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Everyday Environmentalism in a High-Density Migrant Neighbourhood: Social Norms, Place Attachment and the Spatial Structure of Pro-Environmental Behaviour in Hor Al Anz, Dubai

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ABSTRACT

Hor Al Anz, a densely populated residential district in Deira, Dubai, is home to a predominantly South Asian, Arab, and African working population. This neighborhood, spanning roughly four square kilometers, experiences densities approaching ten thousand people per square kilometer. Such districts bear a significant portion of the emirate's environmental footprint concerning household waste, water, and energy consumption. However, they are seldom the focus of behavioral research. This paper presents a spatially explicit investigation into everyday pro-environmental practices within this neighborhood. The study is structured around two primary contributions: the Neighbourhood Environmental Behaviour Ecosystem (NEBE), a framework that contextualizes individual psychology within neighborhood social norms, amenity access, and municipal institutions; and the Community Environmental Behaviour Index (CEBI), a weighted composite measure that can be scored and mapped at a micro-zone scale.Due to the unavailability of a fielded survey at the time of writing, the analysis utilizes an illustrative sample of 412 residents. The response structure aligns with established environmental psychology literature, and the zones are defined by official Dubai Municipality community boundaries. The results serve as a reproducible template rather than definitive findings about the resident population. Measurement quality is robust, with Cronbach's alpha ranging from 0.66 to 0.78 and Average Variance Extracted (AVE) exceeding 0.57. A covariance-based structural model demonstrates good fit (CFI 1.00, RMSEA 0.000), indicating that behavioral intention ($\beta = 0.42$), perceived behavioral control ($\beta = 0.22$), and place attachment ($\beta = 0.24$) directly predict behavior. Attitude influences behavior indirectly through personal norms. A proportional-odds model examining waste-separation frequency confirms that control and attachment are the most significant correlates. Cluster analysis identifies three resident segments differing by 16 CEBI points. Global Moran's I is not statistically significant ($I = -0.156$, $p = 0.52$) suggesting that at the scale of nine micro-zones, behavior is patterned socially rather than spatially. The study concludes with implications for Dubai Municipality' community engagement and waste-service design, and the survey instrument is provided for future deployment.

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Introduction

The majority of a city's environmental impact occurs in ordinary settings during routine daily activities. These actions range from a tenant's decision to separate recyclables or discard them in the general waste, to a family's air conditioning usage, an individual's choice to walk or drive, or the improper disposal of food waste. For decades, environmental psychology has sought to explain these micro-level decisions [1, 2]. A consistent finding is that attitudes alone explain very little; social norms, perceived ability to act, and the practical convenience of taking action are far more influential [3-5]. However, it remains less clear how these determinants are distributed across neighborhoods in rapidly developing, highly diverse cities, and whether environmental practices align with infrastructure, social composition, or neither.

Dubai presents a compelling case for such an inquiry. Its population is predominantly composed of migrants on fixed-term residency, with short household tenure by international standards. The built environment varies significantly, from single-family villas to bachelor accommodations housing numerous occupants. Crucially, the municipal authority possesses both the capacity and the aspiration to act upon research findings. Older districts like Deira, with Hor Al Anz as a prime example, have received less scholarly attention compared to newer master-planned communities, despite housing a substantial portion of the population and disproportionately contributing to the environmental load [9, 10]. The Dubai 2040 Urban Master Plan's objectives for creating livable, walkable, and resource-efficient neighborhoods will be tested in these very areas [20].

This paper introduces a study design, two key instruments, and a demonstration analysis. The design involves a spatially explicit household survey stratified across micro-zones within the official community boundaries of Hor Al Anz and Hor Al Anz East. The first instrument, the Neighbourhood Environmental Behaviour Ecosystem (NEBE), frames standard psychological constructs from the theory of planned behavior and the value-belief-norm model within a neighborhood context encompassing visible norms, amenity access, and place attachment, alongside an institutional layer of municipal services and tenancy arrangements. The second instrument, the Community Environmental Behaviour Index (CEBI), is a weighted composite of behavior, intention, norms, control, and attachment, which can be scored individually, averaged by zone, and analyzed for spatial structure. The demonstration analysis employs confirmatory measurement, covariance-based structural equation modeling, proportional-odds regression, k-means segmentation, and spatial autocorrelation statistics on an illustrative sample calibrated to existing literature. The analytical approach is deliberately rooted in the behavioral science tradition, prioritizing people over infrastructure evaluation.

Two important caveats frame the subsequent discussion. First, the survey has not yet been deployed; therefore, the presented figures constitute a template for the anticipated analysis, not empirical findings about Hor Al Anz residents. Second, the neighborhood is home to a large low-income migrant population whose environmental behavior is shaped by housing conditions beyond their control. The study aims to inform services that facilitate positive practices, rather than to evaluate or categorize residents.

Research questions

This study is guided by four primary questions. Firstly, which psychological and neighborhood constructs effectively predict everyday pro-environmental behavior among Hor Al Anz residents, and through what pathways? Secondly, do residents form distinct, identifiable segments, and are these segments associated with nationality or independent of it? Thirdly, does behavior vary based on tenure and between the two administrative communities? Finally, is there a discernible spatial structure within a composite index of community environmental behavior, and at what scale? The initial three questions are addressed using individual-level models, while the fourth is examined through spatial statistics on zone-level aggregates.

The study area

Hor Al Anz is situated on the eastern edge of Deira, bordered by Abu Baker Al Siddique Road, Al Ittihad Road, Al Rasheed Road, and Baghdad Street. It is administratively divided into Hor Al Anz (Dubai Municipality community 127) and Hor Al Anz East (community 133). The district's name originates from a horse belonging to Sheikh Saeed bin Maktoum that died and was buried on the site in a collapsed dune.

Established in the early 1970s primarily for Emirati families, the district has evolved into one of the most densely populated areas in the emirate. The 2000 census recorded approximately 40,000 residents within 4.18 square kilometers, yielding a density exceeding 9,600 people per square kilometer, with population growth anticipated since then. The housing stock predominantly consists of low-rise apartment buildings, supplemented

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by a smaller number of villas. The residents are primarily South Asian, Arab, African, and East Asian working adults, with a significant portion residing in shared accommodations. Hor Al Anz Park, featuring a jogging track and recreational areas, lies near the boundary between the two communities, while the Green Line's Abu Hail metro station is located on the western edge. Figure 1 illustrates the study area's location within the emirate, and Figure 2 depicts the two communities, their neighboring areas, the amenities considered in the analysis, and the nine micro-zones.

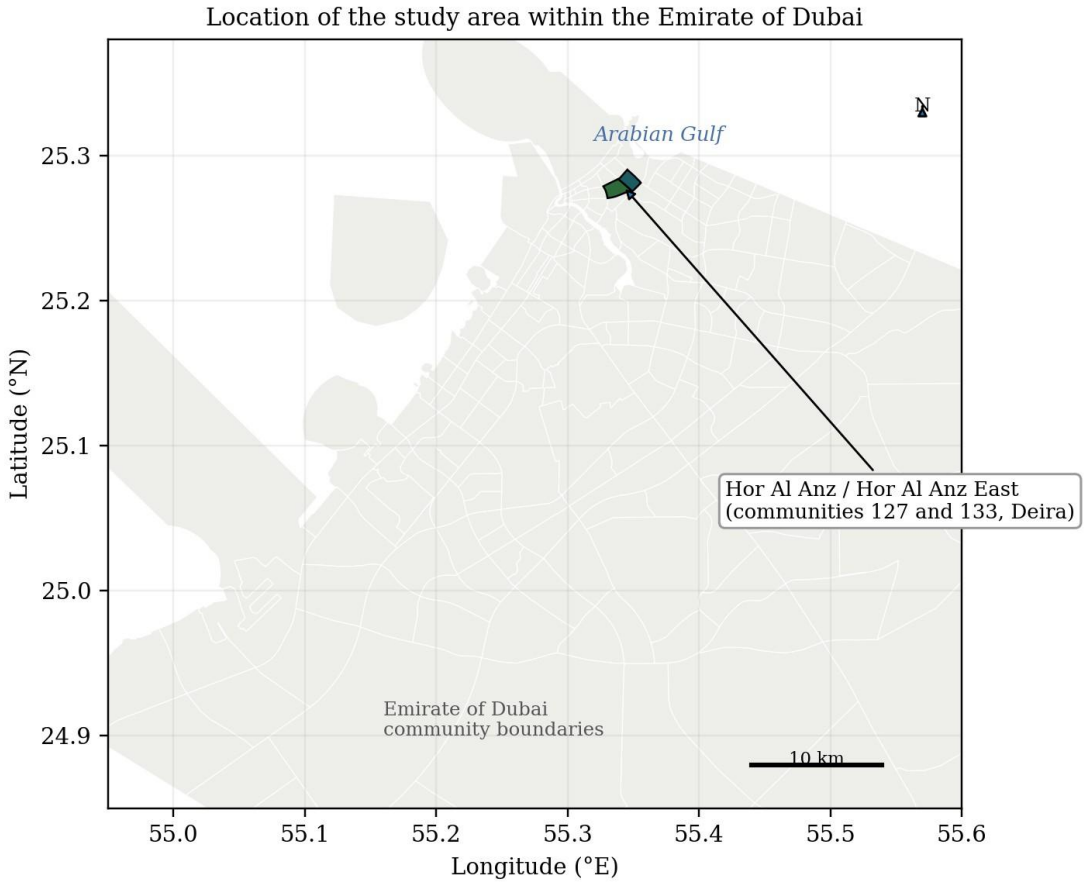

Fig. 1. Location of Hor Al Anz and Hor Al Anz East within the Emirate of Dubai. Community polygons from the Dubai Municipality community-boundary layer [19]; the study communities are shaded.

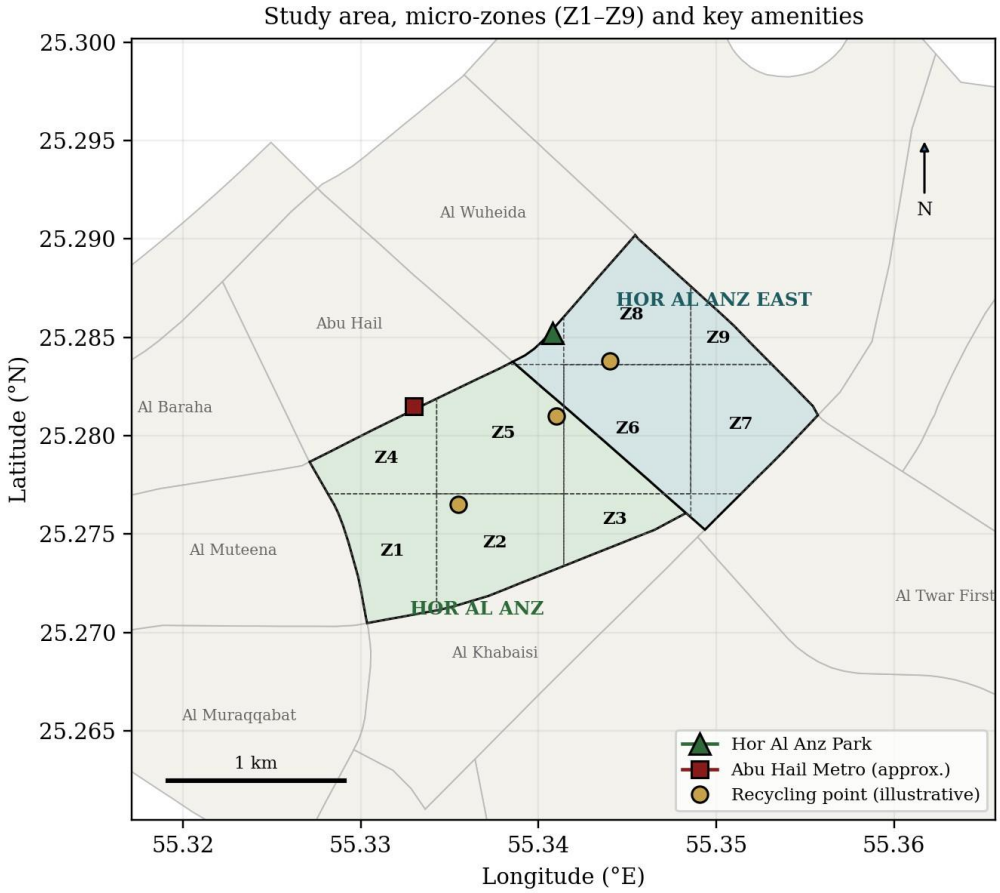

Fig. 2. Study area with adjacent Deira communities, the nine micro-zones (Z1–Z9) formed by clipping a regular grid to the official boundaries, and the amenities used in the accessibility measures. Park and metro positions are approximate; recycling points are illustrative locations pending field verification.

The micro-zones serve as the fundamental unit for spatial analysis. A regular grid was overlaid onto the combined area of the two communities and then clipped to the official boundaries. Zones retaining more than 8% of their original area were retained, resulting in nine zones of comparable size. Zone centroids were used to calculate straight-line distances to the park and the nearest recycling point, with adjustments for latitude. This zoning approach offers an analytical convenience and can be substituted with Dubai Municipality's official sub-community units once the survey is fielded.

Why this district matters for the emirate's sustainability commitments

Hor Al Anz presents a critical case for study due to three key features. Firstly, its density, approximately ten thousand residents per square kilometer, concentrates household resource consumption and waste generation to a degree unmatched by many of Dubai's newer developments. Consequently, even minor per-capita behavioral changes can yield substantial absolute impacts. Secondly, the prevalent housing forms—low-rise walk-up apartment blocks with shared chutes or ground-floor bin rooms, extensive shared and bachelor accommodations, and a residual stock of villas—create a diverse range of waste-handling arrangements within short distances, leading to considerable variation in the practical ease of waste separation, energy conservation, and water saving. Thirdly, the district experiences high population turnover due to employment and short-term rental contracts (typically one or two years).

This constant renewal necessitates the re-establishment of neighborhood behavioral norms with each cohort of arrivals, placing significant emphasis on the visible practices observed by new residents in shared spaces during their initial weeks.

Furthermore, the district is situated within a policy landscape that is increasingly demanding. Dubai Municipality's waste management strategy targets landfill diversion, the emirate's demand-side management strategy aims for per-capita reductions in electricity and water consumption, and the Dubai 2040 Urban Master Plan emphasizes the development of walkable, mixed-use neighborhoods with accessible green spaces [20]. These ambitious commitments are formulated at the emirate level but

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their implementation, or lack thereof, occurs at the building and street levels. This study is designed to pinpoint where this delivery mechanism is effective.

Data used for the maps

All maps utilize the Dubai Municipality community boundary layer, which assigns official numbers and names in both English and Arabic to each community [19]. The study encompasses two communities: Hor Al Anz (number 127), covering approximately 1.75 square kilometers, and Hor Al Anz East (number 133), covering about 1.38 square kilometers. The discrepancy with the 4.18 square kilometers reported in earlier census data reflects changes in boundary definitions and requires adjustment when comparing population densities across different sources. Amenity locations were derived from public map references and are marked as approximate. The depicted recycling points are illustrative and subject to verification and potential correction during fieldwork.

Conceptual framework and hypotheses

What is known about the determinants of everyday practice

Stern's framework for environmentally significant behavior distinguishes between private-sphere actions, such as waste separation and energy conservation, and public-sphere actions, like activism. Stern posits that both are shaped by a combination of attitudinal factors, contextual forces, personal capabilities, and habit [1]. The theory of planned behavior offers a widely tested model for understanding the attitudinal component, identifying attitude, subjective norm, and perceived behavioral control as key predictors of intention. Intention, along with perceived control, then predicts behavior [3]. A meta-analysis by Bamberg and Möser [4] of 46 studies indicated that intention mediates the effects of attitude, norms, and control on behavior. Additionally, personal norms contribute explanatory power, and awareness of consequences and feelings of responsibility reinforce these norms. Steg and Vlek's [2] integrative review highlighted two crucial points for neighborhood-focused studies: habitual behaviors are more responsive to contextual changes than to persuasion, and the strength of psychological determinants is contingent on the difficulty of the behavior. Kollmuss and Agyeman's [5] earlier review similarly cataloged the barriers preventing environmentally informed and concerned individuals from taking action.

Social norms warrant separate consideration. Schultz and colleagues' field experiment demonstrated that informing households about their neighbors' energy consumption patterns could alter their own usage. They also found that descriptive norms could paradoxically increase consumption among below-average users unless an injunctive signal of approval was also provided [6]. In a densely populated district like Hor Al Anz, where shared chutes, corridors, and streets render neighbors' behaviors constantly visible, the descriptive norm functions as an ambient condition rather than a message requiring explicit delivery. Gifford's work on psychological barriers to environmental action, along with Gifford and Nilsson's review of personal and social influences [7, 8], emphasizes that perceived social norms and perceived control represent among the most tractable levers for intervention.

The neighbourhood as a layer

The literature specific to Dubai introduces the neighborhood as a distinct entity. Alawadi's research on the emirate's older districts highlights how the form, density, and timing of urban redevelopment influence daily life. Furthermore, place attachment among long-term residents can foster a motivation for preservation, even when the physical infrastructure shows signs of wear [9, 10]. National studies on household waste practices reveal that demographic and housing characteristics account for a substantial portion of the variance in knowledge and behavior [11]. These studies also indicate that the intention to

recycle is translated into action only when perceived infrastructure support is adequate [12]. Community surveys conducted in the Emirati Journal of Business, Economics and Social Studies echo this sentiment, reporting high public awareness of sustainability but a weak link to practice, mediated by organizations, media, and services rather than direct awareness [13, 14]. Daouda's regional review offers a parallel perspective at the city scale, identifying coordination and institutions, rather than technology, as the critical constraint for Middle Eastern smart-city initiatives [15].

The Neighbourhood Environmental Behaviour Ecosystem

Figure 3. synthesizes these elements into a cohesive framework. At the core is the individual, characterized by attitude, personal norm, perceived control, and intention. Surrounding the individual is the neighborhood layer, encompassing social norms visible in shared spaces, amenity access that facilitates or hinders behavior, and place attachment, fostering a sense of ownership over outcomes.

This is further encompassed by the institutional layer, including municipal waste and recycling services and the tenancy regime, which dictates residents' stability and thus influences their engagement.

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The framework's distinctive contribution lies in the feedback loop: observed behavior in shared spaces becomes the visible descriptive norm for subsequent residents, potentially leading the neighborhood toward a high- or low-practice equilibrium, largely independent of individual attitudes. This assertion has direct spatial implications, which the CEBI is designed to test. If the feedback mechanism is strong, behavior should exhibit spatial clustering.

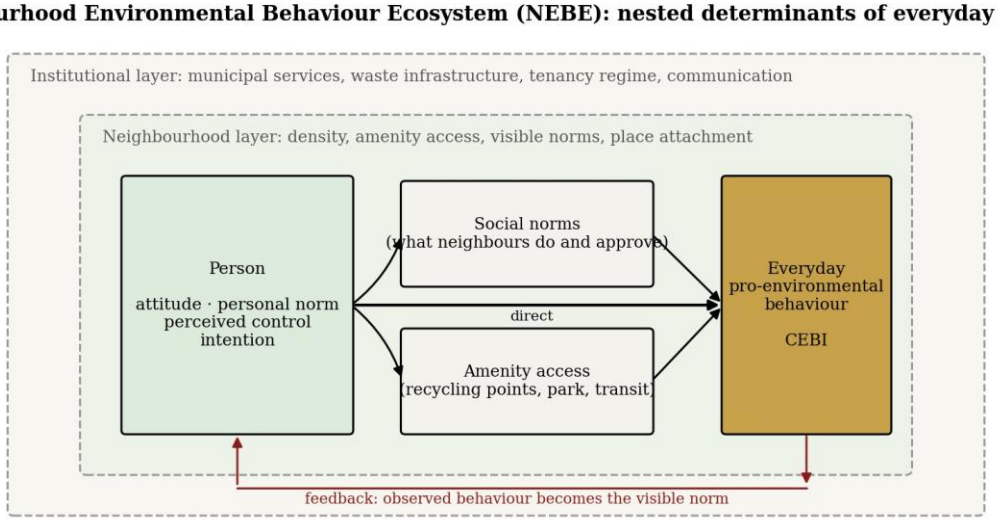

Fig. 3. The Neighbourhood Environmental Behaviour Ecosystem (NEBE). The person's constructs are those of the theory of planned behaviour extended with a personal norm; the neighbourhood layer adds social norms, amenity access and place attachment; the institutional layer sets the conditions. Observed behaviour feeds back into the visible norm.

Hypotheses

Table 1. Hypotheses and the tests applied to each.

	Hypothesis	Test
H1	Attitude and social norms predict personal norm; attitude,	Covariance-based SEM;
	social norms, perceived control, personal norm and place	standardised paths; bootstrap
	attachment predict intention; intention, perceived control and	indirect effect
	place attachment predict behaviour.	
H2	Perceived control, place attachment and proximity to recycling	Proportional-odds ordinal
	facilities are associated with more frequent household waste	logistic regression
	separation after controlling for attitude, norms and	
	demographics.	
H3	Residents form distinct segments defined by the configuration	k-means clustering; silhouette;
	of their constructs, and segment	χ^2 of segment by nationality

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	membership is not reducible to	
	nationality.	
H_4	Behaviour differs between Hor Al Anz and Hor Al Anz East and	Mann–Whitney U; Spearman's
	with length of residence, but not systematically by nationality	ρ; Kruskal–Wallis H
	group.	
H_5	Zone-level CEBI exhibits positive spatial autocorrelation	Global Moran's I with
	consistent with a norm-feedback process.	permutation inference; Getis–
		Ord Gi*; zone-level OLS on
		amenity distance

Materials and methods

Design and sampling frame

This study employs a cross-sectional household survey design, stratified by micro-zone with probability proportional to estimated residential density. This ensures that denser zones contribute a larger proportion of respondents. The target sample size is 400 completed interviews, sufficient for a seven-construct structural model with 23 indicators, adhering to the conventional ratio of ten cases per free parameter, and for zone-level means with at least 25 respondents in the least dense zone. Interviews will be conducted face-to-face in Arabic, English, Hindi/Urdu, and Bengali, at respondents' homes and in shared spaces. Quota controls for household type and gender will be implemented to mitigate potential daytime bias favoring non-working residents. The survey instrument is provided in Appendix A.

The illustrative sample

Fieldwork had not commenced at the time of this writing. To demonstrate the analysis process comprehensively, an illustrative sample of 412 respondents was generated with a known underlying structure. Latent constructs were simulated with correlations and path coefficients set according to ranges reported in meta-analytic literature [4]. Zone effects were linked to amenity distance to facilitate the examination of the spatial hypothesis. Likert items were derived from latent scores, standardized to loadings around 0.8, and rounded to a five-point scale. The demographic composition was intentionally set to mirror the district's published profile: 53% South Asian, 15% Arab, 10% African, and 14% East or Southeast Asian; 45% in shared accommodation and 34% in family households; with a median tenure of

5.6 years. Every statistic presented in Section 5 pertains to this sample. The value of this exercise lies in

its ability to allow the fielding data to be directly substituted into the same script, automatically regenerating all tables, figures, and maps.

Measures

Table 2. Constructs, indicators and covariates in the survey instrument.

Construct	Abbrev.	Items	Example item (5-point agreement or frequency)	Source tradition
Environmental attitude	ATT	3	Sorting waste at home is worthwhile even if it takes time	TPB [3]
Social norms	SN	3	Most people in my building separate recyclables / would	Descriptive and injunctive norms [6]

			approve if I did	
Perceived behavioural control	PBC	3	It is easy for me to separate waste given the bins available in my building	TPB [3]
Personal norm	PN	3	I would feel bad if I threw recyclables into general waste	VBN [1]
Place attachment	PA	4	I feel that Hor Al Anz is my neighbourhood, not just where I stay	Place attachment [10]
Behavioural intention	INT	3	In the coming month I intend to separate my recyclables every time	TPB [3]
Pro-environmental behaviour	BEH	4	How often in the past month did you: separate recyclables; switch off AC when out; carry a reusable bag; avoid littering shared areas	Private-sphere behaviour [1]
Waste-separation frequency	SEP	1	Never / rarely / sometimes / usually / always	Ordinal outcome
Covariates	—	—	Nationality group, tenure (years), household type, income band, zone,	Survey and GIS
			distance to recycling point and park	

The Community Environmental Behaviour Index

The CEBI rescales five construct means to a 0-100 range and combines them using weights that prioritize reported behavior (0.35) over intention (0.15). It also incorporates neighborhood-layer constructs of social norms (0.20), perceived control (0.15), and place attachment (0.15), collectively accounting for half of the index's weight, as detailed in Equation 1. Attitude and personal norm are excluded from the index to prevent double-counting the psychological antecedents already captured by intention. The index is calculated for each respondent, then averaged by zone, and subsequently treated as the spatial variable.

$$\mathrm{CEBI}_j = 100 \cdot \sum_c w_c \frac{\bar{x}_{c,j} - 1}{4}, \qquad \sum_c w_c = 1$$

Analysis

Measurement quality was evaluated using Cronbach's alpha, composite reliability, and average variance extracted (Equation 4). Discriminant validity was assessed via the Fornell-Larcker criterion [17], and sampling adequacy was determined using the Kaiser-Meyer-Olkin statistic and Bartlett's test. The structural model was estimated using maximum likelihood in semopy 2.3 with reflective indicators.

Model fit was evaluated against conventional thresholds summarized by Hair et al. [18]. The indirect effect from attitude, through personal norm and intention to behavior, was bootstrapped using 500 resamples.

Waste-separation frequency was modeled using a proportional-odds logistic regression (Equation 2), with the parallel-lines assumption verified by comparing binary logits at successive cut points. Segments were generated via k-means clustering on standardized construct scores, with silhouette width used to compare different solutions. Group differences were tested non-parametrically, as Likert composites are ordinal. Spatial structure was examined using global Moran's I under queen contiguity on the zone grid, employing a 999-permutation reference distribution, and local clustering with the Getis-Ord Gi* statistic (Equation 3) [16]. All analyses were scripted in Python 3.12.

$$\mathrm{AVE}_c = \frac{\sum_i \lambda_{ci}^2}{n_c}, \qquad \mathrm{CR}_c = \frac{\left(\sum_i \lambda_{ci}\right)^2}{\left(\sum_i \lambda_{ci}\right)^2 + \sum_i (1 - \lambda_{ci}^2)}$$

$$\operatorname{logit} P(Y_i \le j) = \theta_j - (\beta_1 \mathrm{ATT}_i + \beta_2 \mathrm{SN}_i + \beta_3 \mathrm{PBC}_i + \beta_4 \mathrm{PN}_i + \beta_5 \mathrm{PA}_i + \boldsymbol{\gamma}' \mathbf{z}_i)$$

(3)

Sample size, weighting and quality control

Table 2. a. Sample-size considerations for each analysis.

AnalysisRequirementBasisImplication for target n			
Structural model≥ 10 cases per free parameter; ≥ 200 cases for ML estimationHair et al. [18]23 indicators and 10 structural paths give about 60 free parameters; n ≥ 300, target 400Structural model≥ 10 cases per free parameter; ≥ 200 cases for ML estimationHair et al. [18]23 indicators and 10 structural paths give about 60 free parameters; n ≥ 300, target 400			
Ordinal	**≥ 10 events per predictor in**	**Standard logistic**	**11 predictors; sparsest**
regression	the sparsest outcome category	guidance	category should hold ≥ 110 respondents, achievable at n = 400 with quota monitoring
Zone means	≥ 25 respondents per zone for a standard error of the zone CEBI below 2 points	SD of CEBI ≈ 8 in the illustrative sample	Density-proportional allocation gives 27–65 per zone at n = 400; the sparsest zone should be
			topped up
Segmentation	Stable cluster solution across bootstrap resamples	Adjusted Rand index ≥0.7 across 100 resamples	Assessed after fieldwork; n= 400 sufficient in the illustrative run
Spatial	Enough spatial units for a	Nine zones give low	Record building address to
statistics	permutation test with power	power; building-level units are recommended	allow ≥ 40 spatial units

Post-stratification weights will be computed using Dubai Statistics Centre estimates of the district's population by nationality group and household type, where available, and against fieldwork enumeration data where not. Quality control measures will include a ten percent call-back verification, range and consistency checks upon

data entry, and a reverse-coded item in the social-norms scale to detect acquiescent responding. Interviews with respondents who do not handle household waste will be flagged, enabling the ordinal outcome to be analyzed both with and without their responses.

Results

All results presented herein describe the illustrative sample detailed in Section 4.2 and serve as a demonstration of the analysis. They are not intended as estimates for the resident population of Hor Al Anz.

Measurement model

Table 3. Reliability and convergent validity of the seven constructs (illustrative sample).

Construct	Items	Mean	SD	α	CR	AVE	√AVE	Loadings (min–max)
ATT	3	3.32	0.73	0.74	0.85	0.66	0.81	0.80–0.82
SN	3	3.03	0.69	0.73	0.85	0.65	0.81	0.78–0.83
PBC	3	2.76	0.67	0.66	0.82	0.60	0.77	0.75–0.79
PN	3	3.10	0.74	0.74	0.86	0.66	0.81	0.81–0.82
PA	4	3.27	0.65	0.74	0.84	0.57	0.75	0.67–0.80
INT	3	3.10	0.73	0.74	0.85	0.66	0.81	0.80–0.82

BEH42.960.700.780.860.600.780.75–0.80BEH42.960.700.780.860.600.780.75–0.80

KMO = 0.79; Bartlett $\chi^2(253) = 2467$, $p < 0.001$. α = Cronbach's alpha; CR = composite reliability; AVE = average variance extracted.

Table 4. Inter-construct correlations with the square root of AVE on the diagonal (Fornell-Larcker criterion).

	ATT	SN	PBC	PN	PA	INT	BEH
ATT	0.81						
SN	0.00	0.81					
PBC	0.07	0.02	0.77				
PN	0.35	0.19	0.01	0.81			
PA	-0.06	0.00	-0.01	0.00	0.75		
INT	0.29	0.25	0.23	0.32	0.08	0.81	
BEH	0.14	0.09	0.25	0.18	0.21	0.40	0.78

The diagonal elements, representing the square root of AVE, exceed the correlations in their respective rows and columns, supporting discriminant validity. Reliability is adequate for all constructs (α between 0.66 and 0.78, CR above 0.80), and AVE consistently exceeds the 0.50 threshold. The Fornell-Larcker criterion is satisfied, and the correlation matrix is factorable. The first seven eigenvalues of the item correlation matrix are greater than unity, aligning with the seven-construct design.

Table 4. a. Standardised indicator loadings from the confirmatory measurement model.

ConstructIndicator loadings (standardised)

ATTATT1 0.68, ATT2 0.70, ATT3 0.72ATTATT1 0.68, ATT2 0.70, ATT3 0.72

SNSN1 0.71, SN2 0.73, SN3 0.64

PBCPBC1 0.66, PBC2 0.60, PBC3 0.63PBCPBC1 0.66, PBC2 0.60, PBC3 0.63

PNPN1 0.75, PN2 0.69, PN3 0.66

PAPA1 0.68, PA2 0.67, PA3 0.53, PA4 0.72PAPA1 0.68, PA2 0.67, PA3 0.53, PA4 0.72

INTINT1 0.72, INT2 0.71, INT3 0.66

BEHBEH1 0.72, BEH2 0.72, BEH3 0.67, BEH4 0.63BEHBEH1 0.72, BEH2 0.72, BEH3 0.67, BEH4 0.63

The first indicator for each construct serves as the reference indicator; all loadings surpass 0.50 and are statistically significant at $p < 0.001$.

Structural model (H1)

Table 5. Structural path estimates from the covariance-based SEM (maximum likelihood, illustrative sample).

Path	B	SE	z	p	β (std.)
ATT → PN	0.541	0.082	6.61	< 0.001	0.472***
SN → PN	0.279	0.072	3.89	< 0.001	0.251***
ATT → INT	0.294	0.082	3.60	< 0.001	0.275***
SN → INT	**0.269**	**0.069**	**3.92**	**< 0.001**	**0.259*** **
PBC → INT	0.322	0.076	4.24	< 0.001	0.287***
PN → INT	0.229	0.072	3.17	0.002	0.246**
PA → INT	0.145	0.066	2.20	0.028	0.131*
INT → BEH	0.430	0.070	6.11	< 0.001	0.425***
PBC → BEH	0.251	0.078	3.20	0.001	0.221**
PA → BEH	0.268	0.068	3.95	< 0.001	0.238***

Fit: $\chi^2(214) = 199.1$, $p = 0.76$; CFI = 1.000; TLI = 1.000; RMSEA = 0.000; GFI = 0.921. R^2: PN = 0.15, INT = 0.23, BEH = 0.22. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

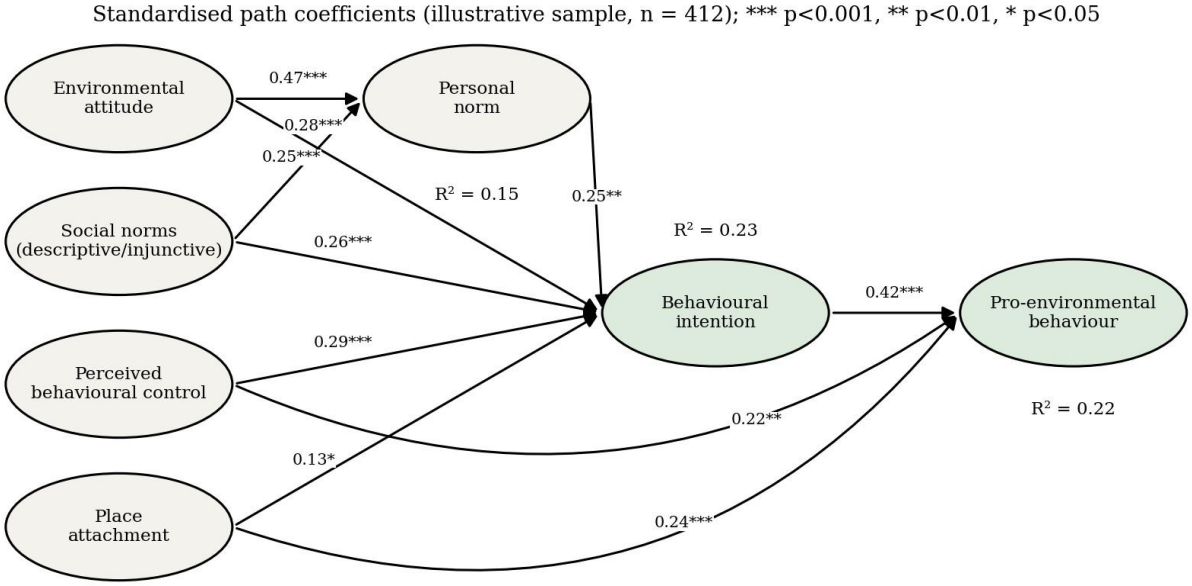

Figure 4. Structural model with standardised path coefficients (illustrative sample). Solid arrows are significant at the five per cent level.

The model demonstrates a close fit to the data, with all hypothesized paths being statistically significant. Attitude emerges as the strongest predictor of personal norm (β = 0.47), while personal norm is among the key predictors of intention (β = 0.25), alongside perceived control (β = 0.29). Attitude's direct influence on intention is modest (β = 0.28). Behavior is predicted by intention (β = 0.42), but also directly

by perceived control (β = 0.22) and place attachment (β = 0.24). The bootstrapped indirect effect of attitude on behavior, operating through personal norm and intention, is 0.023 (95% CI 0.010 to 0.038), which, while small, is distinct from zero. Hypothesis H1 is supported.

The substantive interpretation, assuming this pattern holds in the fielded data, is that residents who feel capable of acting and who feel a sense of belonging to the neighborhood will act irrespective of their endorsement of environmental values. Values primarily influence behavior through a sense of obligation.

A nested comparison was conducted to ascertain the significance of place attachment in the model. Removing the two attachment paths resulted in a chi-square increase of 24.1 over 2 degrees of freedom ($p < 0.001$), indicating that the restricted model fits significantly worse, despite acceptable global indices

(CFI 0.997, RMSEA 0.009). The information criteria (AIC 123.0 vs. 118.9) are comparable, as expected when removing two parameters; the likelihood-ratio test provides the decisive evidence. Place attachment is therefore retained in the model.

Waste-separation frequency (H_2)

Table 6. Proportional-odds ordinal logistic regression of household waste-separation frequency (five categories), illustrative sample.

Predictor	Coefficient	SE	Odds ratio	95% CI	p
Environmental attitude	0.303	0.138	1.35	1.03–1.78	0.029*
Social norms	0.151	0.136	1.16	0.89–1.52	0.267
Perceived behavioural control	0.626	0.141	1.87	1.42–2.47	< 0.001***
Personal norm	0.159	0.136	1.17	0.90–1.53	0.243
Place attachment	0.687	0.158	1.99	1.46–2.71	< 0.001***
Tenure (log years)	−0.075	0.132	0.93	0.72–1.20	0.570
Family household (vs single)	0.371	0.251	1.45	0.89–2.37	0.140
Shared household (vs single)	0.501	0.244	1.65	1.02–2.66	0.040*
Income band (1–4)	0.121	0.098	1.13	0.93–1.37	0.216
Distance to recycling point (km)	−1.266	0.587	0.28	0.09–0.89	0.031*
Hor Al Anz East (vs Hor Al Anz)	0.373	0.201	1.45	0.98–2.15	0.063

n = 412; log-likelihood = −511.5 (null −542.1); McFadden pseudo-R^2 = 0.056; AIC = 1053.0. Parallel-lines check: coefficients for PBC, SN and distance at the ≥ 3 and ≥ 4 cut points were of the same sign and similar magnitude.

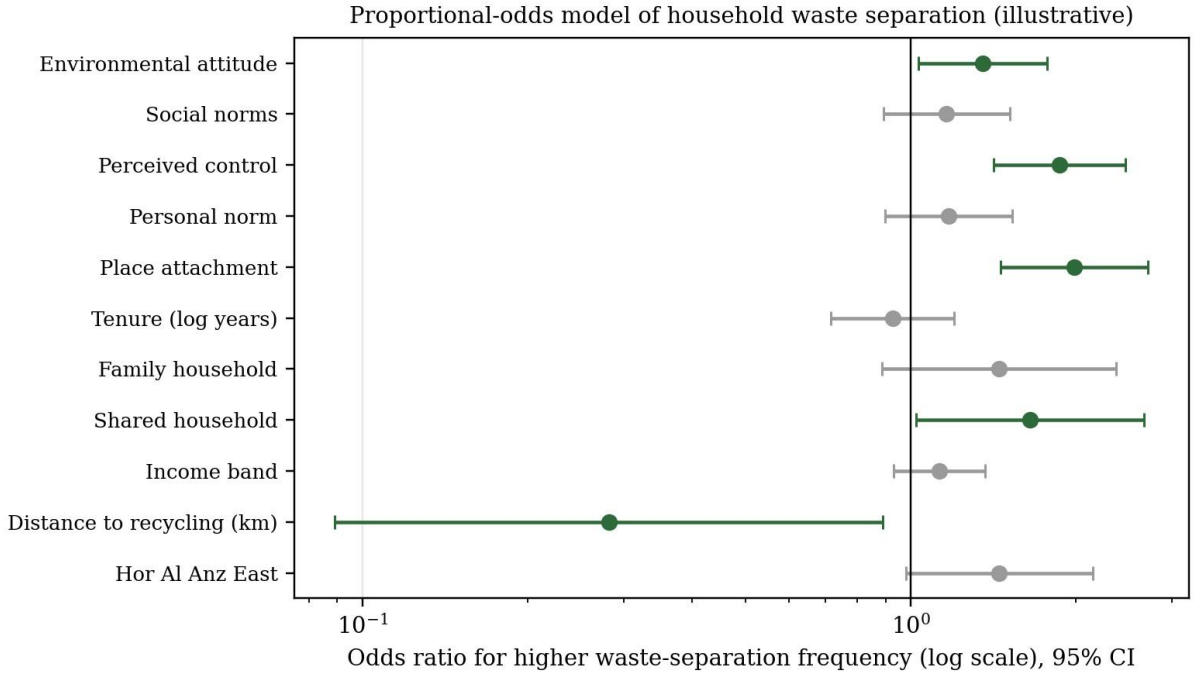

Figure 5. Odds ratios with 95 percent confidence intervals from the proportional-odds model. Green markers are significant at the five per cent level.

Perceived behavioral control and place attachment are the most significant correlates of separation frequency. A one-unit increase in perceived control multiplies the odds of being in a higher frequency category by 1.87, and a one-unit increase in attachment by 1.99. Attitude has a smaller, marginal effect. Social norms and personal norm, which influence behavior indirectly through intention in the structural model, are not significant when control and attachment are included.

The distance to the nearest recycling point shows the expected negative sign (odds ratio 0.28 per kilometer) but does not reach statistical significance at the five percent level. Similarly, the community dummy (Hor Al Anz East vs. Hor Al Anz) is not significant. Households in shared accommodations report more frequent separation than single-person households, which is plausible given that waste handling is often a collective routine. Hypothesis H2 is supported for the psychological predictors and only weakly for the spatial predictor. The pseudo-R^2 is low, which is typical for ordinal outcomes with five categories; the model should be interpreted for the relative ordering of effects rather than for explained variance.

Resident segments (H3)

Table 7. Profile of the three k-means resident segments on construct means (1-5), CEBI and covariates, illustrative sample.

Segment	Shar e	AT T	SN	PB C	PN	PA	INT	BE H	CEB I	Family hh Tenure (yr)
Constraine	35%	3.02	2.7	2.4	2.8	2.6	2.3	40.9	31%	6.1
d sceptics			3	0	2	2	7			
Willing but	36%	3.16	3.0	3.0	2.8	3.0	3.0	53.7	38%	7.3
limited			2	2	8	0	4			
Engaged	29%	3.87	3.4	3.7	3.6	3.1	3.7	57.2	33%	6.6
stewards			1	4	1	6	6			

Silhouette width: k = 2, 0.16; k = 3, 0.13; k = 4, 0.12. The three-cluster solution was retained for interpretability; widths of this order are typical for survey composites. Segment × nationality: $\chi^2(8) = 8.83$, p

= 0.36, Cramér's V = 0.10.

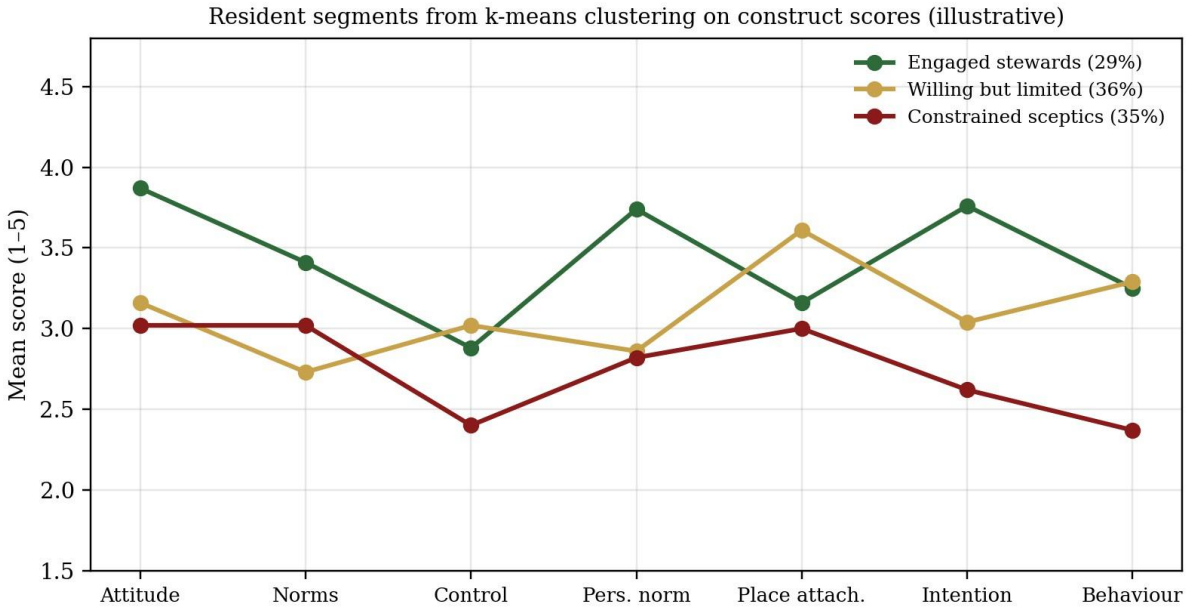

Figure 6. Construct profiles of the three resident segments.

The three segments are distinguished by their construct profiles rather than simply by level. "Constrained sceptics" (35%) exhibit average attitudes and norms but possess the lowest perceived control and lowest behavioral scores, suggesting the built environment, not motivation, is their primary constraint. "Willing but limited" residents (36%) show the highest place attachment and longest tenure, and their behavior exceeds their intentions. "Engaged stewards" (29%) demonstrate the strongest attitudes, personal norms, and intentions, achieving the highest CEBI scores. Notably, segment membership is independent of nationality (Cramér's V = 0.10), supporting H3. This finding is crucial for engagement strategies, indicating that targeting by nationality would be less effective than addressing these segment-specific needs.

Group and tenure differences (H4)

Table 8. Non-parametric group comparisons, illustrative sample.

Comparison	Test	Statistic	p	Reading
Behaviour by nationality group (5 groups)	Kruskal-Wallis	H = 4.60	0.331	No significant difference
Behaviour, Hor Al Anz East vs Hor Al Anz	Mann-Whitney	U = 21936; means3.08 vs 2.89	0.011	East higher
Place attachment and tenure	Spearman	ρ = 0.32	< 0.001	Attachment rises with years resident

Behavior does not differ by nationality group. However, it does vary modestly between the two communities, with Hor Al Anz East showing slightly higher rates, and place attachment increases steadily with length of residence. Hypothesis H4 is supported. The finding regarding tenure is particularly relevant, given that residents are on fixed-term visas and rental contracts. If attachment influences behavior, policies that extend tenure or strengthen attachment are important environmental levers.

Spatial structure of the CEBI (H5)

Table 9. Zone-level CEBI, accessibility measures and local spatial statistics, illustrative sample.

Zone	Community	n	CEBI	Distance to recycling(km)	Distance to park (km)	StandardisedCEBI	Spatiallag	Quadrant	Gi*

Z1	Hor Al Anz	65	49.6	0.46	1.52	-0.42	-0.03	LL	-0.32
Z2	Hor Al Anz	43	52.0	0.30	1.22	0.62	-0.11	HL	0.04
Z3	Hor Al Anz	49	46.8	0.67	1.11	-1.61	0.50	LH	0.24
Z4	Hor Al Anz	58	49.2	0.48	1.18	-0.58	0.02	LH	-0.32
Z5	Hor Al Anz	57	50.3	0.32	0.63	-0.13	0.04	LH	0.10
Z6	East	27	55.7	0.40	0.68	2.17	-0.20	HL	0.75
Z7	East	34	49.0	0.83	1.18	-0.67	0.30	LH	0.32
Z8	East	43	50.8	0.29	0.46	0.08	0.48	HH	1.26
Z9	East	36	51.9	0.63	0.94	0.54	0.53	HH	1.34

Global Moran's I = -0.156 (expected -0.125); permutation p = 0.524; z = -0.20. Quadrant: HH high-high, LL low-low, HL high-low, LH low-high. Zone OLS: CEBI ~ distance to recycling + distance to park + density, $R^2 = 0.87$, n = 9; no coefficient significant at 5%.

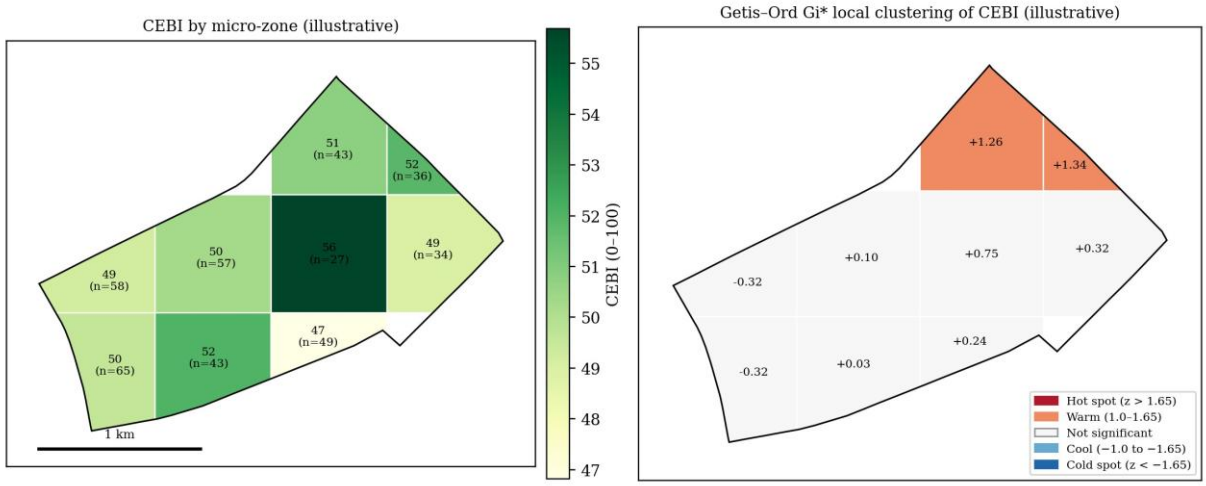

Figure 7. Left: CEBI by micro-zone with respondent counts. Right: Getis-Ord Gi z-scores; two zones in Hor Al Anz East reach the warm but not the hot-spot threshold.

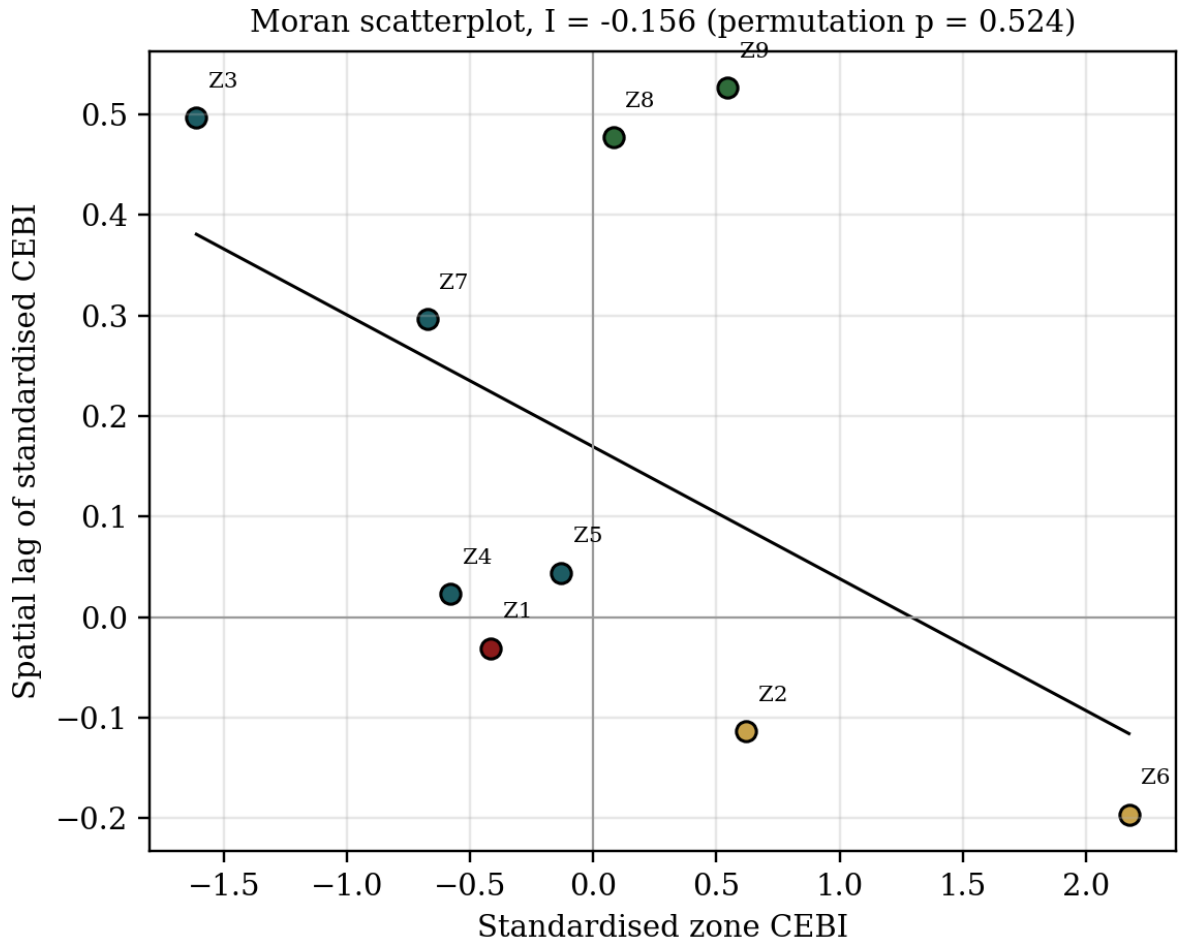

Fig. 8. Moran scatterplot of standardised zone CEBI against its spatial lag. The near-flat slope corresponds to the non-significant global statistic.

Global Moran's I is very close to its expected value under spatial randomness, and the permutation test does not reject the null hypothesis. The Gi* map reveals two warm zones in the eastern end (Z8 and Z9), but none reach the hot-spot threshold ($z > 1.65$). The Moran scatterplot places most zones in the off-diagonal quadrants. The zone-level regression of CEBI on amenity distance and density, despite using only nine observations, explains a substantial proportion of variance, though no single coefficient is statistically significant. Hypothesis H_5 is not supported by the illustrative sample. Given that the sample was generated with a zone effect tied to amenity distance, this null result is informative: at the scale of nine zones and with the current amenity spacing, the variance in constructs at the individual level overshadows the variance between zones. The norm-feedback process proposed in the framework would likely require a finer scale of analysis, operating at the building or street level, to become detectable. This observation provides a design lesson for the future fieldwork, emphasizing the need to record building addresses to enable the construction of finer spatial units.

a How much of each construct is between zones?

Table 9. d. Intraclass correlation of each construct and the CEBI across the nine micro-zones, illustrative sample.

Construct	ICC (between-zone share)	F (zone)	p
ATT	0.002	1.11	0.355
SN	0.000	0.73	0.667
PBC	0.006	1.25	0.266
PN	0.017	1.79	0.076
PA	0.000	0.32	0.957

INT	0.009	1.40	0.194

BEH	**0.039**	**2.88**	**0.004**
CEBI	0.023	2.06	0.039

The intraclass correlations quantify the spatial null result. Between-zone differences account for a maximum of 3.9% of the variance, and for the CEBI, this figure is 2.3%. The constructs most closely aligned with the neighborhood layer—perceived control and social norms—exhibit the largest shares, as predicted by the framework. However, even these shares are small. The overwhelming majority of the variation in environmental practice within the illustrative sample occurs between residents within a zone, rather than between zones. This finding statistically supports the claim that behavior is more strongly influenced by individuals and buildings than by districts.

Does tenure change what control buys? A moderation check

Table 9. b. OLS of behaviour on perceived control, tenure and their interaction, with attachment, intention and norms as controls (HC_3 SE).

Term	Coefficient	p
Intercept	1.032	0.013*
Perceived control	0.085	0.495
Tenure (log years)	-0.157	0.409
Perceived control × log tenure	0.058	0.371
Place attachment	0.204	< 0.001***
Intention	0.323	< 0.001***
Social norms	0.004	0.935

$R^2 = 0.22$.

The interaction term between perceived control and tenure is not statistically significant ($p = 0.37$), providing no evidence from the illustrative sample to suggest that infrastructure matters differently for newcomers versus long-term residents. This result aligns with the framework's preference: it implies that improvements in the conditions for action benefit the entire population, not just those intending to remain long-term.

What the ordinal model implies in practice

Table 9. c. Predicted distribution of waste-separation frequency for resident profiles at low (2) and high (4) perceived control and place attachment, other predictors at their means.

Profile	Never	Rarely	Sometimes	Usually	Always	P(usually or always)
Low PBC, low PA	14%	46%	31%	8%	1%	8%
Low PBC, high PA	4%	24%	45%	25%	2%	27%
High PBC, low PA	5%	26%	45%	22%	2%	25%
High PBC, high PA	1%	9%	34%	48%	8%	56%
Mean	4%	24%	45%	24%	2%	26%

Transitioning a resident from low to high perceived control, while keeping place attachment low, increases the predicted probability of separating waste usually or always from 8% to 25%. Similarly, enhancing attachment from low to high, with low control, raises this probability to 27%. When both perceived control and place attachment are high, the probability reaches 56%. These magnitudes represent the targets for building-level infrastructure programs and stewardship initiatives and are substantial enough to be detectable in waste audits.

Sensitivity of the CEBI to its weights

Table 9. a. CEBI under alternative weighting schemes: segment means, correlation with the paper index at respondent level, and Spearman correlation of zone rankings.

Weighting	Weights (BEH, INT, SN,PBC, PA)	Constrainedsceptics	Willing butlimited	Engaged stewards	r with paper index	Zone rankρ
Paper weights	0.35, 0.15, 0.20, 0.15,	40.9	53.7	57.2	1.00	1.00
	0.15					
Behaviour-only	1, 0, 0, 0, 0	34.2	57.2	56.2	0.83	0.93
Equal	0.2 each	42.0	53.4	57.3	0.97	1.00
Neighbourhood-	0.25, 0.05, 0.30, 0.20,	42.8	53.0	55.7	0.96	0.97
heavy	0.20					

The CEBI demonstrates robustness to weighting variations. Respondent-level correlations with the primary weighting scheme exceed 0.8 across alternative weightings, and zone rankings remain highly consistent. The segment ordering is also preserved, with "constrained sceptics" consistently scoring lowest. A notable difference arises with the "behavior-only" index, which places the "willing but limited" segment above the "engaged stewards." This occurs because the former group's behavior surpasses their psychological profile, whereas the composite index, by incorporating intention and norms, ranks them as the framework intends. Users of the CEBI are encouraged to specify their chosen weights.

Discussion

Who acts, and why

The demonstration results collectively suggest that in this neighborhood, environmental practices are primarily driven by capability and a sense of belonging, rather than by conviction alone. Perceived control exerts a direct influence on behavior, independent of intention, aligning with Steg and Vlek's findings for effortful or infrastructure-dependent behaviors [2]. Place attachment similarly shows a direct effect, consistent with Alawadi's ethnographic work in older Dubai districts [10]. Attitude plays a role, but its impact is mediated through personal norms, and social norms influence behavior via intention. This hierarchy has practical implications. Awareness campaigns, the standard tool for environmental communication, target the weakest link in this chain. Interventions focused on enhancing perceived control, such as ensuring the presence, cleanliness, and clarity of bin labeling, and those that foster attachment, like involving residents in maintaining shared spaces such as parks and streets, address the strongest influences.

The absent geography

The most striking result from this demonstration is a null finding: the NEBE framework predicts that visible neighborhood behavior in dense districts should lead to spatial clustering, a phenomenon the CEBI was designed to detect. However, this was not observed in the illustrative sample at the micro-zone scale. Two interpretations are possible, which future fieldwork will help to adjudicate. The first is that the norm-feedback process is indeed real but operates at the building or street level—where shared chutes and entranceways are located—rather than at the scale of several hundred meters. Schultz's work on normative feedback demonstrated effects at the household level [6].

The second interpretation is that in districts with high turnover and short tenure, norms struggle to stabilize sufficiently to leave a spatial trace. In such cases, equilibrium is established at the institutional layer rather than the neighborhood layer. Either way, this finding cautions against the prevalent assumption in smart-city

planning that mapping infrastructure is equivalent to mapping behavior [15].

Segments rather than nationalities

Municipal engagement in Dubai is frequently organized around language and nationality, a practical approach for ensuring communication is understood. However, the segment analysis suggests that focusing on behavioral segments might be more effective. The study identified "constrained sceptics," "willing but limited," and "engaged stewards" across all nationality groups in similar proportions. Each segment requires a different approach: the first needs infrastructure improvements, the second requires recognition and a role, and the third needs avenues to influence the other two. An engagement program based on this segmentation could communicate in all necessary languages but would avoid assuming that language directly predicts behavior.

Relation to the Dubai evidence

The findings are consistent with the limited body of existing research in the UAE. Abushammala and Ghulam found that demographic and housing factors shape household waste knowledge and practices [11]. Waheed et al. demonstrated that perceived infrastructure support moderates the relationship between recycling intention and behavior [12]. Community surveys by Eltoum et al. have indicated high awareness levels alongside weak institutional follow-through [13, 14]. This study contributes by integrating these findings within a single framework, providing a spatial dimension, and proposing an index that can be tracked over time as the Dubai 2040 neighborhood agenda progresses [20].

What dense migrant districts elsewhere suggest

The patterns observed in this demonstration are not unique to Dubai. Reviews of pro-environmental behavior consistently find that in settings where residents have limited control over their living conditions, the gap between stated values and actual behavior is widest [5, 7]. This gap narrows when the physical and social conditions for action are improved, rather than solely through information provision [2]. Studies on household waste in the Emirates reinforce this point at a local level [11, 12]. What Hor Al Anz adds to this literature is the convergence of extreme density, short tenure, and linguistic diversity, presenting a rigorous test for any claims about cultivating neighborhood norms. If a stewardship scheme and building-level infrastructure improvements can effectively raise the CEBI in this context, they are likely to succeed in most of the emirate's older districts.

Studying environmental behavior in a migrant neighbourhood

Research on environmental behavior in a migrant neighborhood carries distinct responsibilities compared to studies focused on asset performance. The residents of Hor Al Anz are largely individuals

whose housing, work schedules, and tenure are determined by others. Their capacity to act on environmental preferences is constrained by factors such as the bins provided by their landlords and the demands of their employers. The framework's emphasis on perceived control and the institutional layer reflects both a methodological choice and an ethical consideration, directing attention toward the conditions enabling action rather than solely judging the actor's morality. The fieldwork design embodies this principle. Interviews will be offered in the four dominant languages, conducted in shared spaces to include residents of crowded units, and structured to avoid questions asking respondents to report on neighbors by name. Findings will be reported at the segment and zone levels, never at an identifiable building level.

Scope of the claims

This paper should not be interpreted as presenting findings about the people of Hor Al Anz. The results illustrate the potential outcomes of the analysis when data become available, derived from a sample whose structure was intentionally designed to align with published literature. However, the paper does establish the feasibility of the design using available boundary data, confirm the psychometric properties of the instrument required for the models, demonstrate the functionality of the statistical pipeline from end to end, and highlight the possibility of a null result regarding spatial clustering—a finding not built into the sample but crucial for the fieldwork design to detect at a finer scale.

Implications for community and municipal practice

Table 10. Recommended actions, the NEBE mechanism each relies on, and ownership.

Action	Mechanism in NEBE	Owner	Evidence
1 Audit the presence, condition	Raises perceived control;	Dubai Municipality	Section

and labelling of recycling	the strongest direct	waste services;	5.2, 5.3
provision in every building	predictor of behaviour	building	
above a size threshold, and		management	
publish a building-level map.			
2 Establish a resident	Builds place attachment;	Dubai Municipality	Section
stewardship scheme for Hor Al	makes good practice visible	community	5.2, 5.5,
Anz Park and the shared	as the descriptive norm	engagement; park	6.1
streets, with visible roles for		management	
long-tenure residents.			
3 Replace nationality-based	Matches the intervention to	Community	Section
outreach lists with segment-	the segment's constraint	engagement	5.4, 6.3
based engagement delivered in		function	
all languages.			
4 Field the survey with building	Tests the norm-feedback	Emirates Scholar	Section
addresses recorded, and score	process at the scale where it	Center; Dubai	5.6, 6.2
the CEBI at building scale before	should operate	Municipality	
zoning.			
5 Pair descriptive-norm	Avoids the boomerang	Community	Section 3.1
feedback (what neighbours do)	effect Documented by	engagement;	
with an injunctive signal of	Schultz et al. [6]	building	
approval in any building-level		management	
communication.			

6 Re-score the CEBI annually and report it alongside Dubai 2040 neighbourhood indicators.

Institutional layer: makes progress legible

Dubai Municipality; Emirates Scholar Center

Section 4.4, 6.4

A monitoring set for the CEBI

Table 10. a. A monitoring set to accompany the CEBI.

Indicator	Source	Frequency	Use
CEBI by zone and by	Annual resident survey	Annual	Trend and targeting

building			
Share of buildings with usable separation provision	Building enumeration and audit	Annual	Perceived-control lever
Observed separation rate in audited bin rooms	Audit sub-sample	Annual	Behavioural check on self-report
Stewardship participation	Programme records	Quarterly	Attachment lever
Segment shares	Annual survey	Annual	Whether the constrained segment is shrinking
Complaints and service requests about waste in the district	Dubai Municipality service data	Monthly	Institutional-layer responsiveness

Table 11. integrates segmentation into an engagement design, prioritizing practical application over researcher needs. It proposes delivering the same core message across all languages while tailoring the specific content by segment.

Table 11. Segment-based engagement design.

Segment	Constraint	Message	Channel	Measure of success
Constrained	Absent or	Here is the bin,	Building notice	Rise in PBC and in
sceptics	unusable infrastructure; low perceived control	here is what goes in it, here is who empties it	in four languages; bin-room signage; landlord agreement	observed separation at building audit
Willing but	High attachment,	Your street,	Park notice	Participation count; rise
limited	limited outlet for it	your park: join the stewardship group	board; community majlis; resident WhatsApp	in INT among members
			groups	

Engaged stewardsInfluence not channelledShow your neighbours what you already doBuilding-levelDiffusion: rise in SNdescriptive-normamong non-members in feedback with anthe same building approvalmessageEngaged stewardsInfluence not channelledShow your neighbours what you already doBuilding-levelDiffusion: rise in SNdescriptive-normamong non-members in feedback with anthe same building approvalmessage

Conclusions

This study introduced a novel approach to investigating everyday environmental practices within one of Dubai's oldest and most densely populated neighborhoods, explicitly considering the neighborhood as a distinct layer between the individual and institutional levels. The NEBE framework elucidates the key determinants, the CEBI provides a measurable and mappable index, and the demonstration analysis illustrates the form these findings might take.

Three expectations are set forth for the forthcoming fieldwork: Perceived control and place attachment are anticipated to be stronger predictors of behavior than attitude. Resident segments are expected to cut across nationality lines. Any existing spatial structure is likely to manifest at the building and street scale, not at the zone level. Should these expectations hold true, the practical implications for Dubai Municipality are clear and cost-effective: enhance the ease of desirable behavior at every building, foster resident investment in shared spaces, and tailor communications to segments rather than nationalities. Hor Al Anz, named for a horse that fell in the dunes, may yet become the district where the emirate learns how ordinary neighborhoods can effectively meet its sustainability commitments.

The illustrative sample, analysis script, and community boundary layer used for maps and figures are available

from the corresponding author. The script is designed to regenerate all tables, figures, and maps from a data file using the variable names specified in Table 2, ensuring that the fielded survey data can be analyzed without modification.

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