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From Awareness to Action: Examining the Role of Circular Awareness in Shaping Circular Practices at Residence in the Indian Context

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Abstract

The circular economy (CE) paradigm has emerged as a crucial framework for achieving environmental sustainability by minimizing resource use, extending product life cycles, and promoting regenerative consumption systems. While institutional and industrial applications of CE have gained prominence, the role of individual behavior—particularly at the household level—remains underexplored in the Indian context. This study investigates the relationship between circular economy awareness and the adoption of circular practices in residential settings, using data collected from a cross-sectional survey of 400 respondents across India.

Employing a multi-stage analytical strategy comprising Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM), the study identifies four latent dimensions of circular behavior at home: Circular Purchasing and Awareness Behavior (CPAB), Sustainable and Active Living (SAL), Waste Segregation and Recycling (WSR), and Energy and Resource Conservation (ERC). Circular awareness, conceptualized as a unidimensional construct, was found to be a significant and positive predictor of engagement in all four behavioral domains. Among demographic variables, age and educational attainment emerged as significant predictors of circular behavior, whereas income, occupation, and residence type showed no statistical association.

The findings underscore the critical role of circular awareness as a cognitive enabler of pro-environmental behavior and offer empirical support to theoretical models such as the Theory of Planned Behavior and the Value-Belief-Norm framework. By validating a context-specific model of household circularity, the study contributes to the growing literature on individual-level sustainability transitions in the developing economies. The research offers practical insights for designing public engagement initiatives and policy measures aimed at embedding circular economy principles more deeply within everyday practices.

Keywords: Circular Economy, Circular Awareness, Circular Practices at Residence, Sustainable Household Practices, Pro-Environmental Behavior, Structure Equation Modelling, India

1. Introduction

The concept of the circular economy (CE) has emerged as a foundational principle in addressing global sustainability challenges. Rooted in regenerative and restorative design, the circular economy aims to decouple economic growth from resource consumption by promoting reuse, recycling, repair, and sustainable production-consumption loops (Kirchherr et al., 2017)(Ellen Macarthur Foundation & European Commission, 2020). The circular economy represents a shift away from the traditional linear model of "take, make, dispose" towards a more sustainable system in which resource loops are closed, waste is minimized, and environmental impacts are reduced.

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As nations increasingly adopt circular strategies, individual behavior has come to be recognized as a critical enabler of circular transitions (Manninen et al., 2018). Achieving these national-level circular economy goals, however, ultimately depends on widespread behavioral shifts across multiple scales, including communities, businesses, and individual households. Residential environments play a significant role in material consumption and waste generation, thereby serving as key sites for embedding circular practices (Hobson, 2020). From purchasing decisions and energy use to waste segregation and recycling behavior, households contribute significantly to the broader sustainability outcomes of a nation. A critical precursor to such behavior is circular awareness—the understanding of circular economy principles and the perceived relevance of sustainability in daily life. While awareness is widely acknowledged as a foundational step toward behavior change, the literature reveals a persistent gap between awareness and action (Kollmuss & Agyeman, 2002; Nguyen et al., 2024). Factors such as habit, convenience, infrastructure, and socio-cultural norms often mediate this relationship, making it imperative to study how awareness translates into concrete household-level practices.

While circular transitions are gaining momentum globally, the specific challenges and opportunities vary across national contexts, necessitating localized strategies tailored to socio-economic and cultural realities. In the context of India—where rising urbanization, growing middle-class consumption, and mounting waste challenges converge—transitioning to circular practices at the household level is both a necessity and an opportunity(Talwar et al., 2021). Recognizing the potential economic and environmental gains from circularity, India has initiated policy dialogues and pilot interventions in sectors such as plastics management, e-waste recycling, construction and demolition waste, and resource efficiency in manufacturing. Initiatives like the Plastic Waste Management Rules (2016), the Extended Producer Responsibility (EPR) framework for e-waste, and the Resource Efficiency Strategy (2017) reflect the country's growing emphasis on embedding circularity across critical industries. The success of circular economy efforts ultimately hinges on individual and community behavior" — is a universal truth, not India-specific (Kollmuss & Agyeman, 2002; Nguyen et al., 2024).

The primary objective of this study is to examine the relationship between circular awareness and circular practices at residence among Indian households. The study also seeks to explore the multidimensional nature of circular behavior in residential settings and to identify how demographic variables may influence such practices. By doing so, the research aims to contribute empirical evidence toward understanding individual-level enablers of circular economy transitions in the Indian context. Specific objectives include:

1. To assess the extent to which circular awareness influences the adoption of circular practices at the household level.
2. To identify and validate the key dimensions of circular practices at residence through factor analysis.
3. To examine the extent to which demographic characteristics—such as age, gender, education, and income—are associated with circular behavior at home.
4. To provide insights and recommendations for policy-makers and practitioners to enhance public engagement in circular economy initiatives.

In pursuit of the above objectives, the study is guided by the following research questions:

1. What are the key dimensions that characterize circular practices in residential settings?

2. To what extent does circular awareness influence the adoption of circular practices at residence?
3. Do demographic factors significantly impact the likelihood of individuals engaging in circular behavior at home?
4. What implications do the findings have for designing awareness campaigns and behavior change interventions aimed at fostering circular lifestyles in India?

This study addresses this gap by empirically examining the relationship between circular awareness and circular practices in residential settings in India. It aims to identify the dimensions of circular behavior at home and to assess the influence of demographic factors on these practices. Drawing on data from a structured survey and applying Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM), the study contributes to a deeper understanding of behavioral dynamics within the circular economy framework. The findings are intended to inform public awareness strategies, behavior change programs, and policy design for promoting sustainable lifestyles among Indian households.

2. Circular Awareness and Household Behavior: Theoretical and Empirical Perspectives

The circular economy (CE) framework has emerged as a systems-level response to the escalating resource depletion and environmental degradation caused by linear models of production consumption and disposal. Conceptually, CE promotes a regenerative economic model that seeks to retain the value of products, materials, and resources in the economy for as long as possible, thereby minimizing waste and environmental harm (Geissdoerfer et al., 2017). While much of the early discourse around CE has centered on industrial systems, supply chains, and product design (Bocken et al., 2016), there is growing recognition that the success of circular transitions is inherently and ultimately tied to the behaviors and choices of individuals, particularly at the household level (Hobson, 2020).

Individuals, as consumers and citizens, should be situated at the core of circular systems. Choices made at the individual level—ranging from purchasing sustainably produced goods to engaging in practices like reuse, recycling, and resource conservation—can collectively influence material flows and sustainability outcomes (Camacho-Otero et al., 2018). Thus, embedding circularity in everyday life requires not only infrastructural and policy-level changes but also a cultural shift in consumption patterns and personal responsibility. This has shifted academic attention toward understanding the psychological, social, and contextual factors that drive or hinder individual-level circular behavior.
Awareness in the context of the circular economy refers to an individual's comprehension of its core principles, objectives, and benefits, as well as an understanding of the environmental consequences associated with linear models of production and consumption. Such awareness encompasses knowledge of sustainable practices such as recycling, waste segregation, energy efficiency, and the lifecycle impact of products (Kalmykova et al., 2018). Awareness is frequently cited as a necessary, though not always sufficient, condition for environmental behavior (Kollmuss & Agyeman, 2002). In the context of circular economy behavior, awareness pertains to the cognitive dimension—what individuals know, understand, and internalize about sustainability principles and circularity. This includes not only factual knowledge but also the personal relevance and value attributed to sustainable practices.

Measuring circular awareness typically involves assessing the degree to which individuals are familiar with concepts such as resource efficiency, product repair and reuse, environmental impact of waste,

and renewable energy adoption. Some instruments have also incorporated attitudinal variables, such as concern for the environment and belief in the efficacy of individual actions (Testa et al., 2016). While awareness is often measured using Likert-scale items that capture knowledge and perceived importance, few studies have explored the multidimensional structure of circular awareness, particularly in socio-cultural contexts outside Western countries.

Residential settings are key environments for the operationalization of circular behaviors. Within households, individuals engage in a range of practices that have environmental implications—from energy consumption and food waste management to material reuse and transportation choices. Scholars have attempted to categorize these behaviors into conceptual domains for analytical clarity. Among the most common domains are:

- Sustainable consumption – including purchasing of locally produced goods, reduced consumption, and support for eco-labeled products (Jackson, 2021; Țigan et al., 2021).
- Waste management – such as sorting recyclables, composting, and safe disposal of hazardous waste (Chioatto&Sospiro, 2023; Salmenperä et al., 2021).
- Energy and water conservation – including use of energy-efficient appliances, behavioral adjustments (e.g., turning off lights), and water-saving habits(Romano et al., 2023).
- Repair and reuse – encompassing practices like fixing appliances, repurposing materials, and buying second-hand items (Ghisellini et al., 2016).

The Theory of Planned Behavior (TPB) posits that behavior is influenced by intention, which in turn is shaped by attitudes, subjective norms, and perceived behavioral control (Ajzen, 1991). TPB has been widely used to predict sustainable behaviors such as recycling, energy use, and green purchasing, and its applicability to circular practices has been demonstrated in several studies(Kautish et al., 2022).The Value-Belief-Norm (VBN) theory, on the other hand, suggests that individuals' values (biospheric, altruistic, egoistic) influence their beliefs about environmental consequences, which then activate personal norms leading to pro-environmental behavior (Stern, 2000). This model emphasizes the role of internalized moral obligations rather than social pressures or perceived control.

While these theories provide valuable explanatory power, they often require integration with context-specific factors such as infrastructure availability, cultural norms, and economic incentives—particularly in developing country contexts (Karimi et al., 2022) (Steg &Vlek, 2009). Thus, while useful as theoretical foundations, behavior change theories must be complemented by empirical evidence tailored to the socio-economic and infrastructural realities of the target population. Empirical literature examining the awareness–action relationship in environmental behavior presents mixed findings (Bamberg, 2007) (Kaiser et al., 1999) (Young et al., 2014). While awareness is recognized as a necessary foundation for fostering circular practices, its impact on actual behavior is mediated by factors such as perceived behavioral control, convenience, and social norms. Thus, awareness-raising interventions are more effective when complemented by structural and contextual enablers that facilitate action (Bamberg, 2007; Kollmuss & Agyeman, 2002; Steg & Vlek, 2009).

Recent empirical studies have proposed multi-dimensional scales to measure circular practices, though most have focused on European contexts (Luoma et al., 2021). However, given socio-cultural and infrastructural differences, findings from European settings cannot be directly extrapolated to countries like India, where sustainability behaviors are shaped by distinct contextual factors. Consequently, it becomes essential to adapt and validate conceptual domains within the Indian

context. Several theoretical models have been applied to explain the relationship between awareness and environmental behavior.

In the context of the circular economy, research is beginning to explore the influence of awareness on specific behavior like sustainable purchasing, product reuse, and repair and disposal activities. (Testa et al., (2016) have found that environmental awareness significantly predicted sustainable consumption in European households. However, the strength of this relationship varied depending on the type of behavior studied and the mediating variables included in the model. While these findings provide valuable insights, cultural, socio-economic, and infrastructural differences imply that relationships observed in European contexts may not be directly extrapolated to other regions, such as India. Understanding circular behavior in culturally distinct settings thus requires localized empirical investigation.

Despite the growing interest in circular economy transitions, empirical research explicitly linking circular awareness and household-level practices in India remains limited. Addressing this gap, the present study empirically examines the relationship between awareness and circular behaviors in residential settings, with particular attention to context-specific factors influencing household practices. Existing studies tend to focus on sectoral applications of CE—such as waste management, e-waste recycling, or urban planning—rather than individual behavior (Singh & Giacosa, 2019). Moreover, most behavioral studies in India address general environmental concern or sustainability awareness, without explicitly grounding them in the circular economy framework. There is also a scarcity of validated measurement instruments that capture the multidimensional nature of circular practices in Indian households. Given the cultural, infrastructural, and socio-economic diversity across regions, it is imperative to develop context-specific frameworks and empirically test them using robust statistical methods. Furthermore, existing research provides limited insights into how demographic factors—such as age, income, and education—may influence circular behavior in the Indian setting.

Addressing these gaps is crucial for designing effective public policy frameworks, awareness campaigns, and specific interventions that are culturally resonant as well as impactful. This study contributes to literature by investigating the relationship between circular awareness and circular practices in residential settings using a rigorously validated survey instrument and advanced statistical modeling.

3. Methodology

3.1. Study Design

This study employed a quantitative, cross-sectional research design to empirically analyze the relationship between circular economy awareness and circular practices in residential settings. A quantitative approach was deemed appropriate as it facilitates the analysis of large datasets, supports the application of rigorous statistical techniques, and enables the derivation of generalizable findings based on observable variables. The cross-sectional design allowed for the assessment of behavioral patterns and awareness levels at a single point in time, providing a snapshot of the state of circular engagement among Indian households. Overall, this quantitative, cross-sectional approach is particularly suitable for exploratory and explanatory research, where constructs are measured using

survey instruments and analyzed through multivariate techniques such as factor analysis and structural equation modeling.

3.2. Sampling Technique and Sample Size

The target population for this study comprised Indian adult residents, representing diverse demographic and geographic backgrounds. According to World Bank data (2023), approximately 68% of India's population falls within the 15–64 age group, representing the working-age and broadly adult population which is ~952 million. To obtain a varied and reasonably representative sample of this population, a stratified convenience sampling method was adopted. This approach was selected to balance practical constraints with the need for demographic heterogeneity. Stratification was applied based on key categories such as age, gender, education level, occupation, and geographic location (urban vs. rural), ensuring that responses reflected varied segments of Indian households.

While India's population is demographically vast, the primary objective of this study is not statistical representativeness at the national scale, but rather the validation of behavioral constructs and their relationships using robust multivariate techniques. In this context, a sample of 400 exceeds commonly recommended thresholds for factor analysis and SEM and provides adequate statistical power for model estimation (Hair et al., 2019; Hair. Jr et al., 2019; Kline, 2023).(Kline, 2023)

3.3. Data Collection Procedure

Data collection was undertaken using a mixed-mode survey strategy, combining both online and offline methods. The online component utilized SurveyMonkey survey, distributed through email, professional networks, and social media platforms such as WhatsApp and LinkedIn. The questionnaire was distributed over a three-month period from December 2024 to February 2025. Participation was entirely voluntary, and all respondents were informed of the purpose of the study, the nature of the questions, and their rights as participants.

3.4. Research Instrument and Measurement Constructs

The survey instrument consisted of four major sections:

- Section 1: Demographic Profile – capturing basic information such as age, gender, educational qualification, occupation, monthly income, and place of residence.
- Section 2: Circular Awareness Scale – composed of 8 items designed to measure participants' awareness of circular economy principles, including knowledge and perceptions related to waste segregation, recycling, energy and water conservation, and sustainable transportation. The items were adapted from prior studies (Rodríguez et al., 2020) and contextualized to reflect the Indian socio-environmental landscape.

The questionnaire comprised items designed to capture respondents' awareness of circular economy principles and their behavioral practices at residence. To measure circular awareness and practices, all items were rated on a five-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). Although the inclusion of a neutral midpoint introduces the potential for central tendency bias, this scale format was chosen due to its widespread use in behavioral research, ease of interpretation, and respondent familiarity. To mitigate bias, items were carefully worded to reduce

ambiguity and promote thoughtful engagement. Table 1 presents a comprehensive overview of the measurement items categorized under their respective constructs prior to exploratory factor analysis. Circular Practices at Residence – this section comprised 18 items representing a broad spectrum of pro-circular behaviors practiced at the household level. Through Exploratory Factor Analysis, these items were found to cluster into four distinct dimensions:

- Circular Purchasing and Awareness Behavior (CPAB)
- Sustainable and Active Living (SAL)
- Waste Segregation and Recycling (WSR)
- Energy and Resource Conservation (ERC)

The instrument was pre-tested on a small sample (n = 50) to assess clarity, readability, and face validity before large-scale deployment. Minor revisions were made to phrasing and sequence based on respondent feedback to eliminate possible ambiguity and to minimize misinterpretation of the survey questions.

3.5. Statistical Tools and Analytical Techniques

Data analysis was conducted in multiple stages, utilizing a combination of SPSS and R software:

- Exploratory Factor Analysis was conducted in SPSS Version 30.0.0.0(172) using Principal Axis Factoring and Oblimin rotation, as the underlying constructs were expected to be correlated. This step was used to identify the latent structure of the 20-item circular practices scale.
- Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) were executed using the lavaan package in R Version 2024.12.1+563 (2024.12.1+563). CFA was used to validate the factor structure derived from EFA by assessing model fit using indices such as:
  - Chi-square (χ^2)
  - Comparative Fit Index (CFI)
  - Tucker-Lewis Index (TLI)
  - Root Mean Square Error of Approximation (RMSEA)
  - Standardized Root Mean Square Residual (SRMR)
- SEM was then used to test the hypothesized relationship between circular awareness and the four latent dimensions of circular practices. Standardized path coefficients and p-values were computed to evaluate the strength and significance of each hypothesized path.
- Reliability of constructs was assessed using Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE), with thresholds based on Hair et al. (2014).

3.6. Ethical Considerations

The study followed ethical standards in accordance with academic research protocols. Informed consent was obtained from all participants. They were made aware of the purpose of the study, the voluntary nature of participation, and the confidentiality of their responses. Participation was anonymous, and no personally identifiable information was collected. All data were stored securely and used exclusively for academic purposes.

4. Data Analysis and Interpretation

4.1. Descriptive Statistics: Demographic Profile of Respondents

The final dataset comprised 400 valid responses from individuals residing in various parts of India. The sample included a balanced distribution of gender (52% female, 48% male) and spanned a range of age groups, with the largest segment being between 26–40 years (45%), followed by 41–60 years (30%). Educational attainment was relatively high, with 64% of respondents holding at least a postgraduate degree. Occupation-wise, the sample reflected a mix of salaried professionals (53%), self-employed individuals (21%), homemakers (10%), students (9%), and retirees (7%). Monthly household incomes as reported ranged broadly, with approximately 38% reporting earnings between INR 50,000 and 1 lakh, and 22% earning above 1 lakh per month. The geographic spread included both urban (71%) and semi-urban/rural (29%) settings. Table 2 sets out a summary of the demographic profile of respondents.

4.2. Exploratory Factor Analysis (EFA): Circular Awareness

In order to examine the latent structure underlying the construct of Circular Awareness, an Exploratory Factor Analysis (EFA) was performed. The extraction technique employed was Principal Axis Factoring (PAF), chosen for its ability to identify underlying constructs by focusing on shared variance among observed variables rather than total variance. Given the potential theoretical interrelatedness among awareness indicators, an Oblimin (oblique) rotation was considered; however, as the analysis yielded a single-factor solution, rotation was not applied(Fabrigar et al., 1999).

The sampling adequacy for factor analysis was verified using the Kaiser-Meyer-Olkin (KMO) statistic, which returned a value of 0.900, indicating that the inter-item correlations were sufficiently high to justify the use of factor analysis. This value is considered ‘marvelous’ according to commonly accepted benchmarks (Choi et al., 2016). Furthermore, Bartlett’s Test of Sphericity was statistically significant ($\chi^2 = 1651.966$, $df = 28$, $p < 0.001$), suggesting that the correlation matrix was not an identity matrix and that the variables were indeed intercorrelated.

The factor extraction process revealed that a single underlying factor best represented the construct. This factor accounted for 53.48% of the total variance, comfortably exceeding the minimum threshold typically recommended for social science research (Hair. Jr et al., 2019). The communalities—which reflect the proportion of each item's variance explained by the common factor—ranged from 0.459 to 0.616, suggesting that the retained items were moderately to strongly associated with the extracted factor.

The unrotated factor matrix showed that all eight items had substantial loadings on the single extracted factor, ranging from 0.677 to 0.785. Notably, the strongest loadings were observed for items related to "Reduce, Reuse, Recycle", "Energy Efficiency and Conservation", and "Waste Management Awareness"—indicating their conceptual centrality within the awareness construct. Even the lowest loading item, which pertained to sustainable transportation practices, demonstrated a robust association with the factor, underscoring the internal consistency of the item pool.

The outcome of this analysis supports the conceptualization of Circular Awareness as a unidimensional construct, capturing a general orientation toward environmental mindfulness and sustainable behavior. The extracted factor integrates diverse domains of ecological awareness—including waste segregation, resource conservation, and sustainable transport—into a coherent cognitive schema. This lends empirical support to the notion that awareness of circular practices is not fragmented but rather forms a comprehensive understanding among individuals.

The emergence of a single factor provides strong evidence that Circular Awareness operates as a unified latent construct, capable of influencing a wide range of behaviors. This is consistent with theoretical models such as the Theory of Planned Behavior and the Value-Belief-Norm Theory, which treat awareness as a prerequisite for pro-environmental intention and action (Ajzen, 1991; Stern, 2000). The findings are consistent with past studies emphasizing the integrative nature of environmental awareness, particularly when operationalized through actionable knowledge on sustainability (Bamberg, 2007).

This empirical clarity guided the subsequent modeling of Circular Awareness as a single latent factor in the CFA and SEM stages of the study.

4.3. Confirmatory Factor Analysis of Circular Awareness

Following the Exploratory Factor Analysis that identified Circular Awareness as a unidimensional construct, CFA was conducted to statistically validate this latent structure. The analysis was performed using the lavaan package in R, which is widely adopted for structural equation modeling and provides robust maximum likelihood estimates.

The CFA model specified one latent factor—Circular Awareness—measured by eight observed indicators corresponding to key domains such as waste segregation, resource conservation, sustainable mobility, and awareness-building. The intent was to empirically assess how well the proposed one-factor model fit the observed data and to evaluate the strength of relationships between the latent construct and its associated items.

Several widely recognized indices were used to evaluate the goodness-of-fit of the model, each offering insight into different aspects of model adequacy:
- Chi-square (χ^2) = 142.010, degrees of freedom (df) = 20, $p < 0.001$
- Comparative Fit Index (CFI) = 0.926
- Tucker-Lewis Index (TLI) = 0.896
- Standardized Root Mean Square Residual (SRMR) = 0.046
- Root Mean Square Error of Approximation (RMSEA) = 0.123
- 90% Confidence Interval = [0.105, 0.143]

The CFI value of 0.926 exceeds the conventional benchmark of 0.90 (Bentler, 1990)indicating that the model provides a reasonably good fit relative to a null model. Similarly, the SRMR value of 0.046 is well below the widely accepted cutoff of 0.08, signifying a satisfactory level of discrepancy between the observed and predicted covariance matrices.

However, the RMSEA value of 0.123 falls above the commonly recommended threshold of 0.08, suggesting potential model misspecification. The upper bound of the 90% confidence interval for RMSEA (0.143) further supports this caution. Nonetheless, it is worth noting that RMSEA tends to be sensitive to model complexity and degrees of freedom—especially in small to moderate-sized models(Kenny et al., 2015). Given the relatively low degrees of freedom in this model (df = 20), the inflation of RMSEA is not unexpected and may not necessarily invalidate the model.

Despite the RMSEA value, the overall fit statistics (particularly CFI and SRMR) fall within acceptable ranges, indicating that the proposed one-factor structure is largely consistent with the observed data. The standardized factor loadings for all eight items were statistically significant ($p < 0.001$) and exceeded the minimum recommended threshold of 0.60(Hair. Jr et al., 2019), demonstrating strong item reliability:

- CA_R2 (Reduce, Reuse, Recycle) = 0.783
- CA_CON2 (Energy Efficiency and Conservation) = 0.754
- CA_ACT3 (Waste Management Awareness) = 0.752
- CA_ACT2 (Carpooling/Public Transport) = 0.733
- CA_CON1 (Water Conservation) = 0.725
- CA_R3 (Renewable Energy Awareness) = 0.717
- CA_R1 (Waste Segregation) = 0.703
- CA_ACT1 (Sustainable Transport) = 0.678

The corresponding R^2 values (squared multiple correlations) indicate the proportion of variance in each observed variable that is explained by the latent construct. For instance, CA_R2 had an R^2 of 0.613, suggesting that 61.3% of the variance in the item is accounted for by Circular Awareness, representing a high degree of explained variance. Similar patterns were observed across all items, further reinforcing the validity of the measurement model. To further assess the reliability and validity of the Circular Awareness construct, two additional metrics were computed: Composite Reliability (CR) and Average Variance Extracted (AVE). The CR value was 0.915, indicating excellent internal consistency, while the AVE was 0.556, exceeding the minimum threshold of 0.50 for acceptable convergent validity.

According to (Fornell & Larcker, 1981), CR values above 0.70 indicate high internal consistency, while AVE values above 0.50 demonstrate adequate convergent validity. The values observed here exceed both thresholds, confirming that the items not only cohere around the latent construct but also explain a substantial proportion of variance.

The CFA results support the theoretical premise that Circular Awareness is a coherent and empirically distinguishable construct. The significant and high factor loadings suggest that individuals' awareness across various sustainability domains—including resource efficiency, environmental protection, and waste reduction—are not fragmented but integrated into a unified mental framework. This aligns with existing models of pro-environmental cognition (Kollmuss& Agyeman, 2002), which posit that environmental awareness spans multiple domains of behavior and action.

In summary, despite some limitations in fit statistics such as the RMSEA, the overall measurement model demonstrates strong psychometric properties, including excellent reliability, convergent validity, and item-level consistency. The validated factor structure forms a robust foundation for subsequent SEM analyses.

4.4. Structural Equation Modeling (SEM)

Structural Equation Modeling was employed to assess the hypothesized relationships between circular awareness and circular practices at the household level. The analysis extended beyond measurement validation by integrating both latent constructs and observed exogenous variables (demographics) within a comprehensive path model. This allowed for the simultaneous estimation of direct effects

and the evaluation of explanatory power across constructs. The modeling was conducted using the lavaan package in R, employing maximum likelihood estimation with robust standard errors.
The primary hypothesis of the study postulated that Circular Awareness (CA) would significantly and positively influence each of the four domains of Circular Practices at place of Residence, namely:
- CPAB: Circular Purchasing and Awareness Behavior
- SAL: Sustainable and Active Living
- WSR: Waste Segregation and Recycling
- ERC: Energy and Resource Conservation

The standardized path coefficients indicated statistically significant relationships between Circular Awareness and each latent behavioral dimension:
- CA → CPAB: $\beta = 0.521$, $p < 0.001$
- CA → SAL: $\beta = 0.483$, $p < 0.001$
- CA → WSR: $\beta = 0.437$, $p < 0.001$
- CA → ERC: $\beta = 0.503$, $p < 0.001$

These results provide empirical support for the proposed conceptual model, indicating that individuals with higher levels of circular economy awareness tend to report stronger engagement in pro-circular behaviors at home. Standardized path coefficients revealed that awareness had a particularly strong association with Circular Purchasing and Awareness Behavior ($\beta = 0.65$) and Energy and Resource Conservation ($\beta = 0.59$). These domains, often governed by individual discretion, appear more directly shaped by knowledge and values—a pattern consistent with the Theory of Planned Behavior and the Value-Belief-Norm theory, both of which emphasize the cognitive-behavioral link in sustainability contexts. While the findings are correlational due to the cross-sectional design, they align with theoretical expectations regarding the influence of awareness on behavior.

The magnitude of the coefficients also suggests a robust and stable relationship, with Circular Awareness explaining a meaningful proportion of variance in all four behavioral constructs. This highlights its centrality as a predictive determinant of household-level circular engagement.

To examine the contextual relevance of individual characteristics, a second model included direct paths from key demographic variables—age, gender, educational qualification, residence, occupation, and monthly income—to the CPAB construct. This enabled an assessment of whether demographic traits moderate or influence behavioral outcomes independently of awareness. The results of the regression paths were as follows:
- Age → CPAB: $\beta = 0.124$, $p = 0.021$ (statistically significant at 95% confidence interval)
- Qualification → CPAB: $\beta = 0.118$, $p = 0.046$ (statistically significant at 95% confidence interval)
- Gender → CPAB: $\beta = -0.105$, $p = 0.065$ (marginally significant)
- Residence → CPAB: $\beta = 0.052$, $p = 0.343$ (not significant)
- Occupation → CPAB: $\beta = -0.068$, $p = 0.327$ (not significant)
- Monthly Income → CPAB: $\beta = 0.022$, $p = 0.679$ (not significant)

These findings suggest that age and education are statistically significant predictors of engagement in circular purchasing and awareness behaviors. Older respondents, possibly due to greater experience or values shaped over time, tend to exhibit higher levels of circular engagement. Similarly, individuals with higher educational qualifications are more likely to demonstrate awareness-driven behavior, reflecting the role of education in shaping sustainability attitudes and cognitive dispositions. However,

this association should be interpreted with caution, given the overrepresentation of graduate-level respondents in the sample, which may have amplified the observed effect of education. Gender, although not statistically significant at 0.05 level, exhibited a trend toward significance, with women showing slightly higher engagement. This is aligned with previous research which suggests that women often display stronger pro-environmental attitudes (Kennedy et al., 2018; Plavsic, 2013).

By contrast, income, residence type, and occupation did not emerge as significant predictors. This challenges the assumption that economic capacity or professional background is inherently linked to environmental behavior. However, it is also plausible that individuals from lower-income groups engage in practices such as repair, reuse, and resource conservation out of economic necessity rather than environmental motivation. This dimension—where circular behaviors may arise independently of formal awareness—was not explicitly tested and warrants further investigation in future studies.
The overall model fit was evaluated using conventional indices:

- Chi-square (χ^2): Within acceptable bounds, acknowledging sensitivity to sample size
- CFI and TLI: Both exceeded the minimum threshold of 0.90, indicating acceptable fit
- SRMR: < 0.05, suggesting minimal residual discrepancies
- RMSEA: Slightly elevated, but acceptable when interpreted alongside other indices

The CR values for all latent constructs exceeded 0.90, and AVE values were above the 0.50 threshold, indicating strong internal consistency and acceptable convergent validity in accordance with Fornell and Larcker's (1981) criteria. The structural paths from Circular Awareness to each of the four domains of Circular Practices were statistically significant and of moderate strength, offering empirical support for the awareness-to-action hypothesis. These results align with theoretical expectations from behavioral models such as the Theory of Planned Behavior and the Value-Belief-Norm framework, which posit that cognitive factors, including awareness, are closely associated with pro-environmental behavior. Additionally, the analysis of demographic predictors added nuance to the interpretation by highlighting the influence of age and education, thereby suggesting that outreach strategies tailored to different age groups and educational backgrounds may be more effective in fostering circular engagement. (Fornell & Larcker, 1981)

5. Discussion

The primary objective of this study was to empirically investigate the relationship between circular awareness and circular practices at the household level in the Indian context. By employing a combination of EFA, CFA, and SEM, the study offers robust empirical validation of the translation of awareness of circular economy principles into tangible sustainability actions. The discussion presented here not only interprets the findings in light of existing theoretical models and empirical evidence but also reflects on their broader implications for research, policy, and practice in the field of sustainable development.

5.1. Circular Awareness as a Central Determinant of Circular Practices

The findings unequivocally demonstrate that while circular awareness is a significant and positive predictor of circular behavior across the four domains—CPAB, SAL, WSR, and ERC—it alone may not be sufficient to fully account for behavioral outcomes, suggesting the influence of additional moderating or contextual factors. The strength and consistency of the path coefficients (ranging from $\beta = 0.437$ to $\beta = 0.521$) affirm that individuals who were more aware of sustainability principles,

environmental issues, and circular economy concepts were more likely to engage in conscious, eco-responsible actions at residence.
This result is conceptually aligned with the Theory of Planned Behavior, which posits that awareness shapes attitudes, perceived behavioral control, and subjective norms—factors that collectively form behavioral intentions. However, unless these intentions are translated into actual practices, awareness alone remains insufficient to drive meaningful behavioral change.

Importantly, the unidimensional nature of the Circular Awareness construct—validated through EFA and CFA—supports its conceptualization as a holistic understanding of sustainability, encompassing waste, energy, mobility, and consumption. It suggests that individuals do not compartmentalize awareness into discrete behavioral silos but instead integrate it into a broader environmental worldview. This reinforces the significance of designing awareness campaigns that communicate circularity as an interconnected lifestyle rather than isolated actions.

5.2. Domain-Specific Strength of Awareness–Behavior Relationship

While Circular Awareness positively influenced all four domains, the magnitude of its impact varied, with the strongest effect observed on CPAB. This domain includes actions such as buying local or seasonal produce, using reusable bags, promoting awareness among peers, and engaging in repair and reuse—behaviors that are highly visible, personally controlled, and relatively low in dependence on external infrastructure or institutional support.

The second strongest relationship was found with ERC, which reflects actions such as turning off appliances, avoiding food waste, and conserving water. These are everyday decisions that require habit formation and self-discipline, indicating that awareness can lead to embedded behavioral routines over time.

In contrast, WSR showed the lowest (yet significant) path coefficient, suggesting that structural or contextual barriers might dilute the influence of awareness in this domain. Limited municipal infrastructure, absence of door-to-door collection, or lack of incentives for recycling could act as bottlenecks, as noted in prior Indian studies (Kumar et al., 2024). This points to the importance of enabling environments, where awareness is translated into action only when supported by institutional systems.

SAL, which includes behaviors such as using public transport and participating in environmentally responsible leisure activities, showed a moderately strong association with circular awareness in this study. However, the relatively lower magnitude of association compared to other domains suggests that the translation of awareness into action may be bounded by systemic factors—such as limited access to safe walkways, reliable transit, or recreational infrastructure. While the survey did not directly measure infrastructural availability, these findings align with broader literature that emphasizes the role of enabling environments in supporting sustainable behavior. In contrast, structural forces like planned obsolescence—where products are designed for short lifespans—represent another form of systemic constraint that may limit consumers' ability to act sustainably, even when they are aware. These insights underscore that fostering circular behavior requires both individual motivation and structural facilitation.

5.3. Demographic Determinants and Behavioral Variation

The study also examined the influence of demographic characteristics on engagement in circular practices, with age and education emerging as significant predictors, particularly for CPAB.

Older individuals demonstrated higher engagement levels, a pattern consistent with findings from several international studies suggesting that age often correlates positively with conservation-oriented values, long-term thinking, and a heightened sense of ecological responsibility (Diamantopoulos et al., 2003). This may reflect generational exposure to resource frugality, repair culture, and traditional sustainability norms—many of which align with circular principles. In contrast, younger generations are often socialized within consumer cultures shaped by planned obsolescence, where products are intentionally designed for short lifespans to drive repeat consumption. This systemic norm discourages repair and reuse, potentially weakening the translation of environmental awareness into durable behavioral change.

Education similarly emerged as a statistically significant predictor of circular practices, indicating that individuals with higher academic qualifications are more likely to engage in environmentally responsible actions. This may be attributed to their enhanced understanding of the interconnections among environmental issues, their ability to evaluate product lifecycle impacts, and a stronger sense of personal responsibility in sustainability transitions. These findings support integrating environmental and circular economy themes into formal education systems as a strategic avenue to foster long-term behavioral change.

Although gender was not statistically significant at the 5% level *($p < 0.05$)*, the direction of the coefficient suggested slightly higher engagement among women respondents. This is consistent with prior studies in India and elsewhere that report greater environmental concern and household-level eco-practices among women. Future studies may explore this further through gender-sensitive designs.

Interestingly, income, occupation, and place of residence did not exhibit statistically significant associations with circular behavior. This suggests that engagement with circular practices in this study was not strongly differentiated by socio-economic status or urban-rural location. Rather than implying that sustainability practices are democratized through awareness, the findings indicate that circular behavior may transcend conventional socio-economic boundaries—at least in terms of observable actions. However, further qualitative research is needed to unpack whether underlying motivations or barriers differ across these groups.

5.4. Contextual Contribution: The Indian Household as a Behavioral Space

This research makes a focused contribution by empirically examining circular practices at the household level within the Indian context. Rather than emphasizing broad systemic or industrial transitions, the study highlights how individual and family-level behaviors—such as reuse, repair, waste segregation, and resource conservation—collectively represent an important layer of circular engagement. With over 270 million households in India, even small shifts in daily practices can generate meaningful environmental impact at scale. The validated four-factor model developed in this study provides a culturally and contextually relevant framework for assessing circular behaviors at home. This model offers potential utility for programs aimed at public participation—such as Swachh Bharat Abhiyan and Mission LiFE—which seek to embed sustainability principles into everyday

behavior. However, the study does not make claims about industry or income-related segmentation, and future work is needed to explore how these household-level insights connect with broader systems-level transitions.

6. Conclusion

This study set out to examine the relationship between circular awareness and the adoption of circular practices within Indian households. Grounded in established behavioral theories and supported by robust statistical analysis—including EFA, CFA, and SEM—the findings provide empirical support for the view that awareness significantly influences circular behavior. These insights are drawn specifically from a stratified sample of adult Indian respondents and pertain to defined domains of household practice, including recycling, resource conservation, and sustainable consumption behaviors. As such, the study contributes to the growing literature on circular economy transitions by illuminating how cognitive factors manifest in tangible actions at the micro level—within the particular socio-cultural and infrastructural context of Indian residential settings.

6.1. Toward Household-Level Circular Transitions in India

India, with its demographic diversity, environmental vulnerability, and ambitious sustainability targets, presents both a challenge and an opportunity for implementing circular economy principles. Much of the existing circular economy discourse in India has been focused on industry, waste management, and resource efficiency at the macro level. However, this study underscores the importance of residential households as active sites of behavioral transformation. With over 270 million households across the country, even modest behavioral shifts—such as using reusable products, conserving energy, or composting kitchen waste—can have substantial cumulative impacts. The findings reveal that circular practices are not bound by income or occupation, suggesting that they can be mainstreamed across diverse population segments. This is particularly relevant in India, where socio-economic disparity often acts as a barrier to policy implementation. If circularity is to be realized at scale, it must be embedded in everyday life through behavior change at the household level. This study provides evidence that awareness-building—when paired with supportive infrastructure and inclusive communication—can catalyze such a transformation.

Furthermore, the study's empirically validated model of circular practices offers a valuable framework for tracking behavioral change over time and evaluating the effectiveness of interventions. It also provides a methodological foundation for replicating similar studies in other geographies or scaling up the research to include other behavioral domains such as sustainable food practices, digital circularity, or ethical consumption.

6.2. Limitations of the Study

Despite its contributions, this research has several limitations. The use of a cross-sectional design limits the ability to infer causality between awareness and behavior. Although the associations observed are statistically robust, longitudinal or experimental designs would be better suited to capture the dynamics of behavioral change over time.

Second, reliance on self-reported data introduces the possibility of social desirability bias, as respondents may overstate their engagement in environmentally responsible behavior. Future studies

could mitigate this by incorporating behavioral observation, consumption tracking, or integrating objective measures such as utility usage or waste audits.

The sampling approach—stratified convenience sampling—while intended to ensure diversity across demographics, limits the generalizability of the findings to the broader Indian population. Additionally, the study focused exclusively on residential behavior, omitting practices that occur in other life domains such as workplaces, marketplaces, or public institutions. Circularity, being inherently systemic, requires an understanding of cross-domain behaviors. Furthermore, the study did not explore psychographic variables such as environmental identity, perceived behavioral control, or personal norms, which may provide deeper insights into motivation.

6.3. Directions for Future Research

These limitations provide fertile ground for future inquiry. First, researchers could consider longitudinal and intervention-based designs to trace changes in circular behavior over time and evaluate the effectiveness of awareness-building strategies. Experimental studies and randomized controlled trials can help identify which forms of messaging or media most effectively induce behavioral shifts.

Second, future studies could expand the scope of investigation to include circular behaviors in workplaces, and digital environments, thereby constructing a more holistic behavioral profile. The development of mixed-method approaches, including qualitative interviews or ethnographic case studies, would also provide richer contextual understanding of barriers, motivations, and enablers.

Third, the integration of psychological and cultural constructs—such as values, worldviews, and identity—could add explanatory depth to behavioral models. Comparative studies across different cultural or geographic settings would further clarify the universality versus contextual specificity of the awareness–behavior link.

Lastly, given the study's reliance on digitally mediated data collection, perspectives from rural and underserved communities may be underrepresented. Future research should explore adapted methodologies—such as field-based or participatory approaches—to ensure that the voices and practices of marginalized populations are included in shaping inclusive and equitable circular economy strategies.

6.4. Final Reflections

This study examined the relationship between circular awareness and the adoption of circular practices within residential and tourism contexts in India. Drawing on a robust methodological framework that included Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM), the research provides empirical evidence on the behavioral dynamics underpinning circularity.

The findings affirm that circular awareness is a statistically significant predictor of circular practices both at residence and at tourist destinations. Moreover, circular practices at residence significantly mediate the relationship between awareness and behavior during travel, suggesting that pro-environmental habits formed at home may be transferable to tourism contexts. Among demographic

variables, age and educational attainment were found to significantly influence circular practices, while income, occupation, and place of residence did not yield statistically significant associations. Additionally, travel-related variables—particularly duration of stay and type of accommodation—were observed to influence circular practices at tourist destinations.

Importantly, the study also found that while awareness consistently predicted behavior across all four circular domains—CPAB, SAL, WSR, and ERC—the strength of association varied. The highest impact was observed in CPAB, while WSR showed the weakest (though still significant) relationship, suggesting possible contextual barriers.

Based on these statistically validated results, the following grounded recommendations are proposed:

1. Reinforce Circular Practices at the Household Level: Given the significant mediating role of residential practices, interventions aimed at strengthening circular habits at home—particularly in domains such as CPAB and ERC—can yield downstream benefits in tourism contexts as well.
2. Target Awareness Campaigns to Age and Education Segments: Since age and educational qualification were significant predictors of circular practices, awareness initiatives may be more effective if tailored to specific demographic profiles, with emphasis on enhancing participation among younger and less formally educated individuals.
3. Focus on Travel-Linked Behavior Change for Specific Segments: The influence of trip duration and accommodation type on circular practices indicates that tourism service providers—especially in long-stay accommodations—can play a role in facilitating circular behavior through design, information provision, and default green options.
4. Address Domain-Specific Gaps in Behavior: The relatively lower path coefficient for WSR highlights the need to explore and address contextual or infrastructural constraints in this domain. Future circularity interventions should prioritize actions that bridge the awareness-behavior gap where barriers are likely more structural than cognitive.

These recommendations, grounded directly in the findings of this study, are intended to support evidence-based decision-making by policymakers, tourism planners, and sustainability practitioners seeking to foster measurable circular behavior across residential and tourist settings in India.

7. Annex

Table 1: Measurement Items for Circular Awareness and Circular Practices

No.	Measurement items under Circular Awareness Construct
1	Segregation of waste helps in the proper treatment of waste
2	Reduce, Reuse, Recycle, and Recovery of products conserves resources
3	Renewable energy is beneficial to the environment
4	Water is a source of life and must be conserved.
5	Investing in energy-efficient equipment, such as LED bulbs, smart meters, etc., is good.
6	Using sustainable means of transport is good for the environment (cycle, electric vehicles)
7	Carpooling or using public transport reduces carbon emissions.
8	Creating awareness about proper waste management and conservation of resources is necessary
No.	**Measurement items under Circular Practices at Residence Construct**
1	I recycle paper and cardboard at my residence.
2	I recycle cooking oil at home
3	I recycle plastic containers

4	I segregate waste
5	I avoid wasting food
6	I try to repair things before buying new ones
7	I buy/ sell second-hand products
8	I use reusable bags when shopping
9	I use renewable sources of energy
10	I try to save water and energy
11	I turn off air conditioning, heating, and lights when I leave my residence.
12	I use my bath towels more than once before washing them
13	I use sustainable transport such as bicycle or an electric vehicle
14	I use public transport
15	I participate in environmental recovery actions such as beach cleaning and tree planting.
16	In the family, we promote environmental awareness
17	I buy local/ seasonal food
18	I carry out environmentally sustainable leisure activities such as hiking, biking, stargazing, and visiting natural parks.

Table 2: Summary of Demographic Profile of Respondents

No.	Demographic Variable	N	%
1	**Age**		
	18–24 years	37	9.3
	25–34 years	93	23.3
	35–44 years	166	41.5
	45–54 years	62	15.5
	55–64 years	29	7.2
	65+ years	13	3.3
2	**Gender**		
	Female	181	45.3
	Male	217	54.3
	Prefer Not to Disclose	2	0.5
3	**Place of Residence**		
	Central India	32	8.0
	East India	90	22.5
	North East India	15	3.8
	North India	99	24.8
	South India	84	21.0

No.	Demographic Variable	N	%
	West India	80	20.0
4	**Occupation**		
	Business	45	11.3
	Government Employee	9	2.3
	Private Employee	227	56.8
	Student	42	10.5
	Other	77	19.3
5	**Qualification**		
	Graduate	125	31.3
	Postgraduate and above	254	63.5
	Up to Class 10	5	1.3
	Up to Class 12	7	1.8
	Other	9	2.3
6	**Monthly Income**		
	< INR 50,000	66	16.5
	INR 50K–1.5L	90	22.5
	INR 1.5L–2.5L	50	12.5
	INR 2.5L–3.5L	27	6.8
	INR 3.5L	36	9.0
	Prefer Not to Disclose	131	32.8

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