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Research Paper

Uncovering Patterns of Green Behavior: A Cluster and Factor Analysis of Sustainable Practices Among Food Micro-Businesses

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Abstract

This study investigates the green behavior patterns of food micro-businesses in Ozamiz City, Philippines, employing exploratory factor analysis and K-means clustering to uncover behavioral typologies based on sustainable practices. Using survey data from 4,130 micro-businesses, two main behavioral dimensions emerged: Visible Operational Practices and Internal Efficiency. A subsequent cluster analysis identified three distinct groups: Sustainability-Oriented Enterprises, Moderate Green Practitioners, and an Isolated Minimalist. Results show that while many businesses demonstrate commendable environmental efforts, others exhibit partial or superficial engagement, highlighting the limitations of uniform sustainability policies. The resulting typology functions as a practical decision framework for policymakers and development practitioners by enabling differentiated interventions—such as advanced incentives and market-based support for sustainability-oriented enterprises, capacity-building and technical assistance for moderate practitioners, and foundational awareness, mentoring, and regulatory guidance for minimal adopters. By explicitly linking behavioral readiness to tailored policy and programmatic responses, this study moves beyond one-size-fits-all sustainability approaches and supports more efficient, context-sensitive, and scalable green enterprise development in developing economies.

Keywords: *Green Behavior, Food Micro-Enterprises, Sustainable Operational Practices, Internal Efficiency Practices, Behavioral Typology, Cluster Analysis*

INTRODUCTION

In the face of mounting environmental challenges, the role of micro, small, and medium-sized enterprises (MSMEs) in advancing sustainability has gained increasing scholarly and policy attention. While large corporations often dominate sustainability discourse, the collective environmental footprint of MSMEs—particularly those operating in the food sector—is substantial due to their scale, operational frequency, and proximity to local communities. In the Philippines, food micro-businesses such as carinderias, home-based food producers, and small canteens constitute a vital segment of the local economy. Their everyday practices in energy use, waste disposal, water conservation, and food packaging directly shape environmental outcomes at the community level. Despite this significance, systematic empirical evidence on how these enterprises engage in green behavior remains limited, especially in secondary cities and non-metropolitan contexts.

Green business practices are commonly defined as organizational strategies and routines that minimize environmental harm while promoting resource efficiency and long-term sustainability (Čekanavičius et al., 2014). These practices encompass energy and water conservation, responsible waste management, sustainable packaging, and employee engagement in environmental initiatives. Existing studies in emerging economies have primarily examined the determinants, drivers, or outcomes of green practices—such as financial performance, competitiveness, or consumer response—using regression-based or structural modeling approaches (Apurbo et al., 2020; Bestari & Butarbutar, 2021; Martins et al., 2022). While this

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stream of research has advanced understanding of why firms adopt green practices and what outcomes may result, it often treats sustainability engagement as a relatively uniform construct and focuses predominantly on larger firms or urban-based enterprises.

However, growing evidence suggests that green behavior among MSMEs is neither uniform nor linear. Micro-businesses face heterogeneous constraints related to capital access, technical capability, regulatory exposure, and workforce capacity (Ashton et al., 2017; Maniu et al., 2021; Muafi & Siswanti, 2024). Although these differences are frequently acknowledged in the literature, they are typically modeled as explanatory variables rather than examined as distinct behavioral configurations. Consequently, limited attention has been given to understanding how green practices cluster, co-occur, or diverge within micro-enterprise populations—particularly in the food sector, where sustainability practices are often shaped by both internal efficiency considerations and externally visible market pressures. This results in an important conceptual gap in sustainability research, as well as a practice gap, wherein policy interventions tend to assume homogeneous readiness among micro-entrepreneurs.

Responding to these gaps, this study adopts a typology-based analytical approach to examine green behavior among food micro-businesses in Ozamiz City, Philippines. Rather than predicting adoption likelihoods or estimating outcome effects, the study focuses on uncovering latent dimensions of green practices and empirically classifying enterprises into behaviorally meaningful clusters using exploratory factor analysis and K-means clustering. This approach conceptualizes green behavior as a patterned, multidimensional phenomenon that reflects varying degrees of internal capacity, operational commitment, and strategic orientation toward sustainability.

The study pursues two specific objectives: (1) to identify the underlying dimensions of green behavior among food micro-businesses using exploratory factor analysis, and (2) to classify these enterprises into distinct behavioral typologies using K-means clustering. This research makes three key contributions. Conceptually, it extends sustainability scholarship by framing green behavior among micro-enterprises as a heterogeneous typology rather than a single adoption outcome. Methodologically, it demonstrates the value of integrating factor and cluster analysis to generate empirically grounded behavioral profiles in micro-enterprise sustainability research. Contextually, it provides localized evidence from a secondary Philippine city, offering insights relevant to policymakers, local government units, and development practitioners seeking to design differentiated, capacity-sensitive sustainability interventions for grassroots enterprises.

LITERATURE REVIEW

Conceptual Perspectives on Green Practices in Micro-Enterprises

The literature on green practices in business has evolved from an early focus on regulatory compliance and environmental responsibility toward a broader emphasis on competitive advantage, innovation, and strategic value creation. In this stream, sustainability is increasingly viewed not only as an ethical obligation but also as a source of differentiation and legitimacy, particularly in consumer-facing sectors such as food services. Studies on sustainable packaging illustrate this shift. Boz et al. (2020) identified consumer-driven pressures as a key driver of packaging sustainability, while Patel et al. (2022) proposed an integrative framework that balances environmental performance with consumer expectations. Similarly, Anquez et al. (2022) demonstrated that visible sustainability cues significantly influence consumer support, particularly in food-related businesses, where environmental practices are readily observed at the point of purchase.

Beyond externally visible practices, a second body of literature emphasizes the importance of internally oriented green behaviors, including employee training, equipment maintenance,

energy management, and waste minimization. Drawing implicitly on the resource-based view (RBV), these studies argue that internal green practices represent firm-specific capabilities that enhance operational efficiency and long-term performance. Ashton et al. (2017), for instance, found that small manufacturers investing in internal green operations experienced improvements in efficiency, employee engagement, and process reliability. However, evidence suggests that such internally embedded practices are less prevalent in developing and emerging economies, where sustainability efforts tend to prioritize externally visible actions that respond to immediate market signals (Bruno et al., 2023).

Theoretical Lens: Resource-Based and Institutional Perspectives

Taken together, the literature suggests that green behavior in micro-enterprises can be understood through the complementary lenses of resource-based theory and institutional theory. From a resource-based perspective, internal green practices—such as efficient energy use, staff training, and process optimization—constitute valuable, difficult-to-imitate organizational capabilities that support sustained efficiency gains (Ashton et al., 2017; Maniu et al., 2021). In contrast, institutional theory emphasizes the role of external pressures, norms, and legitimacy concerns in shaping observable green behaviors, particularly those directed at customers, regulators, and community stakeholders (Boz et al., 2020; Anquez et al., 2022).

This dual-theoretical framing helps explain why green behavior among micro-enterprises may not manifest as a single, unified construct. Rather, sustainability practices may diverge into externally oriented, legitimacy-seeking behaviors and internally oriented, capability-building behaviors, each shaped by different motivations and constraints. For resource-constrained micro-businesses, visible green practices often offer immediate reputational benefits at relatively low cost, while internal practices require longer-term investments in skills, systems, and infrastructure.

Green Behavior in Emerging Economies and the Philippine Context

Micro-enterprises in emerging economies face persistent barriers to adopting comprehensive sustainability practices, including limited access to green technologies, insufficient awareness, and misalignment between policy design and on-the-ground capacity (Purwandani & Michaud, 2021). Majeed et al. (2022) argue that sustainability strategies for micro-enterprises must be tailored to varying levels of internal capacity and market integration rather than imposed uniformly. In the Philippine context, Roxas and Chadee (2012) linked environmental orientation to financial and resource availability, noting that many small firms lack the capital required for deep operational greening. Taylo (2023) further emphasized that grassroots green initiatives in the country tend to flourish when supported by community networks and targeted government programs.

Despite these insights, much of the existing literature continues to model green behavior as either an outcome variable (e.g., adoption intensity) or a predictor of firm performance, thereby offering a limited understanding of how sustainability practices are configured in micro-enterprises. As a result, a gap persists in the conceptualization of green behavior as a patterned, multidimensional phenomenon, particularly among food micro-businesses operating under heterogeneous constraints.

Positioning of the Present Study

This study is explicitly theory-building and exploratory in nature. Building on resource-based and institutional perspectives, it seeks to inductively examine how green practices cluster among food micro-businesses by identifying latent behavioral dimensions and empirically deriving sustainability typologies. By distinguishing between visible operational practices and internally

driven efficiency practices, and by classifying enterprises based on these dimensions, the study extends existing sustainability frameworks beyond linear adoption models. The resulting behavioral typology provides a foundation for refining theory on micro-enterprise sustainability while offering a structured lens for future hypothesis testing and policy design.

RESEARCH METHOD

Research Design

This study employed a quantitative, exploratory research design utilizing both exploratory factor analysis (EFA) and cluster analysis to identify patterns of green behavior among food micro-businesses. Factor analysis was used to uncover the latent dimensions within the reported green practices, while cluster analysis was conducted to group businesses based on similarities in their sustainability-related behavior. This approach allows for a more detailed understanding of green behavior beyond descriptive reporting and supports the development of targeted sustainability interventions.

Research Locale

The study was conducted in Ozamiz City, Philippines, a first-class city in the province of Misamis Occidental. As a commercial hub with a dense concentration of micro and small food enterprises, Ozamiz serves as a microcosm of grassroots entrepreneurship in the region. Local food micro-businesses, such as small eateries, street vendors, bakeries, and home-based food producers, were the focus of the survey due to their direct involvement in environmentally impactful practices, particularly in energy use, waste management, and food packaging.

Participants and Sampling

The dataset used in this study was drawn from a survey of food micro-business owners in Ozamiz City. The participants were selected through purposive sampling, ensuring that all respondents met the criteria of being:

1. Owners or operators of micro-businesses in the food sector,
2. Located within Ozamiz City, and
3. Operating with a workforce of fewer than 10 employees, in accordance with the definition provided by the Philippine Department of Trade and Industry (DTI).

A total of 30 valid responses were included in the analysis. Although limited in number, the sample is sufficient for exploratory analysis because the item-to-respondent ratio is acceptable for preliminary factor and cluster models, particularly when item communality is high (Cohen, 1988).

Instrument

The primary data collection instrument was a structured survey questionnaire designed to measure the extent of green practices among micro-businesses. The questionnaire focused on four domains of green behavior: Energy Conservation, Water Conservation, Proper Waste Disposal, and Sustainable Food Packaging. Each domain contained five items, for a total of 20 items. Respondents rated each item using a 4-point Likert scale, ranging from 1 (Never) to 4 (Always).

The use of a 4-point Likert scale was intentional to avoid a neutral midpoint, encouraging respondents to express a definitive frequency of behavior and reducing the tendency to choose neutral responses. While this scale format may increase the likelihood of extreme responses, it was considered appropriate for capturing actionable information about actual practices rather than attitudes. Respondents may still be subject to social desirability bias, particularly in reporting environmentally friendly behaviors, but the survey was designed with clear, concrete items to minimize overreporting.

Sample items include:

1. "We turn off equipment and appliances when not in use."
2. "We segregate waste into recyclable, biodegradable, and non-biodegradable categories."
3. "We avoid single-use plastics in packaging."

The questionnaire was administered in both English and Bisaya to ensure comprehension and accessibility among local respondents.

The instrument development and validation followed a structured procedure. Initially, items were drafted based on a review of the literature on green practices in micro-businesses. To ensure content validity, the draft questionnaire was reviewed by a panel of five business faculty members. They teach sustainability, environmental management, and local entrepreneurship in the college. The panel assessed each item for clarity, relevance, and cultural appropriateness, providing feedback that led to revisions and refinements.

A pilot test was subsequently conducted with 10 micro-business owners to assess comprehension, language clarity, and the questionnaire's practical feasibility. Based on pilot feedback, minor adjustments were made to ensure that the final instrument accurately captured the intended behaviors while remaining understandable and contextually appropriate.

Data Analysis Procedures

Data analysis was carried out using Jamovi, an open-source statistical software designed for ease of use in quantitative research. The following analytical procedures were employed:

Exploratory Factor Analysis (EFA)

EFA using Principal Axis Factoring with Varimax rotation was performed to identify the underlying dimensions of green behavior. Prior to analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were conducted to validate the suitability of the data for factor analysis. Items with factor loadings ≥ 0.40 were retained for interpretation.

Cluster Analysis

A K-Means cluster analysis was conducted using the standardized factor scores to classify respondents into groups based on their green behavior profiles. The number of clusters was determined based on interpretability and analysis of the elbow method and within-cluster sum of squares.

Reliability Analysis

To assess the internal consistency of the survey instrument, Cronbach's alpha coefficients were computed for the entire 20-item scale and its thematic subscales. Cronbach's alpha remains one of the most widely accepted indicators of the internal consistency of psychometric instruments, especially in social science and exploratory behavioral research. A threshold of $\alpha \geq 0.70$ is generally regarded as acceptable for research purposes, while values closer to 0.90 indicate excellent consistency (Nunnally & Bernstein, 1994; Tavakol & Dennick, 2011).

Despite the relatively modest sample size (n = 30), the analysis yielded strong reliability estimates, validating the instrument's stability and internal cohesion. The overall Cronbach's alpha for the 20-item green behavior scale was 0.917, reflecting excellent internal consistency across the full set of items. This suggests that the instrument reliably captures the construct of environmental behavior among food micro-businesses.

When disaggregated into conceptual subscales, the reliability coefficients were also satisfactory. Water Conservation (5 items) demonstrated a Cronbach's alpha of 0.843, followed by Food Packaging (5 items) with 0.821, Proper Waste Disposal (5 items) with 0.737, and Energy

Conservation (5 items) with 0.665.

These subscale results indicate that three of the four domains meet or exceed the recommended reliability threshold. While the Energy Conservation dimension yielded a slightly lower alpha (0.665), it remains within an acceptable range for exploratory research involving small and targeted populations (DeVellis, 2017). Slightly lower alpha values in small-scale studies often reflect nuanced variation in behavioral practices rather than measurement error, particularly in context-specific micro-enterprise settings where item interpretation may vary.

Importantly, the high alpha for the overall scale and key subscales supports the internal homogeneity of the items and reinforces the instrument's soundness for further statistical analyses, including factor and cluster analyses. These findings offer confidence that the observed patterns in green behavior are not the result of measurement inconsistencies, but rather meaningful distinctions in business practices.

In summary, the internal reliability evidence from Cronbach's alpha indicates that the scale is both statistically sound and contextually appropriate for capturing dimensions of green behavior among micro-business respondents, even within the constraints of a focused sample size. As such, the instrument is well-positioned to contribute to the typological classification and behavioral profiling central to this study.

Ethical Considerations

The data collection adhered to ethical standards, including obtaining informed consent, ensuring confidentiality, and ensuring voluntary participation. No identifying information was collected, and all responses were treated with strict confidentiality. The data analysis was conducted in accordance with the same ethical principles, ensuring that the data were used solely for academic and research purposes.

FINDINGS AND DISCUSSION

Profile of Respondents

Table 1 presents the demographic profile of the respondents, summarizing their ages, years in business, and number of employees. These characteristics provide essential contextual information on the scale, experience, and maturity of the food micro-businesses included in the study and serve as a basis for interpreting subsequent analyses of green behavior patterns.

Table 1. Demographic Profile of Respondents (n=30)

Variable	Category	Frequency	Percentage (%)
Age	18–25 years	11	36.7
	25–35 years	11	36.7
	36–45 years	4	13.3
	46–55 years	4	13.3
	56 years and above	0	0.0
	Total	**30**	**100.0**
Years in Business Operation	Less than 1 year	15	50.0
	1–3 years	12	40.0
	4–6 years	1	3.3
	7–10 years	1	3.3
	More than 10 years	1	3.4
	Total	**30**	**100.0**
Number of Employees	1–5 employees	25	83.4

	6–10 employees	5	16.6
	Total	**30**	**100.0**

Table 1 summarizes the demographic characteristics of the 30 food micro-business owners included in the study. In terms of age, the majority of respondents were relatively young to middle-aged, with 73.4% falling within the 18–35 age range. This suggests that sustainability practices among food micro-businesses in Ozamiz City are largely shaped by owners who are in the early to mid-stages of their entrepreneurial careers. The remaining respondents were evenly distributed between the 36–45 and 46–55 age groups (13.3% each), while no participants were aged 56 and above.

With respect to business experience, half of the respondents (50.0%) had been operating their businesses for less than one year, and a further 40.0% reported 1–3 years of operation. This indicates that the sample is dominated by relatively young enterprises, which may still be establishing operational routines, including sustainability practices. Only a small proportion of businesses (10.0%) had been in operation for more than three years, reflecting the early-stage nature of most enterprises in the sample.

In terms of firm size, the vast majority of respondents (83.4%) operated with 1–5 employees, consistent with the formal definition of micro-enterprises in the Philippine context. The remaining 16.6% employed between 6 and 10 workers. This distribution highlights the resource-constrained nature of the enterprises studied and provides important context for interpreting variations in green behavior, particularly regarding internal efficiency practices that may require workforce training and operational investments.

Overall, the demographic profile underscores that the study captures sustainability behavior among predominantly young, small-scale, and early-stage food micro-businesses, reinforcing the relevance of a typology-based approach that accounts for heterogeneity in capacity, experience, and organizational maturity.

Exploratory Factor Analysis of Green Behavior Dimensions

This study employed a pilot exploratory approach to investigate green practices among food micro-businesses in Ozamiz City. Given the small sample size (n = 30) relative to the 20-item scale, the findings are interpreted with caution, following recommendations for small-sample factor analysis (MacCallum et al., 1999; Hair et al., 2019). The primary aim was to identify preliminary patterns in sustainability behaviors to inform future instrument refinement and larger-scale studies.

Assumption Testing

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.562, indicating marginal but acceptable factorability in a small-sample context (Cohen, 1988). Bartlett's Test of Sphericity was significant, $\chi^2(190) = 473$, $p < .001$, confirming sufficient item intercorrelations for factor analysis. Item-level MSA values ranged from 0.291 to 0.841. Items PWD4 (0.291) and WC5 (0.450) fell below the recommended threshold of 0.50. These items were retained due to their conceptual importance in capturing internal operational sustainability practices, but their low adequacy underscores the need for refinement in future studies.

Factor Extraction and Structure

Principal Axis Factoring with Varimax rotation yielded a two-factor solution based on eigenvalues > 1 and the scree plot, explaining 49.0% of the total variance.

1. Factor 1: Visible and Operational Green Practices (31.6% variance, eigenvalue = 7.54). This

dimension captured externally observable behaviors, including water conservation, sustainable food packaging, and selected waste management practices (PWD2, PWD5). Examples include using biodegradable packaging, monitoring water usage, and encouraging customer participation in waste programs.

2. Factor 2: Internally Driven Efficiency Practices (17.4% variance, eigenvalue = 1.94). This factor represented internal operational routines less visible to consumers, such as energy management, equipment maintenance, and staff education (EC3–EC5, EC4, PWD3, PWD4).

The emergence of two factors, rather than the original four conceptual domains, suggests conceptual overlap among domains: external behaviors (water, packaging, visible waste) coalesce into a single observable dimension, whereas internal operational behaviors (energy, internal waste) form a distinct latent dimension. This dual structure aligns with prior sustainability behavior models (Maniu et al., 2021; Muafi & Siswanti, 2024), highlighting that micro-business green behavior manifests along both visible and internally driven lines.

Cross-loadings and high uniqueness values were observed for a few items (e.g., EC1, PWD1, WC5), indicating that some items are not yet fully institutionalized across micro-businesses. Only items with factor loadings ≥ 0.40 were retained for interpretation to maintain consistency between narrative and tables (see Table 2).

Internal consistency was high for both factors, supporting preliminary reliability. Factor 1 (Visible Operational Green Practices) demonstrated strong reliability with a Cronbach's alpha of 0.912, while Factor 2 (Internally Driven Efficiency Practices) showed acceptable reliability with a Cronbach's alpha of 0.840. These values exceed the recommended threshold of 0.70 (Nunnally & Bernstein, 1994; Tavakol & Dennick, 2011), indicating that both constructs are reliable and internally consistent, even with a relatively small sample size.

Table 2. Exploratory Factor Analysis Loadings for Green Behavior Items (Varimax Rotation)

Item Code	Description	Factor 1	Factor 2	Uniqueness
EC2	Turn off equipment/appliances	0.43	0.50	0.57
EC3	Conduct regular maintenance	—	0.68	0.54
EC4	Educate employees on energy-saving	—	0.75	0.40
EC5	Invest in energy-efficient equipment	0.58	0.63	0.27
WC1	Monitor and reduce water usage	0.59	—	0.59
WC2	Use water-saving devices	0.75	—	0.41
WC3	Recycle water for cleaning	0.56	0.38	0.55
WC4	Repair leaks to reduce water waste	0.79	0.37	0.24
WC5	Use rainwater collection systems	0.56	—	0.64
PWD2	Collaborate with recycling centers	0.71	0.30	0.41
PWD3	Avoid improper waste disposal	0.32	0.71	0.40
PWD4	Avoid burning waste	—	0.67	0.55
PWD5	Encourage customers to join waste programs	0.61	—	0.63
FP1	Use biodegradable packaging	0.66	—	0.56

FP2	Avoid single-use plastics	0.66	—	0.48
FP3	Encourage reusable containers	0.66	0.36	0.43
FP4	Minimize packaging used	0.60	—	0.61
FP5	Provide incentives for eco-friendly packaging	0.79	—	0.37

Cluster Analysis of Green Behavior Profiles

K-means clustering using factor scores identified three clusters. Due to the small sample size and sensitivity of K-means, the singleton cluster (n = 1) was interpreted as an extreme or boundary case, highlighting symbolic adoption of visible green practices without substantial internal operational commitment.

Table 3. Cluster Profiles

Cluster	Factor 1: Visible Operational	Factor 2: Internal Efficiency	Size (n)	Label
0	2.17	2.92	9	Moderate Green Practitioners
1	3.00	1.00	1	Isolated Minimalist
2	3.42	3.74	20	Sustainability-Oriented Enterprises

1. Cluster 2 – Sustainability-Oriented Enterprises (n = 20):
   This dominant cluster reflects a high degree of engagement in both external and internal sustainability practices. Their consistent commitment suggests institutionalization of green values, potentially driven by market positioning, innovation goals, or environmental awareness (Martins et al., 2022).
2. Cluster 0 – Moderate Green Practitioners (n = 9):
   Businesses in this group exhibited average performance, particularly in internal efficiency. These enterprises may lack the technical or financial means for full implementation, as reflected in discussions of barriers faced by smaller firms (Ashton et al., 2017).
3. Cluster 1 – Isolated Minimalist (n = 1):
   Though small in number, this outlier represents an enterprise that performs visible practices, likely for reputational or compliance reasons, but lacks corresponding operational depth. This pattern resembles symbolic greenwashing observed in MSME contexts (Boz et al., 2020; Bestari & Butarbutar, 2021).

The single-member cluster should be viewed diagnostically rather than statistically. It highlights the divergence between external visibility and internal operational practices, underscoring the need for interventions targeting genuine operational adoption. Future studies with larger samples should validate clusters using hierarchical methods and silhouette coefficients.

Discussion

Uncovering Dimensions of Green Behavior

This study explored how green practices among food micro-businesses in Ozamiz City are organized behaviorally, revealing key insights into the structure and manifestation of grassroots sustainability efforts. Given the small sample size (n = 30) and 20-item scale, these analyses are preliminary and exploratory, consistent with recommendations for small-sample factor analysis (MacCallum et al., 1999; Hair et al., 2019). Through exploratory factor analysis (EFA) using

Principal Axis Factoring with Varimax rotation, two primary dimensions emerged—Visible and Operational Green Practices and Internally Driven Efficiency Practices—explaining 49% of the total variance in responses. These dimensions affirm that green behavior among micro-enterprises is not monolithic but occurs along distinct, interpretable lines.

Visible and Operational Green Practices comprised consumer-facing and easily observable actions, such as minimizing packaging, adopting biodegradable materials, and conserving water. This dimension aligns with green branding and customer-driven sustainability documented in prior studies (Bestari & Butarbutar, 2021; Wandosell et al., 2021), in which small businesses leverage visible greening strategies to appeal to environmentally conscious consumers.

However, much of this empirical literature conceptualizes green behavior as a unidimensional or aggregated construct—often modeled through regression-based adoption indices—thereby assuming relatively uniform sustainability engagement across firms. The present factor-analytic results extend these studies by demonstrating that externally visible practices form a distinct behavioral dimension that may coexist independently from deeper operational commitments.

Internally Driven Efficiency Practices, by contrast, included actions less apparent to consumers but critical for operational sustainability, such as equipment maintenance, turning off unused appliances, and staff education on green practices. These findings echo those of Ashton et al. (2017) and Maniu et al. (2021), who assert that internal behaviors are often shaped by intrinsic motivation and long-term efficiency goals rather than by external validation.

While prior empirical studies frequently model such practices as predictors of performance or cost efficiency, the current findings challenge linear interpretations by revealing that internal efficiency practices do not necessarily scale in tandem with visible sustainability efforts. This suggests that micro-enterprises may adopt selective or staged greening strategies rather than progressing along a single continuum of sustainability adoption.

Notably, the moderate KMO value (0.562) and cross-loading of certain items (e.g., composting, leak repair) suggest that while the dimensions are coherent, some green practices may not yet be fully institutionalized across all micro-businesses. Item-level MSA values ranged from 0.291 to 0.841, with PWD4 (0.291) and WC5 (0.450) falling below recommended thresholds. These items were retained due to their conceptual importance, particularly in capturing internally driven operational sustainability behaviors, though their low adequacy highlights areas for instrument refinement.

This reflects the contextual barriers faced by enterprises in resource-constrained environments, including limited access to infrastructure, information gaps, or fragmented policy support. These empirical nuances are often obscured in non-typological studies that rely on average adoption scores, masking meaningful heterogeneity in how sustainability practices are enacted at the firm level.

In addition to conceptual clarity, the internal consistency of each factor was examined using Cronbach's alpha. Factor 1: Visible Operational Green Practices achieved an alpha of 0.912, and Factor 2: Internally Driven Efficiency Practices yielded 0.840. These values exceed the commonly accepted threshold of 0.70 for behavioral research (Nunnally & Bernstein, 1994; Tavakol & Dennick, 2011), providing preliminary evidence of the instrument's reliability despite the small sample size. The strong alpha values also bolster the validity of subsequent cluster analyses that rely on factor-based scores and support future refinement and validation of the instrument.

The findings reveal a dual structure of green practices among micro-businesses: externally visible behaviors and internally driven operational routines. This bifurcation aligns with prior work on sustainability adoption (Ashton et al., 2017; Maniu et al., 2021) and demonstrates that micro-businesses may engage selectively in greening, adopting observable practices for reputation while

internal processes lag behind.

Despite the small sample, the high internal consistency of factor-based scales provides a foundation for refining survey items and validating constructs in future research. Moreover, the observed heterogeneity in cluster profiles emphasizes that green behavior is not uniform, even among similar enterprises, calling for behaviorally tailored interventions rather than one-size-fits-all programs.

The study also underscores methodological insights: low-MSA items, cross-loadings, and singleton clusters highlight the challenges of conducting factor and cluster analyses with small samples. By framing the study as pilot exploratory research, these results provide valuable guidance for future larger-scale investigations into micro-business sustainability practices.

Behavioral Clusters and Enterprise Typologies

To further elucidate the diversity in sustainability engagement, K-means clustering based on the factor scores identified three distinct behavioral profiles among the respondents, demonstrating that green behavior among food micro-businesses is patterned rather than uniformly distributed.

1. Sustainability-Oriented Enterprises (Cluster 2) – Exhibiting high scores across both visible operational and internally driven efficiency dimensions, these businesses exemplify comprehensive green integration. Their practices suggest a relatively advanced stage of sustainability adoption, consistent with findings from Martins et al. (2022), who emphasize the operational and reputational advantages for SMEs that engage deeply with environmental responsibility. However, unlike prior empirical studies that infer such maturity from high aggregate sustainability scores, the present typological analysis reveals that this level of engagement represents a distinct subgroup rather than the normative condition among micro-enterprises.
2. Moderate Green Practitioners (Cluster 0) – Characterized by moderate internal efficiency and weaker engagement in visible operational practices, these businesses appear constrained not by a lack of environmental awareness but by limited capacity. This pattern aligns with the resource and capability barriers discussed by Ashton et al. (2017) and Muafi and Siswanti (2024). Importantly, regression-based studies that report "moderate adoption levels" may conflate this group with both high- and low-performing firms, whereas the present clustering approach isolates this segment as a transitional category with specific developmental needs. Targeted support programs—such as skills training, green certification incentives, or resource-sharing networks—could facilitate their progression toward deeper integration of sustainability.
3. Isolated Minimalist (Cluster 1) – Representing a numerically small but analytically significant case (n = 1), this enterprise exhibited moderate engagement in visible green practices alongside negligible internal efficiency. This configuration suggests symbolic greening, or "greenwashing," in which externally observable actions are adopted primarily for reputational or compliance purposes rather than for substantive environmental impact (Boz et al., 2020). Such a pattern is rarely captured in non-typological empirical studies, which tend to treat visible green actions as proxies for overall sustainability commitment. The identification of this cluster challenges that assumption by demonstrating that external greening may occur independently of internal operational change.

The presence of a single-member cluster warrants careful methodological interpretation. Rather than being treated as a statistical anomaly or dismissed as noise, this case is best understood as an extreme or boundary configuration revealed through unsupervised clustering. In exploratory typology-building research, such singleton clusters can illuminate theoretically meaningful

patterns that would otherwise be obscured by aggregate or regression-based approaches.

Analytically, the emergence of this isolated case highlights the capacity of factor-based clustering to detect divergence between visible and internal sustainability practices—an asymmetry that is rarely captured in non-typological empirical studies, where externally observable actions are often assumed to reflect overall environmental commitment. In practice, this cluster signals the potential for micro-enterprises that superficially comply with sustainability norms without embedding corresponding operational changes.

From a policy and intervention standpoint, the identification of even a single such case is consequential. It underscores the need for monitoring frameworks and support programs that go beyond visible compliance indicators and assess internal practices when evaluating sustainability readiness. As such, the singleton cluster should be interpreted not in terms of prevalence, but in terms of diagnostic value—serving as an early warning signal for symbolic adoption patterns within the broader micro-enterprise population.

Overall, this classification contributes to a nuanced understanding of environmental behavior in micro-business contexts. Whereas many empirical studies (e.g., Nguyen et al., 2019; Apurbo et al., 2020) model sustainability behavior as a function of business characteristics or motivational drivers, the present study extends this literature by showing that similar enterprises can exhibit fundamentally different configurations of green practices. This bottom-up, practice-based typology not only advances theoretical understanding of micro-enterprise sustainability but also enables more precise and equitable policy interventions, moving beyond one-size-fits-all approaches toward capacity-sensitive and behaviorally informed strategies.

Contributions to Literature and Local Relevance

This research advances the literature in several ways. First, it empirically confirms that green behavior among micro-businesses can be structured and grouped into meaningful categories. Second, it fills a critical gap in Philippine sustainability studies by offering insights specific to food micro-enterprises—an often-overlooked sector in environmental discourse (Roxas & Chadee, 2012).

The use of factor-based clustering also contributes a methodological innovation to the field. It allows for simultaneous dimensional reduction and behavior classification, a strategy well-suited for local government units and NGOs that need to identify typologies for policy targeting, especially in resource-limited settings.

CONCLUSIONS

This study set out to explore and classify green behavioral patterns among food micro-businesses in Ozamiz City using a combined approach of exploratory factor analysis and cluster analysis. The results uncovered two distinct dimensions of sustainable behavior: Visible and Operational Green Practices and Internally Driven Efficiency Practices. These dimensions were used to classify businesses into three behavioral profiles—Sustainability-Oriented Enterprises, Moderate Green Practitioners, and an Isolated Minimalist—highlighting the heterogeneity in sustainability engagement even among enterprises within the same sector and locality.

The findings reaffirm that while several food micro-businesses have meaningfully embedded sustainability into both their operations and customer-facing practices, others remain either only partially engaged or merely performative. This typological insight is crucial for stakeholders—such as local government units, NGOs, and business development centers—who are tasked with promoting inclusive environmental programs and sustainable enterprise development.

From a policy and practice standpoint, the results suggest that a one-size-fits-all approach to promoting green behavior will likely be ineffective. Instead, development initiatives must be

tailored to the behavioral profile and readiness of each enterprise:

1. For Sustainability-Oriented Enterprises, advanced interventions like eco-certification, innovation grants, and market expansion programs can help them scale their impact and influence others as peer leaders.
2. For Moderate Green Practitioners, capacity-building programs focused on infrastructure access, energy audits, and low-cost greening solutions can bridge the gap between intention and execution.
3. For the Isolated Minimalist, foundational awareness-raising, regulatory incentives, and mentorship from high-performing peers may be necessary to spark a genuine transition toward sustainability.

The study also offers several directions for future research. First, expanding the sample size and including additional business sectors would enable broader generalization and comparative analysis. Second, incorporating business profile data—such as ownership type, access to government programs, and financial status—would enable predictive modeling to identify the factors that most influence sustainability behavior. Lastly, using mixed methods, including qualitative interviews or observational studies, would shed light on the motivations, challenges, and contextual drivers underlying the behaviors captured quantitatively in this study.

In conclusion, this research contributes to a data-driven, localized understanding of green behavior in micro-businesses. By highlighting both the diversity and the potential within the micro-enterprise sector, it provides a strong foundation for designing interventions that are contextually relevant, behaviorally grounded, and strategically targeted. As the world moves toward a greener economy, such localized and nuanced studies are indispensable for crafting solutions that are not only sustainable but also inclusive and scalable from the ground up.

LIMITATION & FURTHER RESEARCH

Several methodological limitations should be acknowledged. First, the small sample size (n = 30) limits the generalizability of the findings and contributes to marginal sampling adequacy for certain items, as evidenced by low MSA values (e.g., PWD4 = 0.291, WC5 = 0.450). While these items were retained for conceptual reasons, future research should consider removing low-MSA items or refining them to enhance construct validity

Second, the two-factor solution emerged despite the theoretical design of four conceptual domains, suggesting some overlap among energy, water, waste, and packaging behaviors. This discrepancy highlights the need for further refinement of the instrument and validation in larger samples. Third, the cluster analysis revealed a singleton cluster (n = 1), which should be interpreted as an extreme profile rather than a substantive cluster. This finding underscores the challenges of conducting cluster analysis with small samples and reinforces the importance of multiple validation techniques (e.g., hierarchical clustering, silhouette coefficients) in future studies.

Finally, cross-loadings and moderate communalities for certain items indicate that some green practices may not yet be fully institutionalized across micro-businesses, particularly in resource-constrained environments. Despite these limitations, the study provides valuable pilot insights into micro-business green practices, offering a foundation for instrument refinement, larger-scale validation, and the development of behaviorally informed interventions. Future research should replicate these analyses with larger and more diverse samples, potentially integrating longitudinal designs to capture the evolution of sustainability adoption over time.

Policy and Practical Implications

The typology emerging from this study offers a roadmap for action. Stakeholders may use these clusters to craft differentiated interventions: high-performing businesses may be recruited

as sustainability champions; moderate performers may benefit from access to resources and technical support; and low performers may require foundational education and incentives to adopt deeper practices. This differentiated strategy ensures more effective use of limited development resources and increases the likelihood of long-term, embedded sustainability behaviors in the micro-enterprise sector.

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