectively promote sustainable behaviors in daily life?" Unlike previous studies that primarily focus on green products, green assets, or general eco-friendly behaviors, this research specifically examines green mobile applications as a medium for sustainable consumer engagement.

Accordingly, the study makes three key contributions. First, it provides an integrated framework for understanding the determinants of green application adoption in an emerging economy, accounting for both technological and behavioral dimensions. Second, it extends the concept of green information technology (GIT) to mobile applications, highlighting their direct and indirect roles in fostering sustainability. Finally, it offers practical insights for policymakers, application developers, and sustainability practitioners regarding the design and promotion of green mobile applications that encourage eco-friendly behaviors among a rapidly growing population of smartphone users in Egypt.

2. Literature Review and Conceptual Model

2.1. Stimulus–organism–response theory

This study is grounded in the Stimulus–Organism–Response (SOR) framework proposed by Mehrabian and Russell (1974). Within this framework, perceived eco-innovation represents the stimulus, reflecting the eco-friendly and innovative cues embedded in green mobile applications. Perceived tech-savviness and environmental consciousness constitute the organismic states through which these stimuli are processed and interpreted. Green application use represents the behavioral response. Accordingly, eco-innovative cues are expected to influence usage behavior directly and through users' internal technological and environmental states. These relationships are examined within the boundary conditions of green mobile applications used by smartphone users in Egypt.

2.2. Perceived Eco-innovation: Concept and Definition

The concept of eco-innovation is broadly defined as a set of techniques, processes, systems, and products that reduce or avoid harmful impacts on the environment (Vence & Pereira 2018). While traditional definitions mainly focus on the production and industry level, Kemp and Pearson (2007) define eco-innovation as *"the production, assimilation, or exploitation of a product, production process, service, or management or business method that is novel to the industry and which results, through its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resources as compared to relevant alternatives"* (Kapoor et al. 2014; Sharma et al. 2024a).

Due to rising environmental pressures, eco-innovation has emerged as a critical strategic instrument for achieving sustainable development in manufacturing businesses. In the past, investment in environmental activities was often considered unnecessary. However, stringent environmental legislation and the expansion of environmentalist movements have altered competitive rules and business practices (Sezen and Çankaya 2013).

This study shifts the focus to the consumer perspective. Accordingly, eco-innovation is treated as a perceived attribute. It refers to the extent to which users recognize and evaluate the environmental improvements and innovative features of the application.

2.3. Perceived Eco-innovation and Green Application Use

Green consumption behavior refers to actions that minimize, or have minimal, negative impact on the environment. Such actions often involve recycling, carrying personal shopping bags, and using eco-friendly products and services (Sharma et al. 2024b; Walia et al. 2020).

In the context of this research, green consumption behavior is reflected in the use of green mobile applications to reduce waste and protect the environment. Mobile technology offers environmental researchers and activists new opportunities to promote pro-environmental behavior and environmental consciousness. It is portable, accessible from anywhere, and easy to use, creating an integrated communicative environment in which being online is no longer a discrete state (Typhina 2015).

Applications for mobile devices have a significant impact on consumer purchasing experiences, generating new opportunities for businesses. Mobile applications are projected to exert a substantial influence on consumer purchase behavior while simultaneously contributing to environmental sustainability (Doğan et al. 2022).

Living-green applications are increasingly expanding their reach to support individuals in adopting greener lifestyles. These applications provide a variety of eco-friendly options for everyday activities, such as commuting, shopping, and energy use. Examples include using public transportation or avoiding the use of clothes dryers. Some applications additionally offer lists of improvement suggestions or provide information about local sites and businesses.

The diversity of green applications reflects the wide range of approaches available for living in a more environmentally friendly manner (Zeybek 2020).

The use of green applications aligns with the sustainable development objectives declared by the United Nations in 2015 with a view to 2030. These objectives include Goal 9 (Industry, Innovation, and Infrastructure), which focuses, among other aspects, on fostering innovation, and Goal 12 (Responsible Consumption and Production). The use of mobile applications to encourage pro-environmental behavior has become one of the most significant applications of modern technology and can effectively contribute to the conservation of the natural environment (Balińska et al. 2021).

The literature underlines the importance of green marketing strategies, such as eco-innovation, in influencing consumer behavior toward environmentally friendly products. This suggests that eco-innovation may play an important role in increasing the use of green applications (Ahmed and Prabhakar 2023). In this study, eco-innovation is conceptualized as a perceived attribute rather than an objective technical property. This distinction is critical because consumer adoption is driven by users' subjective evaluations.

Environmental consciousness acts as a cognitive lens. Individuals with higher levels of environmental awareness are more likely to recognize and appreciate the innovative green features of an application. While the technical specifications of an application remain constant, the recognition and valuation of these innovations are shaped by user characteristics. Consequently, a more environmentally conscious consumer is more likely to perceive an application as eco-innovative compared to a less environmentally conscious user.

Accordingly, the following hypothesis is proposed:

H1: Perceived eco-innovation has a positive impact on green application use.

2.4. Perceived Eco-innovation and Perceived Tech-Savviness

Tech-savviness refers to an individual's self-assessed ability and confidence in using modern digital technologies. This includes frequent use of smartphone applications, familiarity with digital features, and a willingness to engage with technological challenges as learning opportunities (Salah and Ayyash 2024).

While much of the prior literature treats technological skills as a pre-existing capability that facilitates the adoption of advanced digital innovations, this study adopts a complementary perspective grounded in the Technological Pervasiveness framework proposed by Cecere et al. (2014). This framework suggests that green information and communication technologies (ICTs) are inherently pervasive, gradually embedding themselves into everyday practices and expanding users' technological familiarity through continuous exposure and interaction within a growing innovation ecosystem.

From this perspective, eco-innovative digital applications do not merely depend on users' existing technological competencies. Rather, they create interactive environments that encourage exploration, experimentation, and engagement with novel features. In emerging markets such as Egypt, green applications frequently incorporate digital–environmental functionalities, including waste-tracking dashboards, sustainability indicators, and reward-based feedback systems. These features require users to interact with unfamiliar digital elements. Through repeated use, such interactions may foster greater perceived technological familiarity and confidence.

Supporting this view, prior research indicates that novel and complex eco-innovations impose greater cognitive demands on users. These demands require individuals to invest time and mental effort to understand how the technology operates and how its features can be effectively utilized (Paparoidamis et al. 2019). Although this process does not necessarily imply objective skill acquisition, it may enhance users' self-perceived technological confidence through cognitive engagement and experiential learning.

Accordingly, tech-savviness in this study is conceptualized as a perceptual construct, reflecting users' self-reported technological familiarity and confidence rather than objective technical skill. Within this perceptual framework, applications perceived as highly eco-innovative are expected to cognitively challenge users and stimulate engagement with advanced digital features, thereby strengthening perceived tech-savviness.

Thus, the following hypothesis is proposed:

H2: Perceived eco-innovation has a statistically significant positive influence on perceived tech-savviness.

2.5. Perceived Tech-Savviness and Green Applications

Technological advancements have influenced many aspects of society, requiring consumers to possess technical skills ranging from basic to advanced levels. Tech-savviness refers to an individual's proficiency in using modern technology. User competence and technological knowledge are believed to play an important role in facilitating technology adoption (Salah and Ayyash 2024).

Tech-savviness varies across demographic groups. Younger individuals, particularly millennials, tend to demonstrate higher levels of tech-savviness due to their exposure to technology-rich environments. In contrast, older generations often experience greater difficulty adapting to new technologies, which results in lower perceived ease of use. Educational attainment and employment status are positively correlated with tech-savviness, while wealthier individuals are more likely to be tech-savvy due to greater access to digital devices and earlier exposure to emerging technologies. Gender differences have also been identified, with women generally reporting lower enthusiasm and higher levels of technology-related anxiety (Nair and Bhat 2021; Sengupta and Tomczyk, 2025).

Dewan and Benckendorff (2013) investigated how tech-savviness influences the use of mobile devices among young travelers, with a particular focus on Generation Y. Their results indicated that tech-savvy individuals tend to use mobile devices for a broader range of tasks while traveling domestically, suggesting that tech-savviness exerts a stronger influence on mobile search behavior than impulsiveness.

Similarly, customers' technological savviness has been found to significantly and directly influence e-commerce adoption among Palestinian SMEs (Salah and Ayyash 2024). Prior studies have also shown that having sufficient awareness of self-service technologies encourages consumers' intentions to use and adopt them (Guan et al. 2021; Skaf et al. 2025).

Previous studies have often relied on self-reported purchasing intentions to measure innovation adoption. In the context of sustainable initiatives, such as green hospitality, green consumption involves active participation in environmentally friendly practices (Sharma et al. 2024b). Similarly, the use of green applications can be viewed as a reflection of an individual's willingness to adopt sustainable technologies. Prior research has consistently shown that tech-savvy consumers are more likely to make online purchases (Menon 2018).

In addition, SMEs led by owners with higher levels of tech-savviness demonstrate a greater likelihood of adopting e-business technologies. This relationship is supported by empirical findings that link IT skills to successful technology adoption (Satar and Alarifi 2022).

This suggests that individuals with higher levels of technological proficiency are more predisposed to embracing new technologies, including those aimed at environmental sustainability, such as green applications in the present research. Despite this, a substantial research gap exists regarding the impact of tech-savviness on the use of green applications, particularly in the context of eco-innovation adoption.

While existing literature has extensively examined the relationship between environmental awareness and green application usage, the effect of tech-savviness remains understudied. Accordingly, this study aims to investigate how tech-savviness influences the adoption and effective use of green applications. By focusing on tech-savviness, the study seeks to provide deeper insights into the factors driving green technology usage in Egypt, where the influence of tech-savviness on green application use has received limited empirical attention.

Therefore, the following hypotheses are proposed:

H3: Perceived tech-savviness has a statistically significant positive influence on green application use.

H4: Perceived tech-savviness mediates the relationship between applications' eco-innovation and green application use.

2.6. Environmental Consciousness and the Use of Green Applications

Environmental consciousness is defined as “an element of the belief system that denotes specific psychological influences related to individuals’ propensity to join pro-environmental behaviour regimes” (Zelezny and Schultz 2000). It is grounded in the premise that human activity contributes to various ecological issues within the ecosystem (Agrawal et al. 2023; Sengupta and Tomczyk, 2025).

Environmental consciousness is increasingly viewed as a pathway toward a sustainable future. It presents both opportunities and challenges for organizations operating in environmentally sensitive markets (Hameed et al. 2022).

Accordingly, in this study, environmental consciousness is operationalized as a cognitive–affective construct that captures environmental awareness, environmental concern, and a general pro-environmental orientation, rather than actual pro-environmental behavior.

Chang et al. (2023) identified a moderating effect of environmental consciousness on consumer behavior and purchasing intentions, indicating that the level of environmental consciousness among recipients of green messages influences their engagement in eco-friendly behaviors. Moreover, environmental consciousness has been shown to foster and influence eco-innovation in the hotel industry, encouraging businesses to adopt green technologies and practices that align operations with sustainability objectives and stakeholder expectations (Sharma et al. 2020).

In addition, environmental consciousness moderates the relationship between perceived consumer effectiveness and green purchase behavior. Specifically, individuals with higher levels of environmental consciousness exhibit a stronger relationship between perceived consumer effectiveness and green purchase behavior than those with lower levels (Kautish et al. 2019). Accordingly, consumers with high environmental consciousness may be more inclined to use green applications when they believe these tools contribute positively to environmental sustainability.

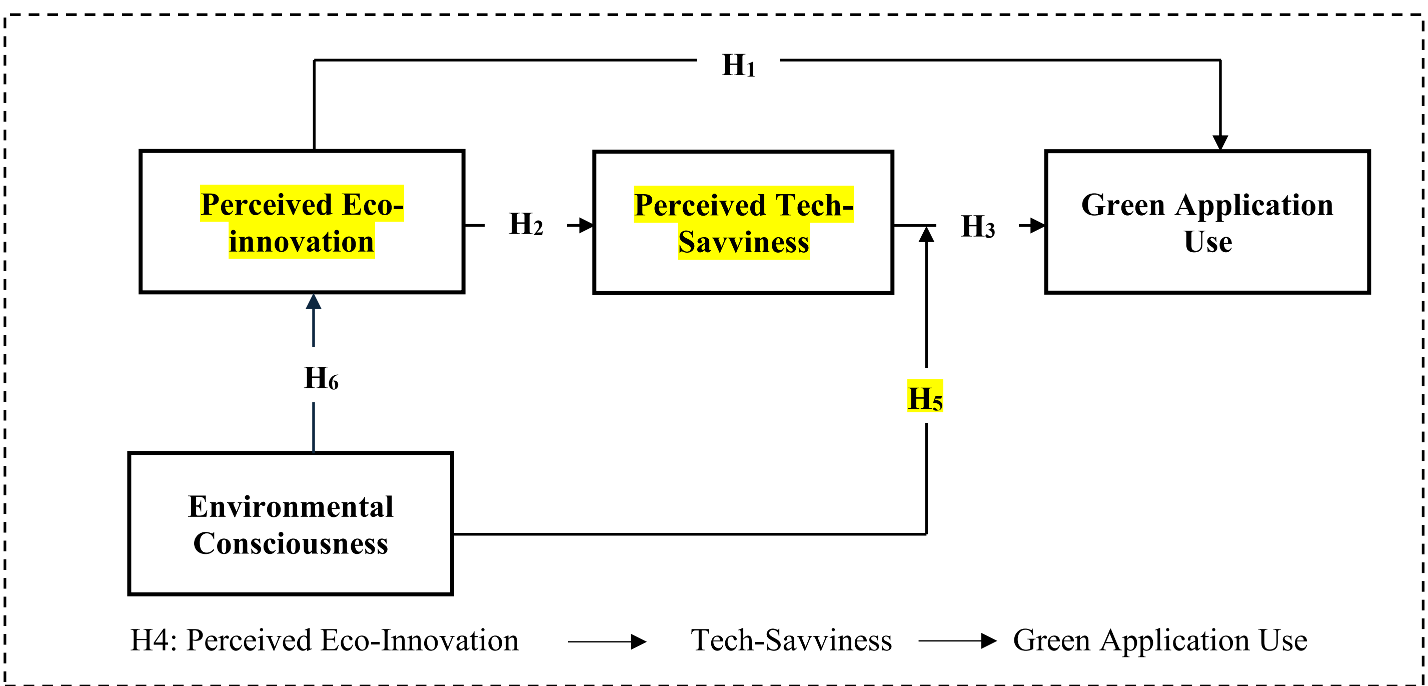
Thus, the following hypotheses are proposed:

H5: Environmental consciousness moderates the relationship between perceived tech-savviness and green application use.

H6: Environmental consciousness has a statistically significant influence on perceived eco-innovation.

Taken together, the preceding theoretical discussion highlights how perceived eco-innovation, tech-savviness, and environmental consciousness interact to shape green application use. Building on this integrated perspective, the following conceptual model synthesizes the proposed relationships and hypotheses examined in this study.

Figure 1. Research model.



***Source: Authors' work**

3. Research Methodology

This research aims to investigate the factors that influence green application use. Therefore, it adopts a deductive research approach. Accordingly, the use of a causal–deductive approach leads to a quantitative research design employing questionnaire-based instruments.

3.1 Research Context

Egypt offers a uniquely fertile context for green application adoption, driven by a convergence of environmental challenges, progressive policy frameworks, and culturally rooted sustainability practices. Anchored in the Egypt Vision 2030 strategy, the country has prioritized sustainable development across multiple sectors (Hegazy and Tohlob 2024), thereby establishing a policy foundation that supports the integration of green technologies.

Rapid urbanization has intensified environmental pressures by diminishing green spaces and increasing energy demand. This context has heightened the relevance of digital green solutions, such as applications that support rooftop greening or energy management (Soliman and Mehanna 2023; Nabawy et al. 2025). The building sector, which accounts for approximately 60% of Egypt's electricity consumption, represents a critical target for sustainability transformation. Green technologies, including solar panels and productive façades, offer high-impact opportunities for reducing energy use and emissions (Helmi et al. 2024).

In the agricultural sector, innovative practices such as solar-powered drip irrigation systems are already demonstrating Egypt's potential for resource-efficient solutions (Abdelhamid et al. 2025). Moreover, Egypt's approach to green infrastructure extends beyond purely environmental considerations to incorporate cultural and historical values, underscoring the importance of context-sensitive sustainability solutions (Abdou et al. 2016).

Although high initial investment costs remain a significant barrier, targeted government support through subsidies, training programs, and infrastructure development can substantially accelerate adoption. Accordingly, Egypt's distinctive combination of policy ambition, urban and environmental urgency, and cultural depth positions it as a compelling case for examining green application adoption within the developing world.

3.2 Research Population and Sampling

Data were collected using an online, self-administered survey distributed via Google Forms. A non-probability convenience sampling approach was employed, which is appropriate given the targeted population of green mobile application users. Respondents were recruited through online channels, including social media platforms (e.g., Facebook and WhatsApp), as well as personal and professional networks.

To ensure sample relevance, specific inclusion criteria were applied. Participants were required to (1) be residents of Egypt, (2) be at least 18 years old, (3) own and regularly use a smartphone, and (4) demonstrate awareness of green applications operating in Egypt. Accordingly, the survey began with a brief explanation of green applications within the Egyptian context, followed by screening questions designed to assess respondents' familiarity with such applications before proceeding to the main questionnaire.

A total of 158 valid responses were obtained, yielding a response rate of approximately 65%. According to Lund (2023), an appropriate survey sample size ranges between 139 and 388 respondents. Therefore, considering time, accessibility, and availability constraints, the final sample size of 158 respondents was deemed adequate for PLS-SEM analysis. Data were collected over a one-month period in July 2024.

3.3 Green Applications Identification Technique

The identification process for green applications followed the selection procedure adopted by Carvalho and Silva (2021). Applications were identified using a search query conducted on the Google Play Store. Only free applications and those available for use in Egypt were included in the study. The search terms used were "Recycling," "Sustainability," "Pollution reduction," "Food waste," and "Energy saving," as summarized in Table 1.

Table 1. Terms used to filter green applications

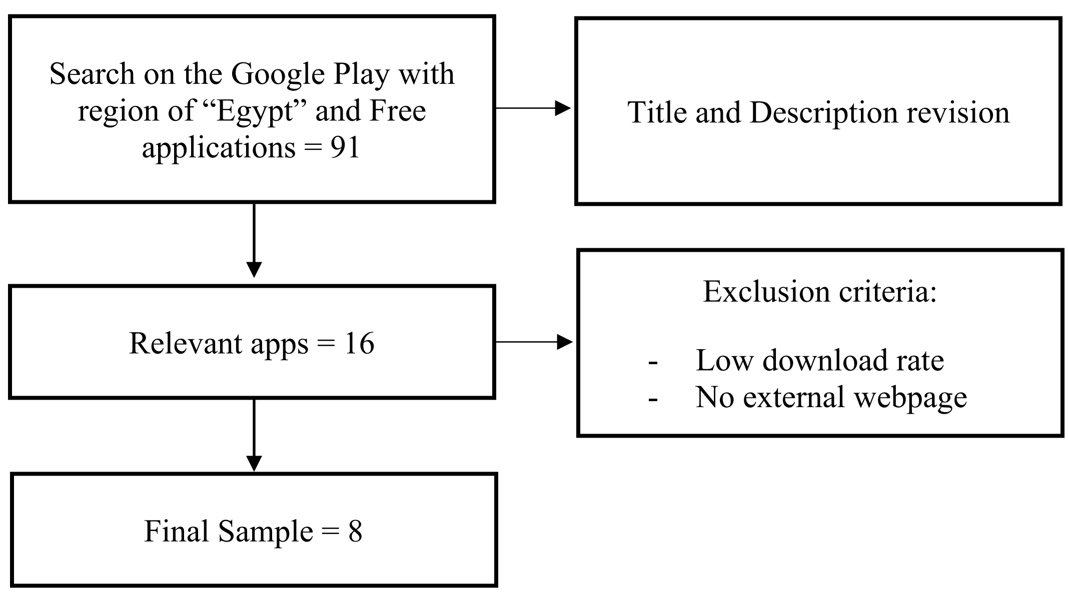
Research query term	Number of results	Number of results included
"Recycling"	28	5
"Sustainability"	30	4
"Pollution reduction"	8	3
"Food waste"	10	2
"Energy saving"	15	2

***Source: Authors' work**

The initial pool consisted of 16 applications; however, not all were suitable for inclusion in the study. Figure 2 illustrates the exclusion process applied to the green applications. First, the application purpose as described on the Google Play Store was reviewed, and only applications with a clear green sustainability message were retained. Second, applications with a low download rate were excluded. Third, applications without an external webpage were also excluded.

After applying these exclusion criteria, the final sample consisted of eight applications, as summarized in Figure 2.

Figure 2. Application selection process.



***Source: Authors' work**

3.2 Measurements and Scale Development

After selecting the applications, a self-administered online survey was designed to measure the study variables. A five-point Likert scale was used for all measurement items. The scale for eco-innovation (EI) was adapted from prior studies to capture respondents' perceptions of application innovativeness. As the data were collected based on users' subjective evaluations rather than technical audits, the construct was treated as perceived eco-innovation.

Perceived eco-innovation was measured using scales adapted from Cheng and Shiu (2012), Yurdakul and Kazan (2020), and Moslehpour et al. (2023). Tech-savviness, in turn, was measured using scales adapted from Alemi et al. (2018), Lavieri and Bhat (2019), and Kriswardhana and Esztergár-Kiss (2024).

Tech-savviness was operationalized as a self-perceived, experience-based construct reflecting respondents' digital engagement, perceived competence, and familiarity with smartphone-based services. The scale items captured (i) the frequency of everyday digital use (e.g., frequent use of smartphone applications and online social media), (ii) perceived competence and confidence in using smartphone features and engaging in online transactions, and (iii) general knowledge of mobile applications.

Furthermore, environmental consciousness was measured using a scale adapted from Alsmadi (2007). Consistent with the conceptualization adopted in this study, the scale captures environmental consciousness as a cognitive–affective construct, reflecting individuals' awareness of environmental issues, emotional concern about environmental degradation, and general pro-environmental orientation. The measurement items assess respondents' understanding of environmental problems, their concern for environmental protection, and their value-based support for sustainable practices, rather than actual pro-environmental behaviors.

This operationalization is particularly appropriate in the context of green application adoption, where users' awareness and concern shape perceptions of, and adoption intentions toward, eco-innovative digital solutions. Finally, green application use was measured using scales adapted from Wan et al. (2012) and Yadav and Pathak (2017).

Although the original measurement scales were developed in firm- or product-level contexts, they were adapted to the mobile application context by rephrasing item wording to reflect individual users' perceptions and experiences with green applications. Specifically, references to "products" or "firms" were replaced with "green mobile applications," while preserving the original conceptual meaning of each item. This adaptation approach is consistent with prior research that applies established innovation and technology perception scales to digital and service-based contexts.

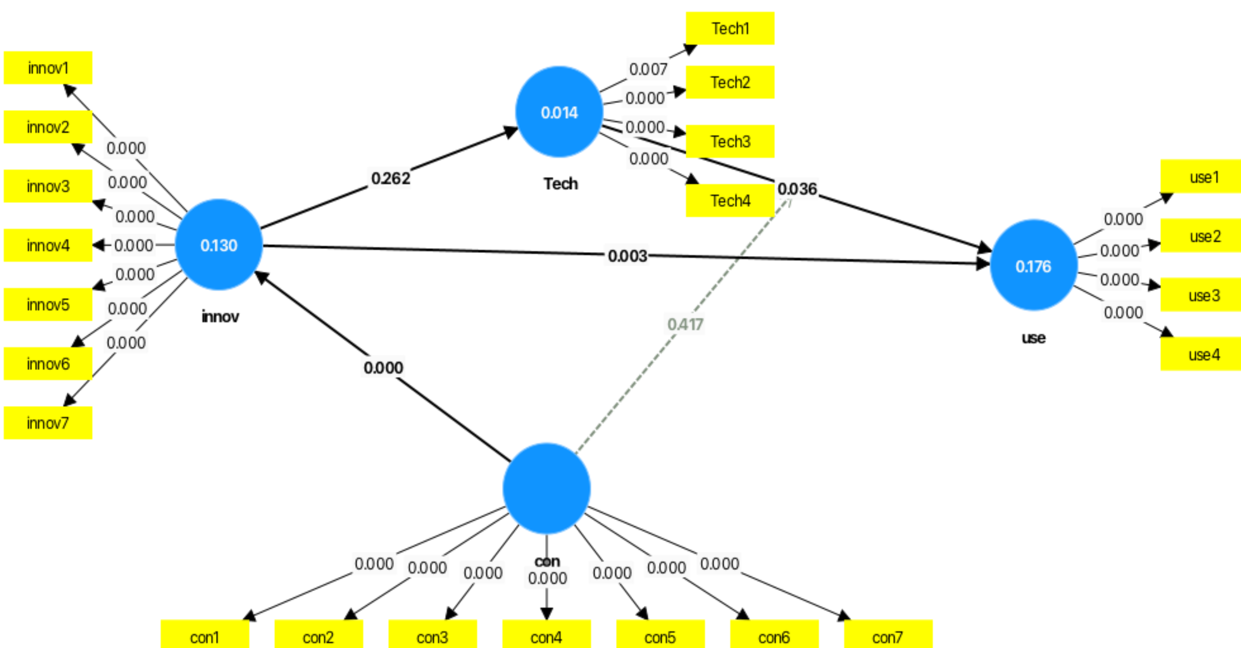
Respondents were first asked to identify any green mobile applications they use. They were then requested to complete the questionnaire, and demographic information was collected at the end of the survey.

4. Data analysis

This section presents the statistical analysis of the data. It begins with a descriptive analysis of the sample and the measurement items. Subsequently, structural equation modeling (SEM) was conducted using SmartPLS, including confirmatory factor analysis (CFA) and path analysis to test the research hypotheses.

According to Hair et al. (2019), partial least squares structural equation modeling (PLS-SEM) is particularly suitable for models involving multiple latent variables and moderating relationships. It also performs well with relatively small to medium sample sizes and does not require strict normality assumptions. Accordingly, PLS-SEM is appropriate for the objectives and data characteristics of the present study. The structural model generated through SmartPLS is presented in Figure 3.

Figure 3. Structure model



***Source: developed by the Authors based on PLS findings**

4.2 Descriptive analysis

A descriptive analysis of SPSS was run to describe some of the characteristics of the sample and to verify some of the assumptions required to perform statistical techniques (ensuring the assumption of the data normal distribution). The demographic characteristics of the respondents are presented in Table 2.

Table 2. Descriptive analysis of sample

characteristics		**Frequency**	**Percent**
Gender	**Males**	**40**	**25.316%**
	Females	**118**	**74.683%**
	Total	**158**	**100%**
Age	**From 18 to less than 25**	**22**	**13.924%**
	From 25 to less than 35	**103**	**65.189 %**
	From 35 to less than 45	**15**	**9.493%**
	From 45 to less than 55	**13**	**8.227%**
	From 55 to less than 65	**4**	**2.531%**
	65 and above	**1**	**0.632%**
	Total	**158**	**100%**
Region Residence	**Giza**	**72**	**45.56%**
	Cairo	**66**	**41.77%**
	Other	**20**	**12.65%**
	Total	**158**	**100%**
Income level	**10K or less**	**70**	**44.3**
	11K to 20K	**50**	**31.6%**

	21K to 30K	**17**	**10.8%**
	31K to 40K	**9**	**5.7%**
	more than 40K	**12**	**7.6%**
	Total	**158**	**100%**
Education level	**Bachelor's or equivalent level**	**90**	**57%**
	Master's or equivalent level	**44**	**27.8%**
	Doctoral or equivalent level	**24**	**15.2%**
	Total	**158**	**100%**

***Source: developed by the Authors based on SPSS finding**

The demographic data of the sample (N=158) reveals a predominant representation of females (74.68%) and younger individuals, with the majority aged between 25 to 35 years (65.19%). Geographically, most respondents reside in urban areas, specifically Giza (45.56%) and Cairo (41.77%). Income distribution is skewed towards lower income brackets, with 75.9% earning 20,000 or less, indicating potential economic constraints within the sample. Educationally, the sample is highly educated, with 57% holding a bachelor's degree and 43% having postgraduate qualifications. The concentration of young, educated females from urban regions and lower income brackets highlights the need to consider potential biases when interpreting the study's findings, as these characteristics may limit the generalizability to other demographic groups.

4.3 Theoretical measures assessment

To assess the validity and reliability measures, a confirmatory factor analysis (CFA) was conducted using PLS as the Structural Equation Modeling tool version 3. As shown in Table 3, the measurement model was assessed according to four main criteria: factor loadings, convergent validity, discriminant validity, and reliability.

Table 3. Assessment of the model

Variables	*Items*	*Factor loading*	*AVE*	*Composite reliability*	*Cronbach's Alpha*	*Mean*	*Standard Deviation*
Perceived eco-innovation	***Eco1***	*0.651*	*0.586*	*0.898*	*0.879*	*3.9471*	*.06123*
	Eco2	*0.799*					
	Eco 3	*0.799*					
	Eco 4	*0.820*					
	Eco 5	*0.578*					
	Eco 6	*0.848*					
	Eco 7	*0.821*					
perceived tech-savviness	***Tech1***	*0.624*	*0.595*	*0.838*	*0.774*	*4.0032*	*.06068*
	Tech2	*0.826*					
	Tech3	*0.719*					
	Tech4	*0.888*					
Application use	***App1***	*0.639*	*0.509*	*0.919*	*0.755*	*3.2273*	*.08687*

Variables	Items	Factor loading	AVE	Composite reliability	Cronbach's Alpha	Mean	Standard Deviation
	App2	*0.635*					
	App3	*0.738*					
	App4	*0.824*					
Environmental consciousness	***Con1***	*0.561*	*0.625*	*0.935*	*0.895*	*4.5937*	*.04897*
	Con2	*0.507*					
	Con 3	*0.863*					
	Con 4	*0.933*	*0.524*	*0.763*	*0.569*	*3.2298*	*.76721*
	Con 5	*0.913*					
	Con 6	*0.819*					
	Con 7	*0.829*					

***Source: developed by the Authors based on PLS findings** According to Hair et al. (2010), factor loadings of more than 0.7 are considered strong, showing a well-defined factor structure, whereas loadings between 0.4 and 0.7 are moderate but still significant. According to this criterion, all factor loadings from the preceding analysis are valid. Furthermore, convergent validity is established because the average variance extracted (AVE) for all variables surpasses 0.50. Furthermore, Cronbach's alpha values exceed 0.70, which is regarded an acceptable level of internal consistency.

Table 4. HTMTs (Discriminant validity)

	Tech-savviness	**Environmental consciousness**	**Eco-innovation**	**Application use**	**con x Tech -> use**
Perceived tech-savviness					
Environmental consciousness	**0.143**				
Perceived eco-innovation	**0.150**	**0.384**			
Application use	**0.293**	**0.241**	**0.398**		
con x Tech -> use	**0.107**	**0.156**	**0.108**	**0.077**	

***Source: developed by the Authors based on PLS findings**

As shown in Table 4, the HTMT values between variables are all less than 0.9, indicating that discriminant validity is established across the constructs.

Table 5. R^2 of dependent variables

	R-square	***R-square adjusted***
Tech	**0.013**	0.007
innov	**0.131**	0.126
use	**0.151**	0.134

***Source: developed by the Authors based on PLS findings**

As presented in Table 5, the R^2 values indicate how much variance in the dependent variables is explained by the model's predictors: tech-savviness ($R^2 = 0.013$), eco-innovation ($R^2 = 0.131$), and application use ($R^2 = 0.151$). The low R^2 for tech-savviness suggests other factors play a significant role. The modest R^2 values for eco innovation and application use show moderate influence from the predictors, but also highlight the need for additional variables. These findings point to the complexity of the studied relationships and suggest further research to improve the model's explanatory power.

Table 6. Full Collinearity Assessment (VIF) for Common Method Bias

Structural Path	***VIF (Original Sample)***
Environmental Consciousness → Eco-innovation	1.000
Environmental Consciousness → Green App Use	1.009
Environmental Consciousness × Tech-savviness → Green App Use	1.008
Eco-innovation → Tech-savviness	1.000

Tech-savviness → Green App Use	1.014

***Source: developed by the Authors based on PLS findings**

To assess potential common method bias, a full collinearity assessment was conducted using the variance inflation factor (VIF) approach in SmartPLS. The results showed that all VIF values for the latent constructs ranged between 1.00 and 1.02, which are well below the recommended threshold of 3.3. This indicates that common method bias is unlikely to be a serious concern in this study (Kock 2015).

Table 7. Effect size (f^2) assessment of the structural model

Path	***f² (Original sample)***
Environmental Consciousness → Eco-innovation	0.151
Environmental Consciousness → Green App Use	0.059
Environmental Consciousness × Tech-savviness → Green App Use	0.010
Eco-innovation → Tech-savviness	0.014
Tech-savviness → Green App Use	0.100

***Source: developed by the Authors based on PLS findings**

Effect sizes (f^2) were assessed to evaluate the substantive impact of the exogenous constructs on the endogenous variables, following the guidelines proposed by Hair et al. (2019) Based on Cohen's (1988) criteria, values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively. The results indicate a medium effect of environmental consciousness on perceived eco-innovation ($f^2 = 0.151$). Small effects were observed for environmental consciousness on green application use ($f^2 = 0.059$) and for perceived tech-savviness on green application use ($f^2 = 0.100$). In contrast, the effect of perceived eco-innovation on tech-savviness ($f^2 = 0.014$) and the interaction effect of environmental consciousness × tech-savviness on green application use ($f^2 = 0.010$) were negligible, which is consistent with the unsupported structural relationships.

Table 8: Predictive Validity (Q^2)

Endogenous Construct	***Q²***
Tech-savviness	0.005
Perceived Eco-innovation	0.099
Green Application Use	0.040

***Source: developed by the Authors based on PLS findings**

Note: Q^2_predict values greater than zero indicate predictive relevance.

Predictive validity was assessed using the PLSpredict (CVPAT) procedure. As shown in Table 8, all endogenous constructs exhibit Q^2 predict values greater than zero (tech-savviness = 0.005; perceived eco-innovation = 0.099; green application use = 0.040), indicating acceptable predictive relevance (Hair et al., 2019).

Table 9. Testing Hypothesis

Hypotheses	***beta coefficient (β)***	***T-value***	***P-value***	***results***
H_1: Eco-innovation significantly influences Using Green Applications.	0.301	3.549	0.000	**Supported**
H_2: Eco-innovation significantly influences tech-savviness.	0.118	1.122	0.262	**Not supported**
H_3: Tech-savviness significantly influences Using Green Applications.	0.215	2.103	0.036	**Supported**
H4: Tech-savviness mediate the relationship between Applications' Eco-innovation and Using Green Applications	0.025	0.92	0.357	**Not supported**
H5: Environmental Consciousness moderates the relationship between tech-savviness and Green Application Use.	0.057	0.812	0.417	**Not supported**

Hypotheses	***beta coefficient (β)***	***T-value***	***P-value***	***results***
H_6: Environmental Consciousness significantly influences eco innovation.	0.361	3.853	0.000	**Supported**

***Source: developed by the Authors based on PLS**

5. Discussion of Results

The findings reveal significant relationships between tech-savviness and green application use, eco-innovation and green application use, and environmental consciousness and eco-innovation. However, the influence of eco-innovation on tech-savviness and the moderating effect of environmental consciousness between perceived tech-savviness and green application use were not observed. Additionally, there was a lack of a mediation effect of tech-savviness between eco-innovation and green application use, which implies that people adopt green applications driven by eco-innovation regardless of how tech-savvy they are, showing that technology skills are not always a deciding factor. These results highlight the importance of tech-savviness, eco-innovation, and environmental consciousness in promoting the use of green applications. Individuals who are more technologically adept are more inclined to adopt environmentally friendly digital solutions, underscoring the critical role of technology skills in advancing sustainable practices through digital channels. This aligns with the studies of Ali and Frew (2014) and Bilgram and Laarmann (2023), which indicate that innovations motivate application use.

Moreover, the correlation between environmental consciousness and eco-innovation suggests that inventive efforts toward sustainability are driven by a heightened sense of environmental responsibility. Prior research attributes the lack of moderation to a deficit in sustainable behavior culture among consumers in developing countries (Debrah et al. 2021; Ismael et al. 2021; Rao and Gaur 2025). However, the absence of a significant relationship between eco-innovation and tech-savviness implies that while eco-innovations are valuable, they do not necessarily enhance people's technological proficiency (Salah and Ayyash 2024; Adel et al. 2018; Bazaraa et al. 2022). In the current Egyptian context, this indicates that existing green apps like Bekia or E-Tadweer may prioritize extreme simplicity in their user interfaces. While this encourages mass adoption, it does not provide enough technical complexity to challenge or grow the user's individual technical skills. Consequently, in this specific market, tech-savviness remains a stable input rather than a dynamic output of the eco-innovation experience.

Furthermore, the lack of a moderating effect of environmental consciousness indicates that individuals with higher technological confidence are likely to adopt green applications regardless of their level of environmental consciousness. According to Ahmed and Prabhakar (2023), these findings emphasize the need to integrate eco-innovations to support and encourage green application usage. The research suggests that eco-innovation in these applications can influence consumer behavior by promoting recycling, reducing energy consumption and pollution, and appealing to users' cultural preferences. However, Egyptian scholars such as Ismael et al. (2021) argue that certain applications face resistance due to social norms and cultural constraints. This insight explains why environmental consciousness did not have a significant impact on green application use.

The model's explanatory power regarding application uses and the very low explanatory power for tech-savviness provide deep insights into the Egyptian digital landscape. The low explanatory power for tech-savviness proves that skills are an inherent trait of the user rather than a result of app interaction. More importantly, the variance explained for adoption indicates that while eco-innovation and tech-savviness are essential, a vast majority of the behavior is influenced by factors outside this model. These likely include economic incentives, social pressure, and perceived ease of use. This context is vital for Egyptian stakeholders; it proves that for green apps to achieve deeper market penetration, they must move beyond green messaging and focus on being economically rewarding and technologically indispensable. In a market characterized by high price sensitivity, the transition from being innovative to being essential will depend on integrating these apps into the daily economic survival and social convenience of the Egyptian consumer (Ismael et al. 2021).

6.Conclusion

This study examined the factors influencing the adoption and use of green mobile applications in Egypt, addressing the persistent underuse of such applications in emerging economies. The findings reveal that perceived eco-innovation and tech-savviness have a direct and positive influence on green application use, while environmental consciousness significantly shapes how users perceive eco-innovation. These results indicate that green app adoption is driven not only by environmental values but also by users' technological perceptions of innovation.

The absence of significant mediation and moderation effects offers important insights into the Egyptian context. Specifically, the lack of a mediating role for tech-savviness suggests that users adopt green applications primarily based on perceived eco-innovation, regardless of their level of technological proficiency. This indicates that technology skills function as a stable individual trait rather than an outcome of interaction with eco-innovative applications. Similarly, the non-significant moderating role of environmental consciousness implies that technologically confident users are inclined to adopt green applications even in the absence of strong environmental concern, reflecting contextual and cultural dynamics that shape sustainable behavior in Egypt.

Overall, the findings directly address the identified research gap by demonstrating that green application underuse in Egypt cannot be explained solely by environmental consciousness. Instead, adoption depends on the interplay between eco-innovation and technological readiness, within a market characterized by high price sensitivity and pragmatic usage motivations. The key message emerging from this study is that promoting green application adoption in emerging economies requires moving beyond green messaging alone. To achieve wider and deeper adoption, green applications must be perceived as both eco-innovative and economically and functionally indispensable within users' daily lives.

7. Implications, Future Research, and Limitations

7.1 Theoretical Implications

From a theoretical perspective, this study contributes to the eco-innovation and green application literature in several important ways. First, it advances understanding of the distinct roles of perceived tech-savviness and environmental consciousness in shaping perceptions of eco-innovation and green application use. While prior research often assumes that eco-innovations inherently enhance users' technological capabilities, the present findings challenge this assumption by showing that eco-innovation does not necessarily translate higher perceived tech-savviness.

Second, the study contributes by clarifying the limited and conditional role of environmental consciousness. Although environmental consciousness is widely treated as a strong driver of green behavior, the findings indicate that its moderating role is more constrained in digital green application contexts. This suggests that awareness and concern alone may be insufficient to amplify technology-driven adoption processes, thereby refining existing theoretical models that place environmental consciousness at the center of green adoption decisions.

Third, by jointly examining perceived eco-innovation, tech-savviness, and environmental consciousness, this research responds to calls for more integrative frameworks in green digital adoption studies. It highlights the need to distinguish between perceptual, cognitive, and technological mechanisms, rather than assuming uniform effects across these constructs. This contributes to a more nuanced theoretical understanding of how users evaluate eco-innovative digital solutions in emerging markets.

7.2 Managerial and Policy Implications

The findings also offer several actionable implications for app designers, businesses, and policymakers, particularly within the Egyptian context.

For green application designers, the results underscore the importance of prioritizing usability and intuitive design. Since eco-innovation does not automatically enhance users' tech-savviness, developers should avoid overly complex interfaces and instead incorporate guided onboarding, simplified dashboards, and in-app tutorials. For example, Egyptian green apps related to waste management, energy monitoring, or transportation could integrate visual cues, step-by-step prompts, and localized language support to accommodate users with varying levels of technological confidence.

For businesses and firms, the findings suggest that promoting green applications solely on the basis of environmental benefits may be insufficient. Firms should combine environmental messaging with practical value propositions, such as cost savings, convenience, or rewards. For instance, companies offering green mobility or recycling platforms in Egypt could emphasize tangible user benefits such as discounts, loyalty points, or reduced utility costs alongside sustainability outcomes. Internally, fostering an organizational culture that values both environmental awareness and digital competence may also encourage employee-driven eco-innovation.

From a policy perspective, the results highlight the need for integrated digital and sustainability policies. Policymakers can support green application adoption by investing in digital literacy programs, particularly targeting young adults and urban populations who are early adopters of mobile technologies. Additionally, policy instruments such as government subsidies, standardized green certifications, and financial incentives (e.g., low-interest loans or tax reductions) can reduce adoption barriers for both developers and users. In the Egyptian context, localized policy interventions developed in collaboration with technology firms, environmental agencies, and educational institutions may further enhance the reach and effectiveness of green digital solutions.

8. Limitations and Future Research Directions

Despite its contributions, this study has several limitations. First, the cross-sectional design limits the ability to infer causal relationships among the studied constructs. Future research could adopt longitudinal designs to better capture how perceptions of eco-innovation, tech-savviness, and environmental consciousness evolve over time.

Second, the study relies on a non-probability convenience sample of 158 respondents that is predominantly young, female, educated, and urban. While this profile reflects a core segment of active smartphone and green app users in Egypt, it limits the generalizability of the findings**.** The results should therefore be interpreted as most applicable to urban, digitally engaged populations, rather than to rural users, older age groups, or individuals with limited access to digital technologies. Future studies are encouraged to employ stratified or quota sampling techniques to enhance representativeness across demographic segments.

Third, the exclusive reliance on quantitative survey data may not fully capture the contextual and experiential dimensions of green application use. Future research could incorporate qualitative methods, such as in-depth interviews or focus groups, to gain deeper insights into users' motivations, resistance, and learning processes. Additionally, examining other potential moderators and mediators such as social influence, financial incentives, or perceived risk could further refine understanding of green application adoption and eco-innovation dynamics in emerging markets.

Declarations

All authors declare that they have no conflicts of interest.

Ethical Approval and Consent to Participate

This study used an anonymous self-administered survey. Participation was entirely voluntary, and informed consent was obtained prior to completing the survey.

Consent for Publication

Not applicable. This manuscript does not contain any individual person's data in any form (including images, videos, or identifiable details).

Funding

Not applicable. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

References

- Abdelhamid, M. A., Abdelkader, T. K., Sayed, H. A., Zhang, Z., Zhao, X. and Atia, M. F. (2025) 'Design and evaluation of a solar powered smart irrigation system for sustainable urban agriculture', *Scientific Reports*, 15(1), 11761. Available at: https://doi.org/10.1038/s41598-025-94251-3
- Abdou, A., Abd Elgawad, I. and Fouad, T. T. (2016) 'Green infrastructure to achieve sustainability in urban design: Nile Corridor in Great Cairo as a case study', *Journal of Al-Azhar University Engineering Sector*, 11(40), pp. 1055–1066. Available at: https://doi.org/10.21608/auej.2016.19410
- Abdullah, N. and Lim, A. (2023) "The Incorporating Sustainable and Green IT Practices in Modern IT Service Operations for an Environmentally Conscious Future", *Journal of Sustainable Technologies and Infrastructure Planning*, 7(3), pp. 17–47. Available at: https://publications.dlpress.org/index.php/JSTIP/article/view/33
- Abed, A.H., Rizk, F.H., Zaki, A.M. and Elshewey, A.M., 2024. The Applications of Digital Transformation Towards Achieving Sustainable Development Goals: Practical Case Studies in Different Countries of the World. Journal of Artificial Intelligence and Metaheuristics (JAIM), 7(01), pp.53-66.
- Adel, H. M. and Mahrous, A. A. (2018) 'Sustainability communication and evaluation: A practice-based case study on British-Egyptian universities value-chain', *The 32nd Annual International Conference of The British Academy of Management (BAM) 2018: Driving Productivity in Uncertain and Challenging Times*, Bristol Business School, University of the West of England, United Kingdom, 4–6 September. Available at: https://ssrn.com/abstract=4186830 or http://dx.doi.org/10.2139/ssrn.4186830

- Agrawal, M., Kalia, P., Nema, P., Zia, A., Kaur, K. and John, H.B., 2023. Evaluating the influence of government initiatives and social platforms on green practices of Gen Z: The mediating role of environmental awareness and consciousness. *Cleaner and Responsible Consumption*, **8**, 100109. https://doi.org/10.1016/j.clrc.2023.100109
- Ahmed, S. and Prabhakar, M.E., 2023. Assessing the factors impacting consumer behaviour towards green marketing and eco-friendly products in Nagaland. *International Journal for Multidisciplinary Research*.
- Alemi, F., Circella, G., Handy, S. and Mokhtarian, P., 2018. What influences travelers to use Uber? Exploring the factors affecting the adoption of on-demand ride services in California. *Travel Behaviour and Society*, 13, pp.88–104. https://doi.org/10.1016/j.tbs.2018.06.002
- Ali, A. and Frew, A.J., 2014. Technology innovation and applications in sustainable destination development. *Information Technology and Tourism*, 14(4), pp.265–290. https://doi.org/10.1007/s40558-014-0015-7
- Ali, D.A., 2020. *The use of special economic zones to drive sustainable development in* Egypt: A case study on the Suez Canal region. *[Master's thesis]. The American* University in Cairo (AUC).
- Alsmadi, S., 2007. Green marketing and the concern over the environment: Measuring environmental consciousness of Jordanian consumers. *Journal of Promotion Management*, **13**(3–4), pp.339–361. https://doi.org/10.1080/10496490802306905
- Asongu, S. and Odhiambo, N.M., 2023. Bank accounts, bank concentration and mobile money innovations. *International Journal of Technology Management and Sustainable Development*, **22**(2), pp.185–204. https://doi.org/10.1386/tmsd_00075_1
- Balińska, A., Jaska, E. & Werenowska, A., (2021), 'The role of eco-apps in encouraging pro-environmental behavior of young people studying in Poland', *Energies*, 14: 16, Available at: https://doi.org/10.3390/en14164946.
- Balińska, A., Werenowska, A. and Jaska, E., 2024. The importance of mobile applications in reducing food waste – the example of the TooGoodToGo application. *Journal of Modern Science*, 56(2), p.190. https://doi.org/10.13166/JMS/188723
- Bazaraa, D.A., Mahrous, A.A. and Elsharnouby, M.H., 2022. How manipulating incentives and participation in green programs affect satisfaction: The mediating role of warm glow.

Journal of Cleaner Production, 362**,** 132306. https://doi.org/10.1016/j.jclepro.2022.132306

- Bilgram, V. and Laarmann, F., 2023. Accelerating innovation with generative AI: AI-augmented digital prototyping and innovation methods. *IEEE Engineering Management Review*, **51**(2), pp.18–25. https://doi.org/10.1109/EMR.2023.3272799
- Bolwig, S., Tanner, A.N., Riemann, P., Redlingshöfer, B. and Zhang, Y., 2021. Reducing consumer food waste using green and digital technologies. *UNEP DTU Partnership*. Available at: https://forskning.ruc.dk/en/publications/reducing-consumer-food-waste-using-green-and-digital-technologies
- Brauer, B., Hildebrandt, B. and Remane, G., 2016. Green by app: The contribution of mobile applications to environmental sustainability. *Pacific Asia Conference on Information Systems (PACIS)*.
- Carvalho, A.A. de and Silva, E.A. da, 2021. Life cycle assessment principles in smartphone apps. *Cleaner Environmental Systems*, **3**, 100041. https://doi.org/10.1016/j.cesys.2021.100041
- Cecere, G., Corrocher, N., Gossart, C. and Ozman, M., 2014. Technological pervasiveness and variety of innovators in green ICT: A patent-based analysis. *Research Policy*, **43**(10), pp.1827–1839. https://doi.org/10.1016/j.respol.2014.06.004
- Chang, H.H., Lu, Y.Y. and Li, P.R., 2023. The Yale model of green message sharing and environmental consciousness on social media platforms. *Online Information Review*, **47**(2), pp.333–355. https://doi.org/10.1108/OIR-04-2021-0200
- Cheng, C.C. and Shiu, E.C., 2012. Validation of a proposed instrument for measuring eco-innovation: An implementation perspective. *Technovation*, **32**(6), pp.329–344. https://doi.org/10.1016/j.technovation.2012.02.001
- Clark, N., 2024. Developing technology policy in Africa. *International Journal of Technology Management and Sustainable Development*, **23**(1), pp.3–10. https://doi.org/10.1386/tmsd_00082_1
- Debrah, J.K., Vidal, D.G. and Dinis, M.A.P., 2021. Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. *Recycling*, **6**(1), p.6. https://doi.org/10.3390/recycling6010006

- Degenhard, J., 2024. Global: number of smartphone users 2014–2029. *Statista*. Available at: https://www.statista.com/forecasts/1143723/smartphone-users-in-the-world
- Desouki, M., Madkour, M., Abdeen, A. and Elboshy, B., 2024. Multicriteria decision-making tool for investigating the feasibility of the green roof systems in Egypt. *Sustainable Environment Research*, 34(1), p.2.
- Dewan, I. and Benckendorff, P. (2013) 'Impact of tech savviness and impulsiveness on the mobile information search behaviour of young travellers', in *Information and Communications Technologies in Tourism 2013*. Austria: Springer, pp. 1–6.
- Doğan, S., Pala, U. and Ekici, N., 2022. Mobile applications as a next generation solution to prevent food waste. *Ege Akademik Bakış (Ege Academic Review)*. https://doi.org/10.21121/eab.1181830
- Dokmai, B., 2018. Switching the behaviour of consumers to circular products and services with particular reference to the appeal of green batteries: An econometric analysis of evidence from Thailand. *International Journal of Technology Management and Sustainable Development*, **17**(1), pp.25–47. https://doi.org/10.1386/tmsd.17.1.25_1
- El Dessouky, N.F., 2023. Green economy policy in Egypt: An advocacy coalition perspective. *Information Sciences Letters*, **12**(6). Available at: https://digitalcommons.aaru.edu.jo/isl/vol12/iss6/51
- Guan, X., Xie, L., Shen, W.G. and Huan, T.C., 2021. Are you a tech-savvy person? Exploring factors influencing customers using self-service technology. *Technology in Society*, **65**, 101564. https://doi.org/10.1016/j.techsoc.2021.101564
- Haas, R., Aşan, H., Doğan, O., Michalek, C.R., Karaca Akkan, Ö. and Bulut, Z.A., 2022a. Designing and implementing the MySusCof app—A mobile app to support food waste reduction. *Foods*, **11**(15), p.2222. https://doi.org/10.3390/foods11152222
- Haas, R., Aşan, H., Doğan, O., Michalek, C.R., Karaca Akkan, Ö. and Bulut, Z.A., 2022b. Designing and implementing the MySusCof app—A mobile app to support food waste reduction. *Foods*, **11**(15), p.2222. https://doi.org/10.3390/foods11152222
- Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E., 2010. *Multivariate data analysis*. 7th ed. Harlow: Pearson.

- Hair, J.F., Risher, J.J., Sarstedt, M. and Ringle, C.M. (2019) 'When to use and how to report the results of PLS-SEM', European Business Review, 31(1), pp. 2-24. https://doi.org/10.1108/EBR-11-2018-0203
- Hameed, I., Hussain, H. and Khan, K., 2022. The role of green practices toward the green word-of-mouth using stimulus-organism-response model. *Journal of Hospitality and Tourism Insights*, **5**(5), pp.1046–1061. https://doi.org/10.1108/JHTI-04-2021-0096
- Haraty, R.A. and Bitar, G., 2019. Associating learning technology to sustain the environment through green mobile applications. *Heliyon*, **5**(1), e01141. https://doi.org/10.1016/j.heliyon.2019.e01141
- Hasan, M.M., Al Amin, M., Arefin, M.S. and Mostafa, T., 2024. Green consumers' behavioral intention and loyalty to use mobile organic food delivery applications: The role of social supports, sustainability perceptions, and religious consciousness. *Environment, Development and Sustainability*, **26**(6), pp.15953–16003. https://doi.org/10.1007/s10668-023-03284-z
- Hegazy, I., Seddik, W. and Ibrahim, H., 2017. Towards green cities in developing countries: Egyptian new cities as a case study. *International Journal of Low-Carbon Technologies*, **12**(4), pp.358–368.
- Hegazy, I.R. and Tohlob, A.A., 2024. Strategic environmental assessment and SDG integration: Enhancing sustainable development in Egypt. *Journal of Umm Al-Qura University for Engineering and Architecture*, **15**(3), pp.340–354.
- Helmi, N.M., Faggal, A.A. and Nessim, A.A., 2024. Enhancing energy consumption in Egypt within adaptive façade techniques. *Journal of Al-Azhar University Engineering Sector*, **19**(70), pp.130–142.
- Hoti, T. D. (2025). The influence of social media on consumer purchase decisions and sales increment of businesses owned by women in Kosovo. International Journal of Technology Transfer and Commercialisation, 21(3), 210-218.
- Huang, Z. and Benyoucef, M., 2023. A systematic literature review of mobile application usability: Addressing the design perspective. *Universal Access in the Information Society*, **22**(3), pp.715–735. https://doi.org/10.1007/s10209-022-00903-w
- Ismael, D., Elsharkawi, S.A. and Ali, S.S.M., 2021. Consumers' intention to adopt digital financial services in Egypt: An extended technology acceptance model. *Journal of Alexandria University for Administrative Sciences*, **59**(3).

- Jenkin, T.A., McShane, L. and Webster, J., 2011. Green information technologies and systems: Employees' perceptions of organizational practices. *Business & Society*, **50**(2), pp.266–314. https://doi.org/10.1177/0007650311398640
- Kanuri, R. R., Nandram, S., & Bindlish, P. (2025). A call for Vedantic worldview towards human centricity in AI ethics. International Journal of Technology Transfer and Commercialisation.
- Kaplinsky, R., Chataway, J., Clark, N., Hanlin, R., Kale, D., Muraguri, L., Papaioannou, T., Robbins, P. and Wamae, W., 2009. Below the radar: What does innovation in emerging economies have to offer other low-income economies? *International Journal of Technology Management and Sustainable Development*, **8**(3), pp.177–197.
- Kapoor, K.K., Dwivedi, Y.K. and Williams, M.D., 2014. Examining consumer acceptance of green innovations using innovation characteristics: A conceptual approach. *International Journal of Technology Management and Sustainable Development*, **13**(2), pp.135–160. https://doi.org/10.1386/tmsd.13.2.135_1
- Karnib, A., Elbendary, N., Abouelhassan, W. and Dawoud, M., 2025. Sustainability assessment of solar-powered drip irrigation for sugarcane in Egypt: A water–energy–food–ecosystem nexus perspective. *World Water Policy*, **11**(2), pp.377–669. https://doi.org/10.1002/wwp2.12247
- Kautish, P., Paul, J. and Sharma, R., 2019. The moderating influence of environmental consciousness and recycling intentions on green purchase behavior. *Journal of Cleaner Production*, **228**, pp.1425–1436. https://doi.org/10.1016/j.jclepro.2019.04.389
- Kemp, R. and Pearson, P., 2008. *MEI project about measuring eco-innovation: Final report*. [online] Maastricht: UNU-MERIT. Available at: http://www.merit.unu.edu/MEI/index.php [Accessed 31 December 2024].
- Kock, N. (2015) 'Common method bias in PLS-SEM: A full collinearity assessment approach', International Journal of e-Collaboration, 11(4), pp. 1–10.
- Kriswardhana, W. and Esztergár-Kiss, D., 2024. University students' adoption of mobility as a service with respect to user preferences and group differences. *Journal of Public Transportation*, **26**, 100079. https://doi.org/10.1016/j.jpubtr.2023.100079
- Lavieri, P.S. and Bhat, C.R., 2019. Investigating objective and subjective factors influencing the adoption, frequency, and characteristics of ride-hailing trips.

Transportation Research Part C: Emerging Technologies, **105**, pp.100–125. https://doi.org/10.1016/j.trc.2019.05.037

- Lund, B., 2023. The questionnaire method in systems research: An overview of sample sizes, response rates and statistical approaches utilized in studies. *VINE Journal of Information and Knowledge Management Systems*, **53**(1), pp.1–10. https://doi.org/10.1108/VJIKMS-08-2020-0156
- Mahmoud, N. and Selman, P., 2011. Natural infrastructure concept in arid regions: Two case studies in Egyptian context. *International Journal of Sustainable Development and Planning*, **6**(3), pp.336–359. https://doi.org/10.2495/SDP-V6-N3-336-359
- Marzouk, M.A., Salheen, M.A. and Fischer, L.K., 2022. Functionalizing building envelopes for greening and solar energy: Between theory and the practice in Egypt. *Frontiers in Environmental Science*, **10**, 1056382. https://doi.org/10.3389/fenvs.2022.1056382
- Mason, R., 2023. Urbanism, climate change, and the public utility of greening Cairo. *The Middle East Journal*, **77**(2), pp.204–222. https://doi.org/10.3751/77.2.14
- Melville, N.P., 2010. Information systems innovation for environmental sustainability. *MIS Quarterly: Management Information Systems*, **34**(1), pp.1–21. https://doi.org/10.2307/20721412
- Mehrabian, A. and Russell, J.A., 1974. An approach to environmental psychology. the MIT Press.
- Menon, B., 2018. Influence of customer tech savviness and proneness to social media, facilitating online purchase intention, supplemented through firms' content generation in Facebook. *Drishtikon: A Management Journal*, **9**(1).
- Moslehpour, M., Chau, K.Y., Du, L., Qiu, R., Lin, C.-Y. and Batbayar, B., 2023. Predictors of green purchase intention toward eco-innovation and green products: Evidence from Taiwan. *Economic Research-Ekonomska Istraživanja*, **36**(2). https://doi.org/10.1080/1331677X.2022.2121934
- Nabawy, M., Mohamed, A.G., Awad, I. and Daoud, A.O., 2025. Green building information modeling framework for sustainable residential development in Egypt. *Buildings*, **15**(7), 1035. https://doi.org/10.3390/buildings15071035

- Nadeemi, A. H., Vilaine, L., Bala, R., & Kaur, F. (2025). Commercial technological advancements in warfare: ethical and strategic challenges. International Journal of Technology Transfer and Commercialisation, 21(4), 362-379.
- Naim, A., 2021. Green information technologies in business operations. *Periodica Journal of Modern Philosophy, Social Sciences and Humanities*, **1**, pp.36–49. Available at: https://periodica.org/index.php/journal/article/view/4
- Nair, G.S. and Bhat, C.R., 2021. Sharing the road with autonomous vehicles: Perceived safety and regulatory preferences. *Transportation Research Part C: Emerging Technologies*, **122**, 102885. https://doi.org/10.1016/j.trc.2020.102885
- NAOS, 2024. *Egyptians and digital: 2023 report*. NAOS Solutions. Available at: https://naos-solutions.com/egyptians-and-digital-2023-report/ [Accessed 31 December 2024].
- Paparoidamis, N.G., Tran, T.T.H., Leonidou, L.C. and Zeriti, A., 2019. Being innovative while being green: An experimental inquiry into how consumers respond to eco-innovative product designs. *Journal of Product Innovation Management*, *36*(6), pp.824-847. https://doi.org/10.1111/jpim.12509
- Rao, A. C., & Gaur, J. (2025). Comparative assessment of green growth indicators for China and India. World Review of Entrepreneurship, Management and Sustainable Development, 21(1), 75-102.
- Salah, O.H. and Ayyash, M.M., 2024. E-commerce adoption by SMEs and its effect on marketing performance: An extended of TOE framework with AI integration, innovation culture, and customer tech-savviness. *Journal of Open Innovation: Technology, Market, and Complexity*, **10**(1), 100183. https://doi.org/10.1016/j.joitmc.2023.100183
- Satar, M.S. and Alarifi, G., 2022. Factors of e-business adoption in small and medium enterprises: Evidence from Saudi Arabia. *Human Behavior and Emerging Technologies*, 2022, pp.1–13. https://doi.org/10.1155/2022/2445624.
- Seif, R., Salem, F.Z. and Allam, N.K., 2023. E-waste recycled materials as efficient catalysts for renewable energy technologies and better environmental sustainability. *Environment, Development and Sustainability*, **26**(3), pp.5473–5508. https://doi.org/10.1007/s10668-023-02925-7

- Sengupta, S. and Tomczyk, P. (2025). Understanding knowledge from customers: a systematic literature review. International Journal of Business and Emerging Markets, 17(4), pp. 393–411.
- Sezen, B. and Çankaya, S.Y., 2013. Effects of green manufacturing and eco-innovation on sustainability performance. *Procedia - Social and Behavioral Sciences*, **99**, pp.154–163. https://doi.org/10.1016/j.sbspro.2013.10.481
- Sharma, C., Goyal, S., & Ahmed, A. (2025). Smart-bin: an innovative approach to waste management in smart cities. International Journal of Technology Transfer and Commercialisation, 21(4), 293-305.
- Sharma, T., Chen, J. and Liu, W.Y., 2020. Eco-innovation in hospitality research (1998–2018): A systematic review. *International Journal of Contemporary Hospitality Management*, **32**(2), pp.913–933. https://doi.org/10.1108/IJCHM-01-2019-0002
- Sharma, T., Chen, J.S., Ramos, W.D. and Sharma, A., 2024. Visitors' eco-innovation adoption and green consumption behavior: The case of green hotels. *International Journal of Contemporary Hospitality Management*, **36**(4), pp.1005–1024. https://doi.org/10.1108/IJCHM-04-2022-0480
- Sharma, T., Chen, J.S., Ramos, W.D. and Sharma, A., 2024a. Visitors' eco-innovation adoption and green consumption behavior: The case of green hotels. *International Journal of Contemporary Hospitality Management*, **36**(4), pp.1005–1024. https://doi.org/10.1108/IJCHM-04-2022-0480
- Shobande, O.A., Ogbeifun, L. and Tiwari, A.K., 2024. Unlocking information technology infrastructure for promoting climate resilience and environmental quality. *Technological Forecasting and Social Change*, **198**, 122949. https://doi.org/10.1016/j.techfore.2023.122949
- Skaf, Y., Nemar, S. E., Vrontis, D., & Dennaoui, H. (2025). Factors affecting green purchase intention, case of Lebanon. International Journal of Business and Globalisation, 41(2), 91-115.
- Soliman, A.M.A. and Mehanna, M.A., 2023. Sustainable and green academic buildings in Al-Azhar University: Case study. *International Journal of Renewable Energy Research*.
- Song, A., Rasool, Z., Nazar, R. and Anser, M.K., 2024. Towards a greener future: How green technology innovation and energy efficiency are transforming sustainability. *Energy*, **290**, 129891. https://doi.org/10.1016/j.energy.2023.129891

- Statista, 2024. *Smartphones - Egypt | Statista Market Forecast*. Statista. Available at: https://www.statista.com/outlook/cmo/consumerelectronics/telephony/smartphones/egypt #revenue [Accessed 31 December 2024].
- Taneja, S., Kumar, P., Grima, S. and Özen, E. (2023) 'Special Issue: Green Asset and Risk Management for Promoting Sustainable Entrepreneurship in the Building of the Green Economy', *International Journal of Technology Management and Sustainable Development*, 22(2), pp. 127–130. Available at: https://doi.org/10.1386/tmsd_00071_7.
- Tarek, S. and Ibrahim Nasreldin, T. (2023) 'Towards applying smart mobility solutions in Egypt: An integrative framework and a case study application', *Ain Shams Engineering Journal*, 14(7), 101987. Available at: https://doi.org/10.1016/J.ASEJ.2022.101987.
- Teniola, O. T., Muharam, F. M. B., and Ramily, M. K. (2025). Entrepreneurship and sustainability goals: measuring strategies for offering support services to entrepreneurs in Nigeria. International Journal of Public Sector Performance Management, 15(2), 194-207.
- The World Bank and ITU (2024) *Measuring the emissions & energy footprint of the ICT sector: implications for climate action*. Washington D.C. and Geneva: The World Bank and International Telecommunication Union.
- Typhina, E. (2015) 'Eco-Apps: Design to Influence Environmentally Friendly Behavior', *International Journal of E-Services and Mobile Applications*, 7(1), pp. 1–21. Available at: https://doi.org/10.4018/ijesma.2015010101.
- Uz Zaman, Q., Zhao, Y., Zaman, S., Batool, K. and Nasir, R. (2024) 'Reviewing energy efficiency and environmental consciousness in the minerals industry amidst digital transition: A comprehensive review', *Resources Policy*, 91, 104851. Available at: https://doi.org/10.1016/J.RESOURPOL.2024.104851.
- Vence, X. and Pereira, Á. (2018) 'Eco-innovation and circular business models as drivers for a circular economy', *Contaduría y Administración*, 64(1), 64. Available at: https://doi.org/10.22201/fca.24488410e.2019.180.
- Walia, S. B., Kumar, H. and Negi, N. (2020) 'Impact of brand consciousness, perceived quality of products, price sensitivity and product availability on purchase intention towards "green" products', *International Journal of Technology Management and Sustainable Development*, 19(1), pp. 107–118. Available at: https://doi.org/10.1386/TMSD_00018_1.

- Wan, C., Cheung, R. and Shen, G. Q. (2012) ‘Recycling attitude and behaviour in university campus: A case study in Hong Kong’, *Facilities*, 30(13), pp. 630–646. Available at: https://doi.org/10.1108/02632771211270595.
- Yadav, R. and Pathak, G. S. (2017) ‘Determinants of consumers’ green purchase behavior in a developing nation: Applying and extending the theory of planned behavior’, *Ecological Economics*, 134, pp. 114–122. Available at: https://doi.org/10.1016/J.ECOLECON.2016.12.019.
- Yurdakul, M. and Kazan, H. (2020) ‘Effects of eco-innovation on economic and environmental performance: Evidence from Turkey’s manufacturing companies’, *Sustainability*, 12(8), 3167. Available at: https://doi.org/10.3390/SU12083167 .
- Zelezny, L. C. and Schultz, P. W. (2000) ‘Psychology of promoting environmentalism: promoting environmentalism’, *Journal of Social Issues*, 56(3), pp. 365–371. Available at: https://doi.org/10.1111/0022-4537.00172 .
- Zeybek, O. (2020) ‘Green apps shaping awareness via virtual world’, *International Journal of Landscape Architecture Research*, 4(1), pp. 55–63.
- Zolkepli, I. A., Mukhiar, S. N. S. and Tan, C. (2021) ‘Mobile consumer behaviour on apps usage: The effects of perceived values, rating, and cost’, *Journal of Marketing Communications*, 27(6), pp. 571–593. Available at: https://doi.org/10.1080/13527266.2020.1749108

Appendixes

Appendix 1 Study Survey

Dear Participant,

This survey is for scientific research purposes, as we are investigating the effect of Eco-innovation on green applications Use. We ask you to kindly take some time to fill it. Knowing that there are no right or wrong answers, we hope that your answer reflects how you feel. Your answers will be used only for the purpose of scientific research **only** and we guarantee the security and privacy of those answers. Thank you for your time and effort, for any other questions please contact us at bkawad@ftd.zu.edu.eg.

Do you know any of the recycling or green companies in Egypt (such as ….) ?

( ) Yes ( ) No

Did you ever use green apps (applications that help reduce pollution and waste, energy-efficient, and environmentally friendly) such as Bikia? ( ) Yes ( ) No

If yes, what type of app did you use?

"Bikia" "recycled bank" "Barakah Other…

Statement	Your level of Agreement 1= strongly disagree, 5= strongly agree				
Application Eco-innovation					
Green applications help in developing products using less material.	1	2	3	4	5
Green applications contribute to developing products that can be recycled easily.	1	2	3	4	5
Those green applications cause the least amount of waste.	1	2	3	4	5
Green applications minimize the damage caused by waste.	1	2	3	4	5
Green applications minimize energy use.	1	2	3	4	5
Green applications provide a verity of options that help the eco-system wellbeing.	1	2	3	4	5

Green applications help in developing products that cause the least amount of waste.	1	2	3	4	5

Tech-savviness					
Statement					
I frequently use smartphone applications.	1	2	3	4	5
I would describe myself as someone who is very skilled at using my smartphone frequently and/or selling things online.	1	2	3	4	5
I frequently use online social media.	1	2	3	4	5
I have general knowledge about mobile applications.	1	2	3	4	5
Environmental Consciousness					
Statement	**Your level of Agreement 1=strongly disagree, 7=strongly agree**				
It would mean a lot to me if I could contribute to protecting the environment.	1	2	3	4	5
If things continue on their present course, we will soon experience a major ecological catastrophe.	1	2	3	4	5
The environment is one of the most important issues facing the world today.	1	2	3	4	5

I understand that the environment is for us and future generations, thus must be well maintained and preserved	1	2	3	4	5
I believe that man and nature have to be in harmony for survival	1	2	3	4	5
I realize that natural resources are scarce, thus must be used wisely	1	2	3	4	5
I get annoyed when someone contaminates the environment	1	2	3	4	5
Green App Use					
I have downloaded green application before.	1	2	3	4	5
I often use the green applications whenever I need to get rid of any materials I don't need.	1	2	3	4	5
I use green apps often when I need solutions to help me in my daily life.	1	2	3	4	5
I have been using green apps for the past 6 months.	1	2	3	4	5

Demographics

1. **Your gender**

   Male – Female

2. **Your Age……**

From 18 to less than 25/ From 25 to less than 35/ From 35to less than 45/ From 45to less than 55/ From 55 to less than 65/ 65and above

3. **Region of Residence….**
4. **Your family estimated monthly income**

10,000 or less / 11K to 20K / 21K to 30K /31K to 40K / more than 40K

5. **Your education**

Bachelor's or equivalent level /Master's or equivalent level/Doctoral or equivalent level