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RESEARCH ARTICLE OPEN ACCESS

Towards Sustainable e-Waste Practices: A Value-Belief-Norm Analysis of Mobile Phone Disposal in Ghana

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ABSTRACT

Electronic waste (e-waste) from mobile phones is a growing concern in resource-constrained contexts, where limited infrastructure and regulatory enforcement promote reliance on informal systems. In Ghana, a rapidly expanding digital market, e-waste accumulation poses significant environmental and social challenges. This study investigates the behavioral drivers behind mobile phone disposal using the Value-Belief-Norm (VBN) theory and aims to extend the VBN framework by applying it to the context of e-waste management in the developing Ghanaian economy. Data collected from 110 participants across Ghana were analyzed with partial least squares structural equation modeling. Findings reveal that while a pro-environmental worldview does not directly heighten awareness of improper disposal consequences, increased awareness enhances responsibility attribution, which strongly shapes personal norms and drives policy support and private-sphere actions. Notably, materialistic values exhibit a negative effect, suggesting that economic and status-related factors may override prosocial motivations. Promoting sustainable disposal practices requires strategies that align economic incentives with enhanced personal responsibility and social norms.

1 | Introduction

The rapid advancement of information and communication technology (ICT) has accelerated product obsolescence, leading to a surge in electrical and electronic waste (e-waste), which includes discarded electrical and electronic equipment (EEE) no longer intended for reuse (Awasthi and Li 2017). Mobile

phones, in particular, contribute disproportionately to this due to their short life cycles, limited repairability, and high turnover rates, resulting in millions of devices being discarded annually—many of which still retain functional and economic value (Islam et al. 2020; Prabhu and Majhi 2022; Yamane et al. 2011). Globally, mobile phone disposal practices remain highly fragmented. In high-income countries, most discarded phones are

Abbreviations: AC, Awareness of consequences; AR, Ascription of responsibility; AV, Altruistic values; AVE, Average variance extracted; CE, Circular economy; CMB, Common method bias; CR, Composite reliability; EC, Environmental citizenship; EEE, Electrical and electronic equipment; EPR, Extended producer responsibility; EV, Egoistic values; e-waste, Electronic waste; GDPR, General data protection regulation; H, Hypothesis; HTMT, heterotrait-monotrait; ICT, Information and communication technology; LM, Linear regression model; M, Mean; MV, Materialistic values; NAM, Norm activation model; NEP, New ecological paradigm; PB, Private-sphere behaviors; PLS-SEM, Partial least squares structural equation modeling; PN, Personal norms; PS, Policy support; RMSE, Root-Mean-Square Errors; SD, Standard deviation; TPB, Theory of planned behavior; TUM, Technical University of Munich; TV, Traditional values; VBN, Value-belief-norm; VIF, Variance inflation factor.

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collected through formal take-back schemes or voluntary recycling programs, yet a substantial proportion still ends up in drawers, landfills, or is exported for treatment abroad (Islam et al. 2021). Public knowledge about available recycling options is often limited, reducing participation in formal schemes and contributing to the common practice of storing unused phones at home (Islam et al. 2020). In low- and middle-income countries, formal collection systems for mobile phone collection are often underdeveloped or inaccessible, leading to widespread reliance on informal handling (Hoeltl et al. 2017; Oteng-Ababio 2010). This not only raises serious environmental and health concerns but often also results in the loss of valuable materials (Baldé et al. 2024).

Like many countries of the Global South, Ghana has experienced rapid growth in mobile phone adoption, driven by increasing affordability and expanding telecommunications infrastructure (GSMA 2023). With a mobile phone penetration rate exceeding 100%, phones have become integral to economic and social activities, for example, by enhancing market efficiency through improved information access or broader financial inclusion through mobile money (Aker and Mbiti 2010; National Communications Authority 2021; Nguyen 2021; Khan et al. 2022). However, this rising adoption has led to a growing volume of discarded devices, posing significant challenges for e-waste management given the limited availability of formal collection and recycling infrastructure in Ghana (Oteng-Ababio 2010; Hoeltl et al. 2017). Current disposal practices in Ghana reflect a complex interplay between individual behavior, institutional gaps, and international dynamics (Owusu-Sekyere et al. 2018). While state agencies expect citizens to voluntarily adopt proper disposal practices, the public, in turn, looks to the government for the development of accessible and reliable disposal channels (Owusu-Sekyere et al. 2018). In the absence of such infrastructure and formal regulations, communities are compelled to establish their own disposal norms, often without regard for environmental or health consequences. As a result, current disposal strategies are largely poorly organized and shaped by individual household decisions rather than coordinated policies from city authorities. Predominant disposal methods include reuse through donation, repair or resale as second-hand goods, and recycling by selling devices to scrap dealers or peddlers (Oteng-Ababio 2012; Owusu-Sekyere et al. 2018). In particular, mobile phone repair has grown into a booming business in recent years, giving rise to local repair ecosystems largely dominated by small, informal repair shops (Lu 2024). Devices sold for recycling often end up in informal recycling facilities, commonly known as “scrap yards,” where many Ghanaians engage in informal activities extracting value from discarded electronics as part of their livelihoods (Asibey et al. 2022). Proper recycling standards are not followed there, causing severe soil and water contamination and significant health risks (Hoeltl et al. 2017). At the international level, developed countries often export outdated electronic devices to Ghana as a form of aid, ostensibly to improve access to technology in resource-constrained settings. However, this practice further burdens local systems and exacerbates the growing e-waste challenge (Hoeltl et al. 2017; Manhart et al. 2024).

To address these pressing issues, sustainable e-waste management strategies must incorporate Circular Economy (CE)

principles that emphasize efficient closed-loop systems to minimize reliance on virgin materials and extend product lifespans while reducing negative environmental and social impacts (Bressanelli et al. 2020; Fraser et al. 2024). However, achieving an effective CE depends not only on infrastructure and regulations but also on consumer participation, as end-users decide whether their devices are resold, repaired, recycled, or discarded (im)properly (Islam et al. 2021; Pérez-Belis et al. 2015; Prabhu and Majhi 2024). Yet, existing studies have primarily emphasized technological and policy-driven interventions, such as improved recycling infrastructure and regulatory frameworks, while behavioral dimensions remain largely underexplored (Kirchherr et al. 2017). To address this gap, this study shifts the focus to behavioral determinants using the Value-Belief-Norm theory (VBN) developed by Stern et al. (1999) to examine how individual values, beliefs, and social norms influence disposal behavior in Ghana. Although the VBN has been widely adopted to understand pro-environmental behavior, its use in e-waste management, particularly in countries of the Global South, remains limited (Awais et al. 2022). Specifically, this study seeks to answer two questions: (a) What factors shape consumer behavior in Ghana regarding circular solutions for end-of-use mobile phones? and (b) What practical implications can be derived to enhance the adoption of circular solutions in Ghana? By addressing these questions, this study fills a critical gap in e-waste research by providing empirical insights into the psychological and normative drivers of mobile phone disposal in Ghana, applying the VBN for the first time in this context. Understanding these behavioral factors is essential for creating e-waste management strategies that resonate with local values, ultimately supporting sustainable practices in Ghana and similar contexts across the Global South. Moreover, the study attempts to derive implications for business opportunities from its findings. By highlighting these options, the study seeks to illustrate how environmental and economic value creation can be mutually reinforced, especially in underserved contexts where affordability, access, and trust are critical. Furthermore, this study evaluates the applicability of the VBN framework for e-waste management in countries of the Global South, questioning whether existing behavioral models sufficiently account for economic and cultural influences in informal waste ecosystems.

1.1 | Literature Review

e-waste management has received significant attention over past decades, as evidenced by a growing body of research analyzing its environmental, economic, and social implications (Zhang et al. 2019). Early research primarily focused on the risks associated with improper disposal and processing, where toxic substances, such as cadmium, pose severe environmental and public health threats (Grant et al. 2013; Ilankoon et al. 2018; Noel-Brune et al. 2013; Sthiannopkao and Wong 2013). While this foundational research highlighted the urgency of improving e-waste handling, subsequent studies shifted toward resource recovery and recycling, emphasizing the potential of e-waste as a secondary source of valuable materials, such as rare earth elements (Ramprasad et al. 2022; Seif et al. 2023; Ueberschaar et al. 2017). Much of this existing literature has concentrated on high-income countries where formal recycling infrastructure and regulatory frameworks shape waste management

strategies. Consequently, it does not sufficiently address the realities of informal systems (Heinrich et al. 2025; Owusu-Sekyere et al. 2022; Shittu et al. 2021).

Among the various e-waste categories that pose sustainability challenges, mobile phones represent a distinctive case due to their widespread adoption, high economic value, and largely untapped potential within CE models (Gaustad et al. 2021; Kastanaki and Giannis 2022). Unlike larger electronic devices, mobile phones are often replaced while still functioning, thereby creating possibilities for a secondary market and opportunities for reuse, refurbishment, and recycling (Islam et al. 2020). Especially in the Global South, CE-related approaches seem to be deeply embedded, as financial and economic constraints foster reuse, repair, and refurbishment as necessity-driven activities (Ahmed et al. 2022; Boon and Anuga 2020; Frimpong et al. 2024; Kirchherr and van Santen 2019). In Ghana, this is exemplified by the widespread presence of mobile phone repair businesses, which play a crucial role in prolonging device lifespans while simultaneously creating economic opportunities (Lu 2024). Nevertheless, despite the widespread reuse and repair practices, several characteristics of mobile phones, such as their small size, rapid turnover, and complex material composition, combined with a lack of regulatory oversight, hinder their proper integration into formal recycling streams and often lead to storage, informal processing, or inappropriate disposal (Apprey et al. 2024; Prabhu and Majhi 2024).

Thus, targeted CE strategies within mobile phone e-waste management are needed. Yet, research has predominantly examined their application in structured, formalized settings (Halog and Anieke 2021; Jabbour et al. 2019; Mishra et al. 2021) or focused on the economic aspects of recycling (Geyer and Blass 2010; Sarath et al. 2015; Wang et al. 2022), global management strategies (Ilankoon et al. 2018; Yahya et al. 2021), and material recovery processes (Heacock et al. 2018; Morell et al. 2025). Behavioral factors influencing whether mobile phones enter formal or informal recycling streams remain largely underexplored (Islam et al. 2021; Prabhu and Majhi 2024). Understanding these behavioral dynamics requires a theoretical framework that captures the underlying motivations and decision-making processes. In this context, social-psychological theories, such as the VBN theory, the Norm Activation Model (NAM), and the Theory of Planned Behavior (TPB), are commonly applied to explain pro-social and pro-environmental behavior (Steg and Nordlund 2018). Among these, the TPB by Ajzen (1991) has been the dominant approach in e-waste research, emphasizing rational decision-making, subjective norms, and perceived behavioral control (Prabhu and Majhi 2024). Although the TPB effectively explains behaviors driven by rational cost-benefit analyses, it may inadequately account for internalized moral obligations, intrinsic motivations, and habitual decision-making factors that become particularly salient in contexts where formal waste management infrastructures are weak or absent (Steg and Vlek 2009; van der Werff and Steg 2016). To better account for moral and normative influences, alternative models such as the NAM (Schwartz 1977) and the VBN theory (Stern et al. 1999) have been introduced, both of which conceptualize moral obligations as key determinants of pro-environmental behavior. The NAM describes pro-environmental behavior as a function of personal

norm activation, which occurs when individuals become aware of environmental consequences and ascribe personal responsibility for addressing them (Schwartz 1977). Building on this foundation, the VBN theory expands the NAM by incorporating value orientations, such as altruistic, traditional, and egoistic values, to explain how individual beliefs shape personal norms and drive pro-environmental behavior (Stern et al. 1999). Our on-site pre-study confirmed the suitability of the VBN theory for analyzing mobile phone disposal behavior in Ghana, revealing that normative considerations, such as responsibility toward future generations and environmental concerns, are deeply embedded in value orientations. Previous research has applied the VBN framework across various contexts, including farming, mining, and consumption, in the Global South (Maumoh and Yindi 2021; Muposhi et al. 2021; Naatu et al. 2024; Obuobi et al. 2022). While these studies examine the role of personal values in shaping sustainable behavior, with mixed outcomes ranging from positive (Obuobi et al. 2022) to negative (Maumoh and Yindi 2021; Muposhi et al. 2021) or non-significant influence (Naatu et al. 2024), they do not investigate their relevance in predicting sustainable disposal behavior specifically in the context of e-waste. Only one study has been identified that focuses on mobile phone disposal, conducted in a high-income country and using a combined TPB-VBN approach; however, it also does not specifically examine the role of personal values in shaping disposal choices (Ylä-Mella et al. 2015).

Other studies have employed alternative theoretical models or integrated social-psychological frameworks to examine mobile phone disposal behavior, particularly in major developing economies such as China, India, Indonesia, and Pakistan (Khan et al. 2022; Prabhu and Majhi 2024; Sari et al. 2021; Zhang et al. 2021). While these studies contribute valuable insights, they vary in their treatment of personal values: Khan et al. (2022) and Zhang et al. (2021) do not include personal values in their models; Prabhu and Majhi (2024) report a significant influence only for biospheric values; and Sari et al. (2021) find significant effects for biospheric, altruistic, and egoistic values. Thus, research on the influence of personal values presents a scattered and sometimes contradictory picture.

This inconsistency underscores the need for context-sensitive investigations that account for regional and socioeconomic differences. To our knowledge, this study is the first to apply the VBN theory to mobile phone disposal behavior in Ghana.

1.2 | Hypothesis Development

As illustrated in Figure 1, the VBN theory explains how values (altruistic, *AV*; egoistic, *EV*; traditional, *TV*; materialistic, *MV*) through environmental beliefs (based on the new ecological paradigm, *NEP*), awareness of consequences (*AC*), ascription of responsibility (*AR*), and personal norms (*PN*), shape pro-environmental behaviors, including environmental citizenship (*EC*), policy support (*PS*), and private-sphere behaviors (*PB*) (Stern et al. 1999). A comprehensive understanding of these constructs, their interrelationships, and their role in the Ghanaian e-waste context is outlined in the attached Nomenclature. This study introduces two key modifications to adapt the VBN framework to Ghana's e-waste context.

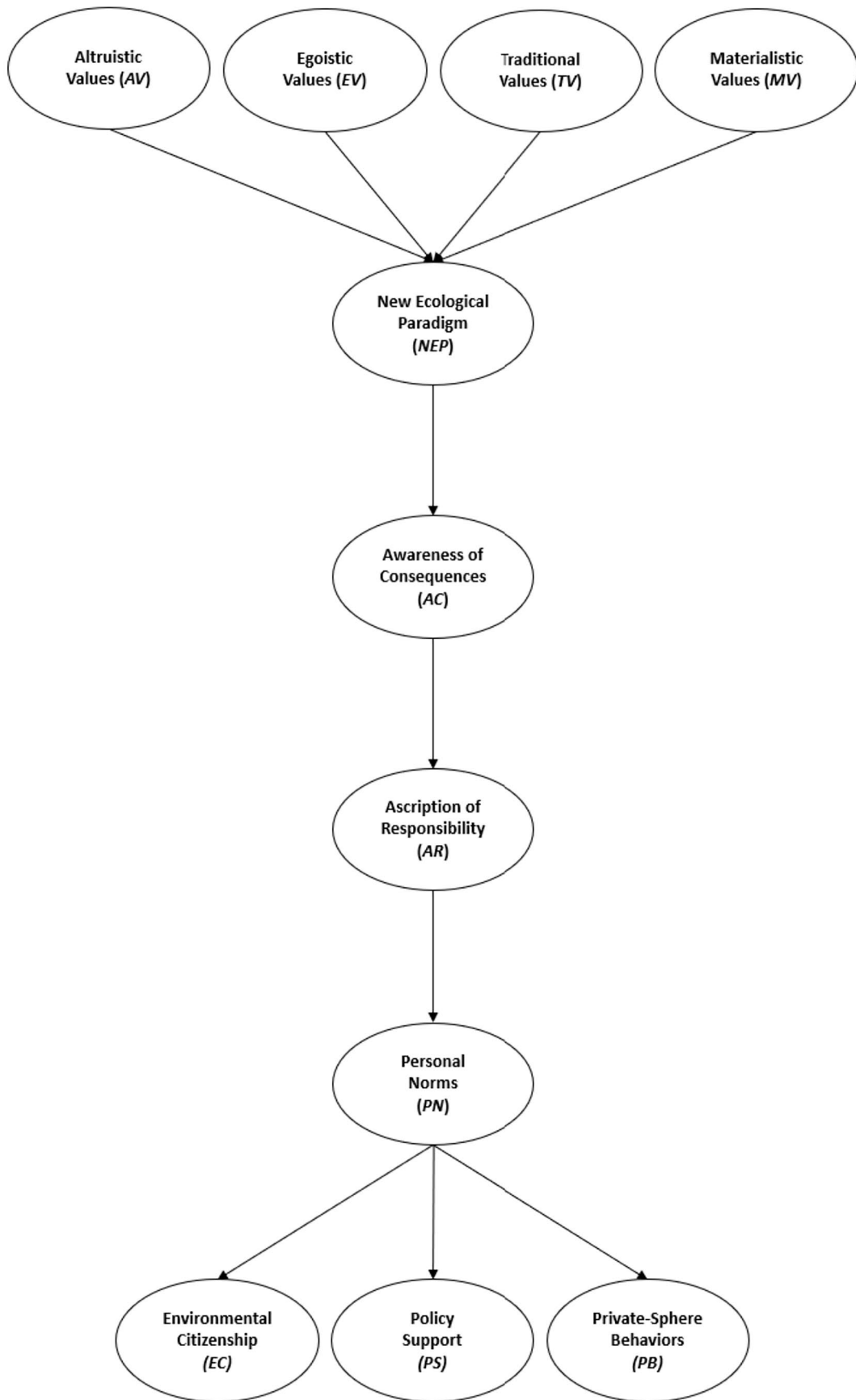


FIGURE 1 | The Value-Belief-Norm theory based on Stern et al. (1999).

First, while not originally included in the VBN model, *MV* is incorporated based on insights from pre-study interviews in Ghana. These interviews revealed that beyond their functional purpose, mobile phones serve as status symbols, with brand and social prestige playing a crucial role in both acquisition and disposal decisions. Given this influence, it is hypothesized that *MV* provide a meaningful extension to the model, enhancing understanding of consumer behavior in mobile phone disposal.

Second, environmental activism, originally part of the VBN model (Stern et al. 1999), is excluded due to its limited applicability in Ghana, where bottom-up engagement in waste management, such as petitioning policymakers or supporting environmental organizations, is less common. Instead, disposal behaviors are primarily influenced by economic incentives and social networks.

Building on this adapted VBN framework, the following hypotheses are tested in this study:

H1. *Consumers' AV positively influence their endorsement of the NEP.*

H2. *Consumers' EV negatively influence their endorsement of the NEP.*

H3. *Consumers' TV negatively influence their endorsement of the NEP.*

H4. *Consumers' MV significantly influence their endorsement of the NEP.*

H5. *Endorsement of the NEP significantly influences AC related to improper disposal of mobile phones.*

H6. *AC significantly influences the AR for environmentally friendly behavior related to the disposal of mobile phones.*

H7. *AR significantly influences the development of PN regarding the environmentally sound disposal of mobile phones.*

H8. *PN related to environmental responsibility significantly influence the engagement in EC, PS and PB in the context of mobile phone disposal.*

2 | Materials and Methods

2.1 | Data Collection

The data for this research was collected via a Qualtrics online survey between September 19 and October 2, 2024. To distribute the questionnaire, the research team leveraged its network in Ghana to directly approach individuals working in thematically relevant fields, employing a convenience sampling method due to its efficiency in terms of time and cost (Etikan et al. 2015). Additionally, the snowball sampling technique was employed to expand the sample (Etikan et al. 2015; Taherdoost 2016). Ethical clearance for this research was obtained from the Ethics Committee of the Technical University of Munich (TUM),

ensuring that all aspects of data collection adhered to ethical standards. Participant confidentiality and anonymity were maintained, and data management practices complied with general data protection regulations (GDPR), following approval from the TUM Data Security Team. Informed consent was obtained from all participants to safeguard their privacy and rights. A total of 158 responses were collected, of which 110 valid responses were used for analysis.

2.2 | Questionnaire Design

The measurement variables for this study were selected or adapted from prior research. To ensure theoretical alignment with disposal behavior in the Ghanaian context, a preliminary field study was conducted in Accra, Ghana, in November 2023, involving 30 semi-structured interviews to determine the most suitable behavioral framework. This field study focused on comparing the applicability of the NAM and the VBN theory. The findings suggested that the VBN framework is most appropriate as it captured the role of personal norms and moral responsibility in shaping disposal decisions under limited regulatory enforcement and infrastructure.

In the subsequent online survey questionnaire of 2024, a total of 11 variables were included, drawing on established scales (see Nomenclature). The indicators of *AV*, *EV*, *TV*, and the *NEP* were based on the frameworks of Schwartz (1992) and Stern et al. (1999). *MV* indicators were integrated from Gomes et al. (2022), while those related to *EC* followed Stern et al. (1999). *AC*, *AR*, *PN*, *PS*, and *PB* indicators were modified based on Stern et al. (1999), Steg et al. (2005), Ghazali et al. (2019), Obuobi et al. (2022), Naatu et al. (2024), and Li et al. (2018).

To reduce the likelihood of common method bias (CMB), several ex-ante methodological adjustments were incorporated during the questionnaire design phase, following the recommendations of Podsakoff et al. (2003). First, different scale formats were applied across construct groups to reduce response consistency artifacts (Podsakoff et al. 2003). Specifically, value-based constructs (i.e., *AV*, *EV*, *TV*, *MV*) were measured on a 9-point Likert scale, while belief- and behavior-related constructs (i.e., *NEP*, *AC*, *AR*, *PN*, *EC*, *PB*, *PS*) used shorter 4-point agreement scales (Schwartz 1992; Stern et al. 1999). In addition, constructs were grouped into visually and thematically separated blocks, supported by neutral section headers and uniform but non-leading instructions. This separation aims to create psychological distance between predictor and criterion variables, thereby reducing method-induced correlations (Podsakoff et al. 2003). Furthermore, full anonymity was guaranteed throughout the survey process to reduce evaluation apprehension and social desirability bias. These procedural strategies are consistent with best practices in survey design and align with guidance on CMB mitigation, such as that provided by Kock et al. (2021).

2.3 | Data Analysis

The data analysis was carried out in two phases. However, to ensure the integrity and reliability of the dataset, preliminary

tests for non-response bias and CMB were conducted before proceeding with further analysis (see Appendix 1). In the first phase, descriptive statistics were generated using IBM SPSS Statistics (IBM Corp 2023) to examine the socio-demographic characteristics of the respondents and prepare the dataset for further analysis. Collected survey data was imported into SPSS, where key descriptive measures, such as means, standard deviations, and ranges, were calculated for each construct, following established practices in similar research (Momenpour et al. 2024; Naatu et al. 2024). During this phase, reverse coding was applied to specific items (*MV_3_Reversed*, *NEP_1_Reversed*, and *NEP_3_Reversed*) where higher scores indicated negative outcomes, ensuring the accuracy and consistency of the data. In the second phase, Partial Least Squares Structural Equation Modeling (PLS-SEM) was conducted using SmartPLS 4, a software developed by Ringle et al. (2024). PLS-SEM was selected for its ability to handle smaller sample sizes and its suitability for both predictive and explanatory research objectives, particularly when the structural model is complex and involves numerous constructs, indicators, and relationships (Hair et al. 2021). In line with sample size recommendations, the decision to apply PLS-SEM was further supported by the “10-times rule” (Hair et al. 2021), which requires the sample size to be at least 10 times the number of structural paths directed at the most complex construct. A minimum of 40 cases was required, given that the most complex construct received four incoming paths. The final sample of 110 thus met the recommended threshold (Hair et al. 2011). Consistent with standard SEM procedures, the measurement model was first evaluated to confirm the reliability and validity of all latent constructs, irrespective of whether these constructs were being modeled reflectively or formatively. Once the indicators were verified to sufficiently capture their underlying constructs, the structural model was examined to test the proposed hypotheses (Hair et al. 2021).

3 | Results

3.1 | Respondents' Socio-Demographic Information

Of the 110 valid participants, 72.7% self-identified as male, 26.4% as female, and 0.9% preferred not to specify their gender. In terms of age distribution, most of the respondents (41.8%) were between 25 and 34 years old, followed by 24.5% aged 35–44 years. Older age groups were less represented, with only 16.4% aged 45 or above. Overall, the sample was highly educated, as 91.8% of participants reported holding at least a bachelor's degree. Monthly disposable income showed notable variation, tending towards two extremes: 36.4% reported incomes exceeding 2500 Ghana Cedi, whereas 30.0% reported 500 Ghana Cedi or less, including 19.1% with no income at all. These findings suggest a predominantly male and highly educated sample exhibiting notable income disparities. This imbalance may affect the generalizability of the results and will be further considered in the study's limitations (see Section 4.3). A detailed demographic profile is presented in Table 1.

TABLE 1 | Demographic results.

Demographic variables	N	Percentage %
Gender		
Male	80	72.7%
Female	29	26.4%
Prefer not to say	1	0.9%
Age		
18–24 years	19	17.3%
25–34 years	46	41.8%
35–44 years	27	24.5%
45 years or above	18	16.4%
Education level		
High school	8	7.3%
Vocational training	1	0.9%
Bachelor's degree or higher	101	91.8%
Monthly income		
I have no income	21	19.1%
Up to 500 Ghana Cedi	12	10.9%
501–1000 Ghana Cedi	12	10.9%
1001–1500 Ghana Cedi	2	1.8%
1501–2000 Ghana Cedi	3	2.7%
2001–2500 Ghana Cedi	5	4.5%
More than 2500 Ghana Cedi	40	36.4%
Prefer not to say	15	13.6%

3.2 | Factors Influencing Consumer Behavior Towards Engaging in Circular Solutions for End-of-Use Mobile Phones

Descriptive statistics provide a foundational overview of constructs, illustrating the distribution and central tendencies of attitudes and behaviors related to mobile phone disposal. As presented in Table 2, *TV* (Mean (M) = 5.16, Standard Deviation (SD) = 1.69) and *AV* (M = 5.09, SD = 1.69) recorded the highest means among constructs measured on a 7-point Likert Scale, indicating a strong emphasis on societal norms and collective welfare. Conversely, *MV* exhibited the lowest mean (M = 2.13, SD = 1.48), while *EV* showed a moderate mean (M = 3.25, SD = 1.64), suggesting lower prioritization of self-interest and material possessions. For constructs measured on a 4-point Likert Scale, *AC* (M = 3.60, SD = 0.50) and *PN* (M = 3.68, SD = 0.47) demonstrated high means, indicating strong environmental awareness and internalized moral obligations. In contrast, *PB* (M = 2.15, SD = 0.74) and *PS* (M = 2.78, SD = 0.78) exhibited low to moderate means, highlighting a gap between awareness and pro-environmental actions. *EC* measured on a

TABLE 2 | Descriptive statistics.

Construct	Scale	Min.	Max.	Mean	SD	Interpretation
AV	7-point Likert scale	-1.00	7.00	5.09	1.69	High
EV	7-point Likert scale	0.00	7.00	3.25	1.64	Moderate
TV	7-point Likert scale	-0.75	7.00	5.16	1.69	High
MV	7-point Likert scale	-0.75	5.25	2.13	1.48	Low
NEP	4-point Likert scale	2.00	4.00	3.20	0.57	Moderate
AC	4-point Likert scale	1.33	4.00	3.60	0.50	High
AR	4-point Likert scale	1.00	4.00	2.95	0.84	Moderate
PN	4-point Likert scale	1.50	4.00	3.68	0.47	High
EC	Binary*	0.00	1.00	0.42	0.24	Low
PS	4-point Likert scale	1.00	4.00	2.78	0.78	Moderate
PB	4-point Likert scale	1.00	4.00	2.15	0.74	Low

Note: The minimum value for *TV* and *MV* is -0.75, as no participant selected the answer coded as -1 for all related items. Similarly, the minimum value for *AC* and *PN* is 1.33 and 1.50 respectively, since no participant chose the answer coded as 1 for all items.

Abbreviations: AC, Awareness of consequences; AR, Ascription of responsibilities; AV, Altruistic Values; EC, Environmental Citizenship; EV, Egoistic Values; MV, Materialistic Values; NEP, New Ecological Paradigm; PB, Private-Sphere Behaviors; PN, Personal norms; PS, Policy Support; TV, Traditional Values.

**EC* combined binary and metric items, therefore the metric item (*EC_3*) was rescaled to align with the binary scoring system (0-1), following Stern et al. (1999).

0-1 scale combining binary and rescaled metric items recorded a low mean ($M=0.42$, $SD=0.24$), suggesting limited engagement in civic pro-environmental activities.

3.3 | Evaluation of Measurement Models

The reliability and validity of the measurement models were evaluated following the assessment procedure recommended by Hair et al. (2021).

First, indicator reliability was initially assessed using outer loadings, with values above 0.70 considered acceptable. Items with outer loadings between 0.40 and 0.70 were retained for further analysis but closely examined for their impact on the constructs' overall reliability and validity measures, while items with outer loadings below 0.40 were deleted (*EV_2*, *MV_3_Reversed*, *NEP_2*, *NEP_4*, *PB_4*) (see Appendix 2 for all initial values).

Second, the model was re-estimated without the deleted indicators to examine internal consistency and convergent validity. The remaining items with outer loadings between 0.40 and 0.70 (*EV_3*, *MV_4*, *AC_1*, *AC_2*, *PN_2*, *PN_3*, *EC_1*, *EC_2*) were assessed for internal consistency reliability and convergent validity (Hair et al. 2022). Internal consistency reliability, which reflects the reliability of the measures at the construct level, was assessed using composite reliability (CR) (Hair et al. 2011). Values between 0.70 and 0.90 are considered “satisfactory to good,” whereas values above 0.95 may indicate item redundancy, potentially undermining construct validity (Hair et al. 2019). In this study, no issues with item redundancy were observed. However, the construct *EC* did not meet the minimum threshold for CR ($CR=0.642$, see Appendix 2), indicating insufficient internal consistency reliability based on these criteria.

Convergent validity, defined as the degree to which indicators of a construct are correlated, was assessed through the average variance extracted (AVE) for each construct. The recommended threshold for the AVE is 0.50 or higher, indicating that the construct explains at least 50% of the variance of its items (Hair et al. 2021). Based on this criterion, the constructs *AC* ($AVE=0.497$) and *EC* ($AVE=0.388$) failed to meet the AVE threshold (see Appendix 2). As suggested by Hair et al. (2021), in cases where AVE is slightly below 0.50 but CR is acceptable, it is recommended to remove the item with the lowest outer loading to assess whether AVE improves without compromising convergent validity. Accordingly, item *AC_1* was removed. In contrast, the construct *EC* did not meet the minimum thresholds for either AVE or CR, indicating both insufficient convergent validity and internal consistency reliability and was thus removed completely.

Third, after removing these items (*AC_1*, *EC_1*, *EC_2*, *EC_3*), the measurement model was again re-estimated. The revised model demonstrated improved measurement properties, with all constructs exceeding the acceptable threshold for CR, ranging from 0.806 to 0.950, and achieving AVE values above 0.50, ranging from 0.527 to 0.863, with construct *AC* retained in the model based on its recalculated AVE of 0.527 (see Table 3).

Discriminant validity was subsequently evaluated using the Heterotrait-Monotrait (HTMT) ratio of correlations, which is regarded as a more robust method than the Fornell-Larcker criterion and cross-loadings (Henseler et al. 2015). HTMT is defined as the mean value of the item correlations across constructs relative to the geometric mean of the average correlations for the items measuring the same construct (Hair et al. 2019). It assesses the extent to which constructs are empirically distinct by comparing the correlations between items of different constructs to those within the same construct. Values

TABLE 3 | Construct validity and reliability.

Construct	Items	Outer loading	CR	AVE
AV	AV_1	0.917	0.950	0.863
	AV_2	0.932		
	AV_3	0.937		
EV	EV_1	0.935	0.837	0.636
	EV_3	0.683		
	EV_4	0.753		
TV	TV_1	0.895	0.942	0.803
	TV_2	0.914		
	TV_3	0.919		
	TV_4	0.854		
MV	MV_1	0.939	0.864	0.682
	MV_2	0.837		
	MV_4	0.680		
NEP	NEP_1_ Reversed	0.838	0.810	0.680
	NEP_3_ Reversed	0.811		
AC	AC_2	0.610	0.847	0.527
	AC_3	0.689		
	AC_4	0.837		
	AC_5	0.720		
	AC_6	0.757		
AR	AR_1	0.834	0.892	0.674
	AR_2	0.708		
	AR_3	0.897		
	AR_4	0.834		
PN	PN_1	0.748	0.828	0.548
	PN_2	0.705		
	PN_3	0.643		
	PN_4	0.850		
PS	PS_1	0.726	0.806	0.581
	PS_2	0.744		
	PS_3	0.813		
PB	PB_1	0.804	0.859	0.604
	PB_2	0.806		
	PB_3	0.744		
	PB_5	0.723		

Note: The items *EV_2*, *MV_3_Reversed*, *NEP_2*, *NEP_4*, *AC_1*, *EC_1*, *EC_2*, *EC_3*, *PB_4* were already removed.
Abbreviations: AVE, Average Variance Extracted; CR, Composite Reliability.

below the 0.90 threshold indicate adequate discriminant validity, confirming that the constructs are empirically distinct and appropriately measured (Hair et al. 2019). This signifies that each construct within the model captures a unique theoretical concept without significant overlap, ensuring clear differentiation between constructs. All constructs satisfied the discriminant validity criteria, with HTMT values below 0.90 for all construct pairs (see Table 4). This finding indicates that the constructs are not only conceptually but also statistically distinct, thereby ensuring that no overlap exists in the measured constructs within the model.

3.4 | Evaluation of Structural Model

Following the structural model assessment guidelines outlined by Hair et al. (2021), collinearity among constructs was re-examined using the VIF values of all constructs after the removal of items due to insufficient reliability and validity (see Section 3.3). In line with Hair et al. (2022), VIF values exceeding 5 indicate potential collinearity issues in the structural model, whereas values between 3 and 5 warrant caution. As presented in Table 5, all VIF values in the revised model remain well below 3, suggesting a minimal risk of collinearity and reinforcing the robustness of the structural model.

Following the examination of collinearity issues, the significance and relevance of the path coefficients (β) were assessed using bootstrapping procedures with 10,000 subsamples, as recommended by Hair et al. (2021). Path coefficients represent the strength and direction of relationships between constructs, ranging from -1 to 1 , with positive values indicating positive relationships. A path coefficient is considered statistically significant at the 5% level if its associated t -value exceeds 1.96, the 95% confidence interval does not include zero, and the corresponding p -value is below 0.05 (Hair et al. 2022). By meeting all three conditions, a hypothesized relationship can be deemed empirically valid. Table 5 provides the full set of hypothesis test results, including path coefficients, p -values, t -statistics, and 95% bias-corrected confidence intervals derived from bootstrapping.

As shown in Table 5 and illustrated in Figure 2, *MV* exerted a significant negative influence on the *NEP* (**H4**: $\beta = -0.253$, $p = 0.011$), confirming **H4** that stronger materialistic values correspond to lower pro-environmental beliefs. In contrast, *AV* (**H1**: $\beta = 0.176$, $p = 0.146$), *EV* (**H2**: $\beta = -0.068$, $p = 0.621$), and *TV* (**H3**: $\beta = 0.208$, $p = 0.050$) did not significantly predict *NEP*, indicating that **H1**, **H2**, and **H3** are not supported. These results suggest that participants' pro-environmental worldview is more strongly undermined by materialistic aspirations (*MV*) than shaped by *AV*, *EV*, or *TV*. The endorsement of a pro-environmental worldview, measured by *NEP*, did not significantly heighten awareness of the specific environmental consequences (*AC*) of mobile phone disposal (**H5**: $\beta = 0.178$, $p = 0.123$), and thus **H5** is not supported. *AC* emerged as a positive and significant predictor of *AR* (**H6**: $\beta = 0.247$, $p = 0.011$), confirming **H6**. *AR* strongly and positively influenced *PN* (**H7**: $\beta = 0.453$, $p = 0.000$), upholding **H7** by highlighting that a heightened sense of responsibility substantially fosters internal moral obligations. Moreover, *PN* exerted a

TABLE 4 | Discriminant validity.

	AC	AR	AV	EV	MV	NEP	PB	PN	PS	TV
AC										
AR	0.297									
AV	0.271	0.082								
EV	0.099	0.165	0.198							
MV	0.157	0.119	0.109	0.754						
NEP	0.266	0.152	0.429	0.180	0.382					
PB	0.282	0.268	0.209	0.232	0.197	0.145				
PN	0.635	0.535	0.359	0.165	0.141	0.574	0.277			
PS	0.342	0.643	0.158	0.421	0.278	0.358	0.548	0.535		
TV	0.166	0.184	0.728	0.389	0.170	0.412	0.133	0.312	0.105	

Note: Heterotrait-Monotrait ratio (= HTMT) is defined as the mean of all correlations of indicators across constructs measuring different constructs relative to the (geometric) mean of the average correlations of indicators measuring the same construct (Hair et al. 2021).

TABLE 5 | Assessment of collinearity issues and hypothesis testing.

Hypothesis	VIF	β	T-statistic	Testing criteria		p	Decision
				Confidence interval			
				2.50%	97.50%		
H1: $AV \rightarrow NEP$	1.789	0.176	1.454	-0.067	0.412	0.146	Not supported
H2: $EV \rightarrow NEP$	1.636	-0.068	0.494	-0.322	0.238	0.621	Not supported
H3: $TV \rightarrow NEP$	1.837	0.208	1.957	0.002	0.418	0.050	Not supported
H4: $MV \rightarrow NEP$	1.570	-0.253	2.533	-0.459	-0.066	0.011**	Supported
H5: $NEP \rightarrow AC$	1.000	0.178	1.542	-0.054	0.393	0.123	Not supported
H6: $AC \rightarrow AR$	1.000	0.247	2.534	0.058	0.445	0.011**	Supported
H7: $AR \rightarrow PN$	1.000	0.453	6.484	0.323	0.601	0.000***	Supported
H8: $PN \rightarrow EC$	Construct was dropped due to insufficient CR and AVE values						
H8: $PN \rightarrow PS$	1.000	0.394	5.218	0.260	0.560	0.000***	Supported
H8: $PN \rightarrow PB$	1.000	0.228	3.235	0.120	0.377	0.001***	Supported

Note: ** $p < 0.05$, *** $p < 0.01$.

Abbreviations: H, Hypothesis; β , Path Coefficient.

significant positive effect on *PS* (H8: $\beta = 0.394$, $p = 0.000$) and *PB* (H8: $\beta = 0.228$, $p = 0.001$), confirming H8 and underscoring the importance of internalized moral norms for public and individual pro-environmental engagement.

These findings highlight *MV* as the primary influence inhibiting pro-environmental beliefs, while *AV*, *EV*, and *TV* exert no significant direct effect. Conversely, *AC* plays a pivotal role in strengthening *AR*, which subsequently enhances *PN*. These *PN*, in turn, drive *PS* and encourage *PB*, emphasizing the crucial role of internal moral obligations in fostering sustainable mobile phone disposal practices. Therefore, addressing materialistic aspirations while reinforcing awareness and responsibility may offer a viable pathway toward more effective circular solutions in Ghana's e-waste context.

The model's explanatory power was next assessed by examining the coefficient of determination (R^2) and the effect sizes (f^2) (Hair et al. 2021). The R^2 value reflects the proportion of variance in an endogenous construct (e.g., *NEP*) explained by its predictor variables (e.g., *AV*, *EV*, *TV* and *MV*) (Shmueli and Koppius 2011). R^2 values range from 0 to 1, with higher values reflecting stronger explanatory power (Hair et al. 2011). However, R^2 tends to increase as more predictors are included, potentially overestimating the model's explanatory capacity. To mitigate this, the adjusted R^2 is calculated, correcting for the number of predictors relative to the sample size (Hair et al. 2021). As shown in Figure 2, adjusted R^2 values for *NEP* (0.170), *PN* (0.198), and *PS* (0.148) suggested a comparatively stronger level of explanatory power, whereas *AC* (0.023), *AR* (0.052), and *PB* (0.043) remained low (for detailed R^2 values and their interpretation see Appendix 3).

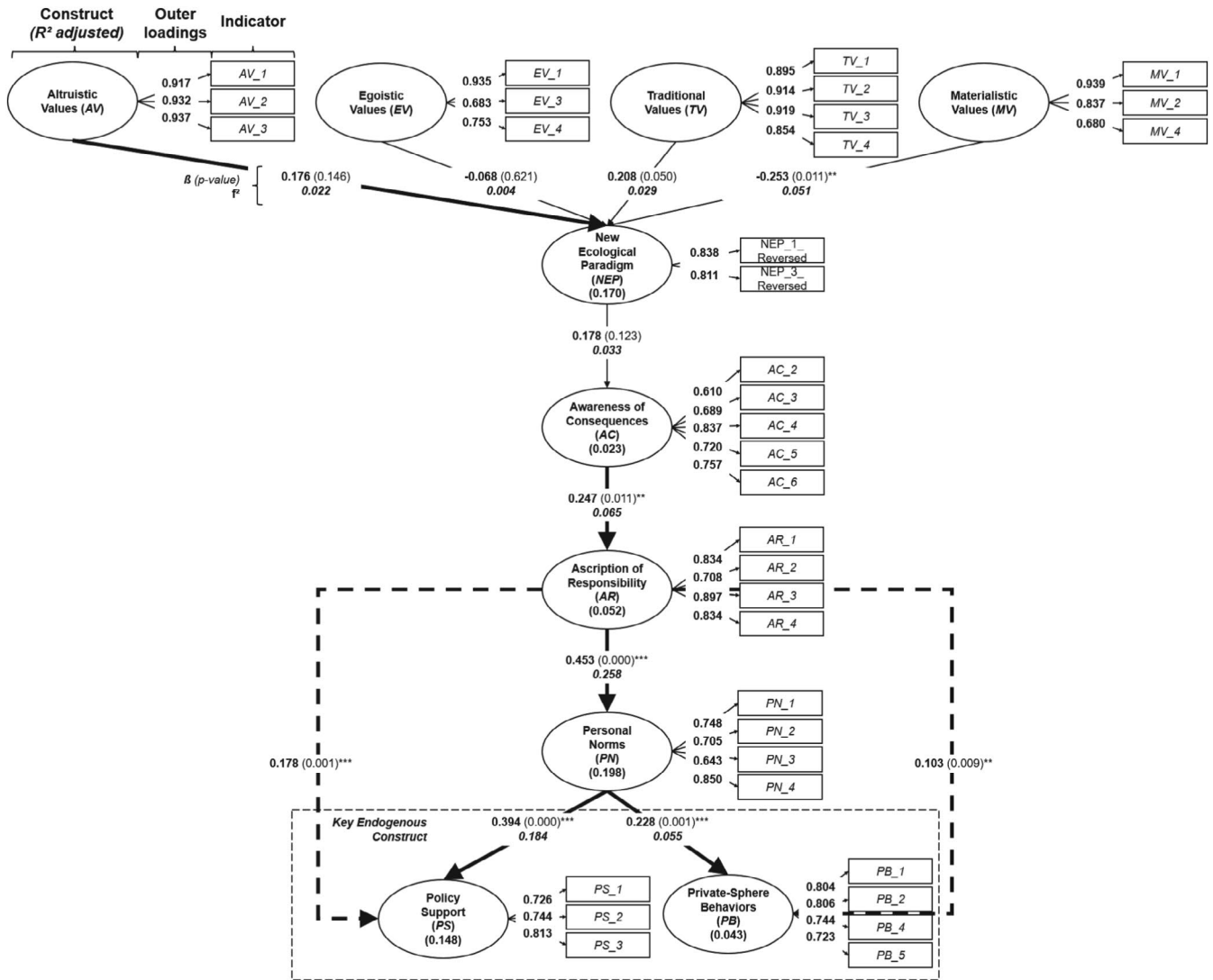


FIGURE 2 | Results of the structural model (** $p < 0.05$, *** $p < 0.01$).

The f^2 effect size provides deeper insight into the relative importance of individual predictors by quantifying how the removal of a specific predictor construct influences the explained variance of an endogenous construct, thereby clarifying each predictor's contribution to the model (Cohen 1988). According to Cohen (1988), f^2 values are categorized as small (≥ 0.02), medium (≥ 0.15), and large (≥ 0.35). These classifications allow for a more nuanced interpretation of the model's explanatory power by identifying which predictors contribute meaningfully to the variance explained. As shown in Figure 2, the path from AR to PN ($f^2 = 0.258$) and from PN to PS ($f^2 = 0.184$) exhibited medium effect sizes, underscoring their meaningful influence. Conversely, the path from EV to NEP showed a negligible effect ($f^2 = 0.004$), indicating minimal explanatory contribution. Other relationships demonstrate small effect sizes (for detailed f^2 values and their interpretation see Appendix 3).

Since R^2 values and f^2 effect sizes capture the model's in-sample explanatory power, they provide no insight into its ability to predict new data (Hair et al. 2021). Thus, assessing the model's predictive ability is essential for evaluating its forecasting potential, which was examined using out-of-sample prediction

via PLSpredict, focusing on the key endogenous constructs PS and PB (Shmueli et al. 2019). These constructs were selected as they represent the measurable outcomes of pro-environmental engagement, aligning directly with the study's objective of examining how personal norms drive environmental actions. First, Q^2 predict values were calculated to determine predictive relevance. A Q^2 predict value ≤ 0 indicates that the model fails to outperform the naïve benchmark that solely relies on the mean value derived from the training sample, which is the subset of data used to estimate the model's parameters. Consequently, constructs with such Q^2 predict values are considered irrelevant for further predictive evaluation, as the model fails to provide added forecasting value over this simple approach. For indicators with Q^2 predict > 0 , further evaluation focuses on root-mean-square error (RMSE) values. The RMSE measures the average deviation of predicted values from actual observations, where lower RMSE values indicate higher predictive accuracy. In the PLSpredict method, these RMSE values are compared to a linear regression model (LM) benchmark, which serves as a simplified baseline for prediction (Danks and Ray 2018). If the PLS-SEM RMSE is lower than the LM RMSE, the model outperforms the benchmark, indicating effective use of structural

TABLE 6 | PLSpredict results.

Key construct	Q ² predict	PLS-SEM RMSE	LM-RMSE	Predictive relevance
PS_1	0.001	1.037	1.090	Yes
PS_2	0.001	0.988	1.074	Yes
PS_3	0.001	1.043	1.112	Yes
PB_1	0.000			Not analyzed as Q ² predict value ≤ 0
PB_2	0.001	0.141	1.216	Yes
PB_3	0.000			Not analyzed as Q ² predict value ≤ 0
PB_5	0.000			Not analyzed as Q ² predict value ≤ 0

TABLE 7 | Mediating effects.

Path	β	T-statistic	Confidence interval		p	Outcome
			2.50%	97.50%		
AR → PN → PS	0.178	3.327	0.072	0.284	0.001***	+√
AR → PN → PB	0.103	2.599	0.025	0.181	0.009**	+√

Note: ** $p < 0.05$, *** $p < 0.01$. +√ = positive partial mediation.

relationships for prediction. Higher PLS-SEM RMSE values suggest overfitting, misspecification, or weak predictive relationships (Shmueli et al. 2019).

As shown in Table 6, *PS* demonstrated medium predictive relevance with all three indicators (*PS_1*, *PS_2*, and *PS_3*) yielding positive Q²predict values (0.001) and RMSE values lower than the LM benchmark (Hair et al. 2022). In contrast, *PB* showed limited predictive ability, as only one indicator (*PB_2*) had a positive Q²predict value (0.001). While *PB_2* achieved an RMSE (0.141) below the LM benchmark (1.216), the other indicators (*PB_1*, *PB_3*, *PB_5*) had Q²predict values of 0, indicating no predictive relevance and precluding further evaluation. This suggests that while the model exhibits higher predictive relevance for *PS*, its ability to predict *PB* appears to be weaker. This finding highlights the need for further refinement of constructs influencing *PB* to enhance its predictive capacity.

3.5 | Mediating Effects

While the direct effects analysis (see Table 5) assessed the direct relationships between constructs, mediation analysis was conducted to explore the indirect pathways through which variables influence pro-environmental behavior (Nitzl et al. 2016). Drawing on empirical insights from prior studies that highlight the mediating role of *PN* in linking antecedent variables to pro-environmental actions (Chen 2015; Kim and Seock 2019; Naatu et al. 2024; Obuobi et al. 2022), this study concentrated on *PN* as a bridge between *AR* and subsequent outcomes such as *PS* and *PB*. This targeted focus was both methodologically prudent and theoretically justified, as analyzing all potential mediation paths would have introduced unnecessary complexity and increased the risk of multiple testing errors, thereby obscuring key relationships. Consistent with the direct effects assessment, the

significance of mediation was determined using bootstrapping procedures with 10,000 subsamples. Indirect effects were considered statistically significant if their *t*-values exceeded 1.96, the 95% confidence intervals did not include zero, and the *p*-values were below 0.05 (Hair et al. 2021). As presented in Table 7 and illustrated in Figure 2, *AR* exerted a positive significant indirect influence on *PS* through *PN* ($\beta = 0.178$, $p = 0.001$), while also indirectly and positively influencing *PB* through the same mediator ($\beta = 0.103$, $p = 0.009$). These mediations are classified as positive partial mediations, as the mediator, *PN*, partially accounts for the relationship between the independent and dependent variables, with both direct (see Table 5) and indirect effects being significant and positively aligned (Nitzl et al. 2016). This underscores the pivotal role of *PN* in translating responsibility into concrete actions. Therefore, fostering stronger personal norms could make people be more likely to align their actions with their values, leading to more consistent support for pro-environmental practices and policies. This process could help bridge the gap between responsibility and action, making pro-environmental behaviors a natural outcome of heightened awareness and responsibility.

4 | Discussion

In the following, the key factors influencing pro-environmental behavior are identified, followed by the derivation of actionable strategies to enhance its adoption, thereby addressing the research questions outlined in Section 1.

4.1 | Theoretical Implications

Addressing the first research question, this study investigated which psychological and contextual factors drive or inhibit

consumer engagement in circular disposal practices for mobile phones in Ghana. The findings contribute to this question by confirming the relevance of *MV*, *AC*, and *AR* as key influencing factors of pro-environmental norms and behavior. Among these, *MV* emerged as the primary inhibiting factor, demonstrating a significant negative relationship with the *NEP* ($\beta = -0.253$, $p = 0.011$, see Table 5). This reinforces prior evidence of the inherent conflict between materialism and pro-environmental worldviews (Hurst et al. 2013; Kilbourne and Pickett 2008). The results align with the findings of Kilbourne and Pickett (2008) and Nepomuceno and Laroche (2015), demonstrating that in contexts where consumer goods, such as mobile phones, hold strong symbolic value or are associated with social status, materialistic aspirations may take precedence over environmental considerations, thereby reducing the likelihood of sustainable disposal behaviors. While the original model by Stern et al. (1999) does not explicitly account for *MV*, their inclusion extends its explanatory power, highlighting the necessity of adapting behavioral theories for e-waste management in Global South contexts.

The study confirmed a significant positive relationship between *AC* and *AR* ($\beta = 0.247$, $p = 0.011$), which is in line with the VBN's assertion that awareness of environmental consequences drives a sense of responsibility (Stern et al. 1999). This correlation indicates that individuals who recognize the environmental consequences of improper mobile phone disposal are more likely to internalize a sense of personal responsibility for mitigating these impacts, which is consistent with prior studies in the Ghanaian context (Naatu et al. 2024; Obuobi et al. 2022).

Furthermore, *AR* emerged as a pivotal factor influencing pro-environmental behavior, demonstrated by its strong and positive impact on *PN* ($\beta = 0.453$, $p = 0.000$). This highlights the critical role of perceived responsibility in shaping internalized moral obligations, as observed in related studies focusing on developing countries (Banunle 2025; Muposhi et al. 2021; Obuobi et al. 2022).

In addition, the results revealed significant positive effects of *PN* on both *PS* ($\beta = 0.394$, $p = 0.000$) and *PB* ($\beta = 0.228$, $p = 0.001$), highlighting the critical role of *PN* in driving pro-environmental behavior. The results of the mediation analysis (see Section 3.5) further reinforced the central role of *PN* in translating perceived responsibility into action. The strong positive influence of *PN* on *PS* suggests that individuals who internalize a moral obligation to act are more likely to endorse systemic changes, such as accepting and adhering to environmental policies that may require personal sacrifices, such as higher taxes and stricter regulations (Stern et al. 1999). This finding also corresponds to other pro-environmental studies from Denley et al. (2020), Landon et al. (2018), and Naatu et al. (2024). Similarly, the impact of *PN* on *PB* illustrates the importance of fostering everyday sustainable practices, even in the face of economic or infrastructural barriers. This is consistent with existing studies such as Landon et al. (2018), Liao and Yang (2022), and Kim and Seock (2019).

However, the moderate effect sizes observed in this study suggest that while the VBN theory captures key normative influences, it may not fully account for the economic and structural constraints shaping disposal behavior in informal waste economies. Given the prominence of financial limitations and social

pressures in such contexts, pro-environmental intentions may not always translate into action. This raises the need to refine behavioral models for e-waste management in resource-constrained settings, potentially by integrating economic and contextual variables to better reflect the realities of informal waste economies.

In sum, this study addresses the first research question by integrating and identifying *MV* as a key psychological barrier to circular disposal behavior and confirms the enabling role of *AC* and *AR* in shaping pro-environmental norms. Furthermore, the findings highlight the pivotal role of *PN* in translating internalized responsibility into both *PS* and *PB*, reinforcing the central mechanism proposed by the VBN framework. While the model proved applicable in the Ghanaian context, the results also underscore the need to account for structural constraints when modeling circular behavior in informal e-waste settings.

4.2 | Practical Implications

Addressing the second research question, this section identifies concrete interventions and business model opportunities to enhance the adoption of circular mobile phone disposal practices in Ghana.

First, addressing the strong inhibiting influence of *MV* requires a combination of consumer-focused and policy-driven interventions. Consumer-focused interventions should reframe sustainable behaviors as aspirational actions by presenting them as innovative and environmentally responsible choices (Hurst et al. 2013). Furthermore, transparency, warranties, and clear communication of economic advantages are essential for building consumer trust and shifting perceptions (Mahmoodi and Heydari 2021). Policy-driven measures, such as limiting advertisements that promote frequent consumption, can also help reduce social pressure to upgrade devices.

Second, the findings highlighted that strengthening *AR* is critical, as it plays a central role in reinforcing *PN*, which in turn drives pro-environmental behavior. To enhance *AR*, collaboration between governments, manufacturers, and service providers is essential. The Extended Producer Responsibility (EPR) framework serves as a prominent example of such partnership-driven approaches (Oteng-Ababio 2010), by holding producers accountable for the environmental impact of their products throughout their lifecycle. By implementing take-back schemes, deposit-refund systems, and reducing hazardous materials in production, EPR fosters a sense of shared responsibility and offers consumers structured options for sustainable disposal (Daum et al. 2017).

Third, the study highlighted the importance of linking individual awareness to broader environmental outcomes. This can be achieved through educational campaigns and community-based initiatives that explicitly link individual actions to broader environmental consequences, such as pollution and resource depletion, reinforcing personal awareness for disposal practices (Naatu et al. 2024; Oteng-Ababio 2010).

However, the persistence of structural barriers, such as limited access to formal disposal channels, suggests that behavioral

motivation alone may not be sufficient (Bimpong et al. 2023). In this study, respondents demonstrated strong normative motivation, as reflected in a high mean score for *PN* ($M=3.68$). Yet, actual engagement in formalized pro-environmental practices appears limited, with lower means reported for *PB* ($M=2.15$), *PS* ($M=2.78$), and *EC* ($M=0.42$). This discrepancy, which is further underscored by the moderate effect sizes observed in the model, indicates a gap between intention and action. Addressing this implementation gap requires systemic solutions, particularly from formal market actors, as individual behavioral change alone is often insufficient in the absence of enabling market structures and institutional support (Daum et al. 2017). This presents a strategic entry point for businesses to intervene by offering formalized collection schemes that offer fixed, transparent payments above informal market rates, for instance, by paying users a guaranteed amount per returned phone based on material recovery value rather than haggled scrap prices. Recent pilot programs in Ghana have shown that monetary incentives increase return rates, especially when combined with convenience and professional service delivery (Manhart et al. 2024). Embedding such schemes within trusted retail environments, such as certified electronics shops, can further boost uptake by offering reliable data deletion, verifiable transactions, and visible brand accountability, which are often missing in informal systems (Asibey et al. 2022; Oteng-Ababio 2010). This not only enhances consumer trust but also facilitates traceable resource recovery and value creation, enabling companies to secure valuable materials such as cobalt, copper, and rare earth elements. In parallel, public-private partnerships could link these commercial mechanisms with broader infrastructure and policy efforts, for example, by co-funding collection points or standardizing quality and safety procedures across actors. In this sense, circular business models offer a strategic opportunity to create shared value, defined as the simultaneous pursuit of economic success and positive societal outcomes (Porter and Kramer 2011). By aligning profitability with environmental and social benefits, such models help build inclusive market systems that are both commercially viable and beneficial to society (Schaltegger et al. 2012).

In summary, enhancing circular mobile phone disposal in Ghana requires a combination of consumer-focused and policy-driven interventions to reduce *MV*, strengthen *AC* and *AR*, and link individual behavior to environmental outcomes. Given persistent structural barriers, business-led solutions, such as formalized, incentive-based collection schemes, offer a strategic entry point. When embedded in trusted environments and supported through public-private partnerships, these models can foster consumer trust, enable traceable resource recovery, and create shared value by aligning economic success with positive societal and environmental impact.

4.3 | Limitations

Despite its theoretical and practical contributions, this study has limitations.

First, the use of convenience and snowball sampling may limit the generalizability of the findings, as participants were not randomly selected. In addition, the sample was disproportionately composed of highly educated male respondents, introducing potential demographic bias in the observed relationships.

Second, the study relies on self-reported survey data, which may be subject to response biases. While several ex-ante procedural controls were implemented to reduce common method bias (see Section 2.2), it cannot be entirely ruled out. Moreover, the behavioral constructs reflect stated intentions rather than actual behavior, which may lead to overestimations of pro-environmental engagement.

Third, although the sample size of 110 respondents meets the commonly applied “10-times rule” for PLS-SEM (Hair et al. 2011), it limits the ability to detect smaller effects. Based on the inverse square root method (Hair et al. 2022; Kock and Hadaya 2018), detecting path coefficients below 0.15 with sufficient statistical power would require sample sizes of 250 or more. This means that while medium-sized effects were reliably tested, weaker relationships may have gone undetected. Future studies should consider larger and more diverse samples to explore subtler dynamics within the model.

Finally, although the VBN model proved applicable to the Ghanaian context, the country’s distinct cultural norms, regulatory structures, and infrastructural conditions may limit the generalizability of the findings to other regions in the Global South. Moreover, the moderate effect sizes observed in key paths indicate that the VBN framework alone may not fully capture the complexity of disposal behavior in informal e-waste settings, where decisions are often shaped not only by norms and values, but also by material constraints and limited alternatives.

4.4 | Future Research Opportunities

Building on these limitations, future research should employ more representative sampling strategies and conduct cross-country comparisons to assess the transferability of normative models across diverse socioeconomic contexts. Integrating additional predictors, such as perceived behavioral control, economic constraints, or infrastructure access, could enhance the explanatory power and understanding of informal e-waste systems. Longitudinal or mixed-method designs may further clarify the gap between stated intentions and actual disposal behavior. Finally, hybrid frameworks that combine normative and instrumental drivers offer promising avenues for capturing the complexity of e-waste decisions in the Global South.

5 | Conclusion

This study advances the application of behavioral theories in resource-constrained settings by applying the VBN theory by Stern et al. (1999) to examine mobile phone disposal behavior in Ghana. The findings confirmed that *MV* inhibit pro-environmental beliefs, reinforcing the conflict between material aspirations and ecological concern. In contrast, *AC* strengthened *AR*, which in turn played a critical role in shaping *PN*, a key driver of *PS* and *PB*. The mediation analysis further highlighted *PN* as a central mechanism translating perceived responsibility into sustainable actions. These findings underscore the need for targeted interventions that address both psychological and structural barriers to sustainable mobile phone disposal. Effective strategies include consumer campaigns, educational initiatives, and policy tools such as EPR to

establish structured and accessible systems. In addition, the study highlights opportunities for circular business models, including fixed, incentive-based collection schemes and cross-sector collaborations that harness consumers' normative motivations. By pursuing these approaches, businesses can reduce environmental harm,

secure valuable secondary raw materials, and build trust while reaching underserved markets, ultimately positioning circularity as a business-driven catalyst for inclusive and sustainable market development.

Nomenclature

Construct	Definition in the context of this study	Measurement indicators
Altruistic Values (AV)	AV emphasize responsibility for the well-being of others, including both humans and the environment, and are linked to a moral obligation to minimize negative environmental impacts Bouman et al. (2020); Steg et al. (2014). Individuals with strong AV are more likely to adopt an ecological worldview and prioritize sustainable decisions, driven by a perceived duty to protect the environment for future generations Naatu et al. (2024); Stern et al. (1999). In this study, AV reflect the ethical responsibility of individuals to dispose of used mobile phones through environmentally friendly means, such as recycling or proper disposal channels	AV1: Preventing pollution, conserving natural resources AV2: Respecting the earth, harmony with other species AV3: Protecting the environment, preserving nature
Egoistic Values (EV)	EV prioritize personal benefit and material gain, which can sometimes conflict with pro-environmental behavior Steg et al. (2014); Stern et al. (1999). Research suggests that individuals with strong EV are less likely to recognize environmental consequences (AC), as sustainability initiatives may be perceived as opposing personal interests de Groot and Steg (2008); Stern et al. (1999). In Ghana, EV may influence mobile phone disposal decisions, leading individuals to weigh economic considerations, such as resale value, alongside environmental concerns	EV1: Social power, control over others, dominance EV2: Influential, having an impact on people and events EV3: Wealth, material possessions, money EV4: Authority, the right to lead or command
Traditional Values (TV)	TV emphasize stability, family cohesion, and adherence to cultural norms, reinforcing established mobile phone disposal practices Schwartz (2012); Stern et al. (1999). Within the VBN framework, TV may hinder sustainable disposal behavior when existing norms conflict with the shifts required for more environmentally responsible actions Awais et al. (2022). In Ghana, social expectations and family obligations may shape how used devices are handled, potentially encouraging practices such as passing them down within the family or selling them through informal channels rather than utilizing formal recycling systems	TV1: True friendship, close supportive friends TV2: Self-discipline, self-restraint, resistance to temptations TV3: Family security, safety for loved ones TV4: Honest, genuine, sincere forgiving, willing to pardon others

Construct	Definition in the context of this study	Measurement indicators
Materialistic Values (MV)	<p>MV emphasize possessions and social status, influencing both purchasing and disposal behaviors. While not originally included in Stern et al.'s (1999) model, pre-study interviews revealed that brand prestige and status significantly shape mobile phone choices in Ghana, potentially discouraging sustainable disposal practices such as repairs or purchasing refurbished devices. Empirical findings on materialism and sustainability remain mixed—some studies suggest it fosters environmentally friendly purchases, while others indicate a negative correlation when sustainability requires reduced consumption or personal sacrifice Gomes et al. (2022); Hurst et al. (2013); Stern et al. (1995). These contradictions underscore the nuanced role of MV in shaping pro-environmental attitudes, particularly in Global South contexts Hurst et al. (2013)</p>	<p>MV1: The things I own say a lot about how well I'm doing in life</p> <p>MV2: I like to own things that impress people</p> <p>MV3: I try to keep my life simple, as far as possessions are concerned*</p> <p>MV4: I'd be happier if I could afford to buy more things</p>
New Ecological Paradigm (NEP)	<p>The NEP measures environmental attitudes, assessing individuals' awareness of ecosystem fragility and the need for sustainable practices. In this study, it examines how Ghanaian consumers perceive the environmental consequences of improper mobile phone disposal. Typically assessed using the NEP scale developed by Dunlap and van Liere (1978) Dunlap et al. (2000), the NEP reflects the perceived connection between human actions and ecological limits. Research suggests that stronger endorsement of the NEP is linked to greater awareness of consequences (AC), reinforcing environmental responsibility and pro-sustainability behavior Stern et al. (1999)</p>	<p>NEP1: The so-called "ecological crisis" facing humankind has been greatly exaggerated*</p> <p>NEP2: The earth is like a spaceship with limited room and resources. If things continue on their present course, we will soon experience a major ecological catastrophe</p> <p>NEP3: The balance of nature is strong enough to cope with the impacts of modern industrial nations*</p> <p>NEP4: Humans are severely abusing the environment</p>
Awareness of Consequences (AC)	<p>Within the VBN framework, AC refers to an individual's awareness of the environmental and health consequences of their actions, particularly their impact on valued entities, other people, and the biosphere Stern et al. (1999). Research suggests that this awareness can foster a sense of responsibility for mitigating environmental harm Naatu et al. (2024). In the context of mobile phone disposal in Ghana, AC may encourage individuals to engage in more sustainable disposal practices</p>	<p>AC1: Improper disposal of electronic scrap/waste significantly contributes to environmental and health hazards for me and my family</p> <p>AC2: The increasing amount of electronic scrap/waste is a serious problem for society as a whole</p> <p>AC3: Improper disposal of mobile phones contributes significantly to environmental degradation</p> <p>AC4: Recycling mobile phones helps reduce environmental pollution and conserves natural resources</p> <p>AC5: Extending the life-cycle of mobile phones through repair or resale improves environmental quality</p> <p>AC6: The continuous release of toxic substances from improper disposal/recycling of electronic scrap/waste will be a serious problem for the environment and biodiversity</p>

Construct	Definition in the context of this study	Measurement indicators
Ascription of Responsibility (AR)	<p>AR reflects the belief that one's actions contribute to environmental harm and that individuals have a moral obligation to mitigate these impacts Stern et al. (1999). It mediates the relationship between AC and PN, transforming the recognition of environmental harm into a sense of personal accountability Schwartz (1977). In the context of this study, AR assesses the extent to which individuals take responsibility for the sustainable disposal of mobile phones</p>	<p>AR1: I feel jointly responsible for the environmental problems caused by the improper disposal of mobile phones.</p> <p>AR2: I feel jointly responsible for disposing my used mobile phone in an environmentally sound way</p> <p>AR3: I feel jointly responsible for health problems caused by the improper disposal of mobile phones</p> <p>AR4: Not only governments and industries are responsible for the rising amount of mobile phone waste, but me too</p>
Personal Norms (PN)	<p>PN are internalized moral obligations that motivate individuals to act in line with their environmental values and beliefs Schwartz (1977); Stern et al. (1999). Within the VBN theory, PN are activated through AC and AR, making them a key driver of pro-environmental behavior. In the context of mobile phone disposal in Ghana, PN reflect the ethical commitment of consumers to properly dispose of or recycle their devices rather than relying on informal, environmentally harmful disposal methods</p>	<p>PN1: I feel a personal obligation to reduce the amount of electronic scrap/waste, especially from disposed mobile phones</p> <p>PN2: The government should take stronger action to ensure responsible recycling and disposal of mobile phones</p> <p>PN3: Companies in the mobile industry should adopt and promote practices like repairing, reprocessing, and recycling to minimize electronic scrap/waste</p> <p>PN4: Regardless of what others do, I feel morally obligated to properly dispose of or recycle old mobile phones</p>
Environmental Citizenship (EC)	<p>EC refers to non-activist behaviors that support environmental protection, such as boycotting environmentally harmful companies or supporting businesses with sustainable practices Stern et al. (1999). In the context of mobile phone disposal in Ghana, EC can involve choosing brands that offer recycling programs, advocating for responsible e-waste management, or encouraging peers to adopt sustainable practices</p>	<p>EC1: In the last 12 months, have you boycotted or avoided buying products from a company because you believed it contributed to electronic scrap/waste or environmental harm through improper disposal practices?</p> <p>EC2: In the last 12 months, have you spoken well of a company because it strongly supports environmental protection and responsible disposal of electronic scrap/waste?</p> <p>EC3: Do you feel the environmental movement, which promotes recycling, reduces pollution, and conserves resources, does great good and deserves strong support, or does it do more harm and deserve strong opposition?</p>
Policy Support (PS)	<p>PS serves as an indicator of public acceptance of systemic environmental policies and the perceived necessity of regulatory action to address e-waste challenges Stern et al. (1999). PN can influence PS, as individuals with strong moral obligations toward sustainability are more likely to support such measures. In the context of this study, this may include endorsing stricter e-waste regulations, higher taxes on electronics lacking sustainable end-of-life solutions, or producer responsibility mandates for take-back programs</p>	<p>PS1: I would be willing to pay higher taxes to support environmental friendly electronic scrap/waste practices</p> <p>PS2: I would be willing to accept a lower standard of living (e.g., buying used or refurbished phones) to reduce electronic scrap/waste</p> <p>PS3: I would be willing to pay higher prices for mobile phones from companies committed to environmental protection</p>

Construct	Definition in the context of this study	Measurement indicators
Private-Sphere Behaviors (PB)	<p>PB encompass everyday behaviors that reduce an individual's environmental footprint through actions such as recycling mobile phones, repairing devices, or purchasing refurbished phones Stern et al. (1999). PN play a key role in shaping PB by providing the moral framework that translates awareness and responsibility into concrete pro-environmental actions.</p> <p>In Ghana, where formal recycling infrastructure is limited, PB may include alternative sustainable practices such as selling old phones to certified recyclers, donating functional devices, or participating in manufacturer-led take-back programs. These actions help mitigate e-waste and resource depletion while reducing the environmental impact of mobile phone disposal</p>	<p>PB1: When buying a mobile phone, do you make a special effort to choose refurbished or second-hand devices to reduce electronic scrap/waste?</p> <p>PB2: Do you make a special effort to recycle or properly dispose of your old mobile phones?</p> <p>PB3: Do you avoid buying mobile phones from companies known for contributing to electronic scrap/waste or poor environmental practices?</p> <p>PB4: Do you choose to repair your mobile phone rather than replace it with a new one?</p> <p>PB5: Do you participate in trade-in or recycling programs ('swapping') for your old mobile phones?</p>

* Reverse coded measurement item.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data will be made available on reasonable request.

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TABLE A1 | Non-response bias results.

Construct	Variances assumption	Levene's test for equality of variances		t-test for equality of means		Outcome
		F	P	T	Two-sided p	
AV	Equal	0.196	0.659	-1.000	0.319	Not significant
	Not equal			-1.009	0.316	Not significant
EV	Equal	0.040	0.842	-0.761	0.448	Not significant
	Not equal			-0.755	0.453	Not significant
TV	Equal	0.001	0.969	-0.170	0.865	Not significant
	Not equal			-0.170	0.866	Not significant
MV	Equal	0.003	0.953	-1.014	0.313	Not significant
	Not equal			-1.003	0.319	Not significant
NEP	Equal	0.097	0.756	0.912	0.364	Not significant
	Not equal			0.888	0.378	Not significant
AC	Equal	6.299	0.014	-0.952	0.343	Not significant
	Not equal			-1.101	0.273	Not significant
AR	Equal	10.896	0.001	-1.926	0.057	Not significant
	Not equal			-2.201	0.030**	Significant
PN	Equal	0.559	0.456	-0.324	0.747	Not significant
	Not equal			-0.346	0.730	Not significant
EC	Equal	1.766	0.187	1.342	0.182	Not significant
	Not equal			1.396	0.166	Not significant
PS	Equal	2.594	0.110	0.011	0.991	Not significant
	Not equal			0.010	0.992	Not significant
PB	Equal	3.536	0.063	-1.956	0.053	Not significant
	Not equal			-1.848	0.069	Not significant

Note: **p < 0.05, ***p < 0.01.

TABLE A2 | Common method bias results.

Hypothesis	VIF
H1: AV → NEP	1.798
H2: EV → NEP	1.422
H3: TV → NEP	1.815
H4: MV → NEP	1.431
H5: NEP → AC	1.000
H6: AC → AR	1.000
H7: AR → PN	1.000
H8: PN → EC	1.000
H8: PN → PS	1.000
H8: PN → PB	1.000

Abbreviation: H, Hypothesis.

Non-response bias occurs when respondents and non-respondents differ systematically in key attributes, potentially distorting conclusions and compromising the reliability of findings (Berg 2005; Sax et al. 2003). Identifying and addressing such biases is essential to ensure the credibility and generalizability of the results. In this study, early respondents (i.e., those participating in the first week) were compared with late respondents (i.e., those participating in the final week) using Levene's Test as well as independent *t*-tests at the 5% significance level to assess potential non-response bias (Johnson et al. 2000; Lohr et al. 2016). The underlying assumption is that individuals who respond later (i.e., only after reminders) are more similar to those who never respond at all, as they are former non-respondents (Studer et al. 2013). The findings revealed a significant difference for the construct AR ($p = 0.001$), indicating the presence of non-response bias. No significant differences were observed for the remaining constructs (see Table A1).

To address CMB, the bias that arises when observed relationships reflect the measurement method rather than the underlying latent constructs (Kock 2017), a full collinearity test was performed. In contrast to Harman's single-factor test that only analyses whether one dominant

factor explains the majority of variance and therefore does not distinguish between vertical and lateral collinearity, the full collinearity test, proposed by Kock and Lynn (2012), evaluates both vertical and lateral collinearity via variance inflation factors (vifs) (Fuller et al. 2016). A VIF exceeding 3.3 indicates potentially problematic collinearity and

possible CMB contamination (Kock 2017). As shown in Table A2, the highest VIF recorded in the model is 1.815, which falls well below the critical threshold. This result indicates that collinearity or CMB concerns do not play a role, reinforcing the reliability and validity of the subsequent analyses.

Appendix 2

Construct Validity and Reliability Prior to Removal of Items EV_2, MV_3_Reversed, NEP_2, NEP_4, AC_1, EC_1, EC_2, EC_3, and PB_4

Construct	Items	Outer loadings	CR	AVE
Altruistic values	AV_1	0.917 (0.920)	0.950 (0.950)	0.863 (0.864)
	AV_2	0.932 (0.930)		
	AV_3	0.937 (0.938)		
Egoistic values	EV_1	0.935 (0.896)	0.837 (0.690)	0.636 (0.422)
	EV_2	-(0.047)		
	EV_3	0.683 (0.692)		
	EV_4	0.753 (0.697)		
Traditional values	TV_1	0.895 (0.897)	0.942 (0.942)	0.803 (0.803)
	TV_2	0.914 (0.914)		
	TV_3	0.919 (0.918)		
	TV_4	0.854 (0.853)		
Materialistic values	MV_1	0.939 (0.896)	0.864 (0.760)	0.682 (0.479)
	MV_2	0.837 (0.795)		
	MV_3_Reversed	-(0.216)		
	MV_4	0.680 (0.660)		
New ecological paradigm	NEP_1_Reversed	0.836 (0.794)	0.810 (0.604)	0.680 (0.341)
	NEP_2	-(0.309)		
	NEP_3_Reversed	0.813 (0.793)		
	NEP_4	-(0.107)		
Awareness of consequences	AC_1	0.579 (0.584)	0.854 (0.856)	0.497 (0.499)
	AC_2	0.671 (0.684)		
	AC_3	0.702 (0.696)		
	AC_4	0.812 (0.813)		
	AC_5	0.700 (0.700)		
	AC_6	0.745 (0.742)		
Ascription of responsibility	AR_1	0.836 (0.836)	0.892 (0.892)	0.674 (0.674)
	AR_2	0.708 (0.708)		
	AR_3	0.897 (0.897)		
	AR_4	0.833 (0.833)		
Personal norms	PN_1	0.778 (0.778)	0.823 (0.823)	0.541 (0.541)
	PN_2	0.680 (0.679)		
	PN_3	0.616 (0.615)		
	PN_4	0.847 (0.847)		

Construct	Items	Outer loadings	CR	AVE
Environmental citizenship	EC_1	0.531 (0.531)	0.642 (0.642)	0.388 (0.388)
	EC_2	0.468 (0.469)		
	EC_3	0.814 (0.814)		
Policy support	PS_1	0.724 (0.772)	0.806 (0.816)	0.581 (0.581)
	PS_2	0.743 (0.742)		
	PS_3	0.816 (0.802)		
Private-sphere behaviors	PB_1	0.806 (0.808)	0.859 (0.834)	0.605 (0.513)
	PB_2	0.803 (0.804)		
	PB_3	0.778 (0.781)		
	PB_4	-(0.392)		
	PB_5	0.720 (0.708)		

Note: Composite Reliability = CR and Average Variance Extracted = AVE. Values in parentheses reflect the original model before item removal. Reported values show the re-estimated model after excluding items with outer loadings smaller than 0.40 (*EV_2*, *MV_3_Reversed*, *NEP_2*, *NEP_4*, *PB_4*).

Appendix 3

Explanatory Power and Effect Sizes

Exogenous construct	Endogenous construct	R ² adjusted	Explanatory power	f ²	Effect
AV	NEP	0.170	Moderate	0.022	Small
EV	NEP			0.004	Negligible
TV	NEP			0.029	Small
MV	NEP			0.051	Small
NEP	AC	0.023	Low	0.033	Small
AC	AR	0.052	Low	0.065	Small
AR	PN	0.198	Moderate	0.258	Medium
PN	PS	0.148	Moderate	0.184	Medium
PN	PB	0.043	Low	0.055	Small