How important is Accessibility in a 15 minutes Hot-Arid City?: A Hybrid Choice Modelling Approach

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ABSTRACT

The 15-minute city is commonly operationalized through objective proximity measures, yet less is known about perceptions about which activities matter most to have nearby, especially in hot-arid settings. This paper examines accessibility priorities in Abu Dhabi through an importance-based ranking of nearby amenities. We estimated a hybrid choice model with an exploded logit structure and latent variables capturing neighbourhood satisfaction and lifestyle. The model incorporates purpose-specific willingness to walk under nice and hot weather. Results show that groceries and work/school dominate overall rankings and prioritizing nearby access is associated more strongly with existing walkability practice than with activity frequency. Weather also matters: greater willingness to walk in pleasant weather reduces the urgency of nearby location, whereas willingness to walk under hot conditions identifies purposes that remain essential despite heat. The findings support a perceived-accessibility interpretation of the 15MC in which local accessibility is purpose-specific, socially differentiated, and climate-conditioned.

Keywords: 15-minute city; accessibility; hybrid choice model; latent variables; willingness to walk

1. INTRODUCTION

The 15-minute city (15MC) has gained significant traction in recent years as an influential framework in transport and urban planning by shifting attention toward proximity-based access in daily life. The 15MC envisions cities in which most essential daily needs (such as work, shopping, education, healthcare, and recreation) can be reached within a 15-minute walk or bike ride from home (Moreno et al., 2021). By making everyday functions accessible within a short active trip, the concept aims to reduce car dependence while improving sustainability, health, and neighborhood livability.

The 15MC is often misunderstood as merely a proximity measure (Guzman et al., 2024). Its operationalization has been inconsistent across cities (Lu & Diab, 2023), and in many cases it appears mainly in strategic planning documents without statutory weight (Gower & Grodach, 2022). Many studies rely on GIS-based indicators that count amenities within fixed thresholds or assess whether key services fall inside 10-, 15-, or 20-minute walking isochrones. While such approaches are useful for benchmarking, they imply that the same activities matter equally to all residents, that a single time threshold is behaviorally meaningful across cities and social groups, and that walking time is stable across contexts.

However, accessibility is also shaped by perceptions and transport conditions (Geurs & van Wee, 2004; Guzman et al., 2024). Travel behavior varies across demographic groups and built environments (Kim et al., 2018; Sarmiento et al., 2021), and a people-oriented planning concept must address more than the needs of the average person by also considering vulnerable groups and seasonal conditions (Willberg et al., 2023). Nevertheless, only a limited number of studies have directly examined residents' perceptions of accessibility within a 15MC framework (Diab et al., 2026; Sharma et al., 2025; Guzman et al., 2024).

A further limitation is that walkability is often treated as climatically neutral. In many operationalizations, the meaning of a "15-minute walk" is assumed to remain fixed regardless of season. However, walking under heat stress can significantly alter pedestrian route choice, increase perceived walking distance, and reduce access to important destinations (Basu et al., 2024; Jia et al., 2022). This issue is especially relevant in hot-arid and hot-humid urban regions, where thermal exposure can severely constrain active mobility for long periods of the year. High temperatures can increase pedestrian discomfort (Alawadi et al., 2022) and effectively lengthen trips, since the shortest route may not coincide with the thermally preferable shaded route, thereby reshaping what constitutes a viable walking path (Wen et al., 2025).

Taken together, the literature points to a clear gap. First, 15MC research has made substantial progress in measuring proximity, but many studies still rely on static time thresholds and treat walking as climate-neutral. Second, heat-and-walkability research shows that heat affects walking behavior, route choice, perceived effort, and effective accessibility. Third, the perceived-accessibility literature demonstrates that accessibility is purpose-specific, mode-specific, and filtered through attitudes, habits, and social context. What remains relatively underexplored is the integration of these three insights within a single empirical framework and the mediating impact of weather conditions in the 15MC evaluation.

This paper addresses these gaps by studying perceived accessibility priorities in Abu Dhabi through ranked activity preferences and climate-differentiated willingness to walk. Respondents rank the trip-purpose activities they most want to have accessible from home—work/school, groceries, worship, retail/errands, and social/outdoor activities—while also reporting their willingness to walk under both nice and hot weather conditions. Methodologically, the analysis employs an exploded logit model embedded in a hybrid choice framework with latent variables for neighborhood satisfaction, active lifestyle, and social lifestyle. In doing so, the paper repositions the 15MC debate from a fixed spatial threshold toward a behaviorally grounded account of what residents actually want nearby, and under what climatic conditions they are willing to reach it on foot.

2. DATA

Data was collected through an online survey administered to members of university communities in Abu Dhabi, including students, faculty, and staff. The final sample consists of 194 valid observations. To be eligible, respondents were required to be at least 18 years old and to have resided in Abu Dhabi for a minimum of three months prior to the survey. This restriction was intended to ensure that participants had at least a basic level of familiarity with the city and its local accessibility conditions. The survey gathered information on socio-demographic characteristics, travel-related behaviour, ranked accessibility priorities across different trip purposes, and attitudinal indicators. Table 1 shows the sociodemographic information of the respondents, Purpose-specific trip-variables are shown in Table 2 and indicator responses are shown in Table 3.

Table 1. Sociodemographic characteristics

Group	Category	Frequency	Percentage
Gender	Female	92	47.42
	Male	99	51.03
	Other	3	1.55
Age group	<25	63	32.47
	25-40	79	40.72
	40-60	47	24.23
	60+	5	2.58
Region	Emirati	22	11.34
	Western	33	17.01
	Arabic	41	21.13
	Asian	70	36.08
	Other	28	14.43
Years in UAE	<2 years	29	14.95
	2+ years	165	85.05
Education	Higher education	158	81.44
	High School or Lower	36	18.56
Driving license	Has license	140	72.16
	No license	54	27.84
Household	Single Member	51	26.29
	Two Members	44	22.68
	More than two members	99	51.03
	Has baby/toddler	24	12.37
	Has member with disability	170	87.63
Household Monthly Income	Low income (<10k)	79	40.72
	Medium income (10k-50k)	92	47.42
	High income (>=50k)	23	11.86
Car availability	Car available	104	53.61
	Bike available	49	25.26

For each trip purpose, respondents were asked the maximum number of minutes they would be willing to walk under two weather conditions: nice weather and hot weather. These responses were then normalised by dividing each reported walking time by the maximum stated willingness-to-walk observed for the corresponding weather condition, producing purpose-specific indices bounded between 0 and 1. Higher values therefore indicate a greater relative willingness to walk for that purpose under the relevant weather condition.

Table 2. Trip characteristics

Variable	Category	Work /School	Groceries	Worship	Retail /Errands	Outdoor /Social
Active trip percentage	Less than 25%	78.4	29.9	79.9	59.8	43.3
	25% to 49%	0.0	15.0	2.6	13.4	17.0
	50% to 74%	0.0	24.2	3.6	11.3	23.2
	75% to 100%	21.7	30.9	13.9	15.5	16.5
No walking indicator	Less than 25%	97.4	99.0	78.9	95.9	97.4
	25% to 49%	0.0	0.0	0.0	0.0	0.0
	50% to 74%	0.0	0.0	0.0	0.0	0.0
	75% to 100%	2.6	1.0	21.1	4.1	2.6
Trip percentage	Less than 25%	52.1	42.3	92.8	84.5	47.4
	25% to 49%	39.2	47.9	5.2	15.0	44.9
	50% to 74%	6.7	9.8	2.1	0.5	7.2
	75% to 100%	2.1	0.0	0.0	0.0	0.5
Willingness to walk (hot weather ratio)	Less than 25%	19.6	15.0	32.5	24.7	27.8
	25% to 49%	4.1	12.9	5.7	10.8	5.7
	50% to 74%	13.9	22.2	16.0	17.5	16.5
	75% to 100%	62.4	50.0	45.9	46.9	50.0
Willingness to walk (nice weather ratio)	Less than 25%	5.7	7.7	27.3	6.7	3.1
	25% to 49%	11.3	17.0	10.8	13.9	8.8
	50% to 74%	21.1	41.2	19.6	31.4	25.3
	75% to 100%	61.9	34.0	42.3	47.9	62.9

Under pleasant weather, work/school and outdoor/social activities show the highest concentration in the top category, suggesting that these are the purposes for which respondents are most willing to walk. Grocery trips, by contrast, are more concentrated in the intermediate range, especially 0.5–0.75 (41.2%), indicating a moderate but less pronounced walking tolerance. Under hot weather, the distributions shift downward for several purposes, meaning that respondents become relatively less willing to walk when thermal conditions worsen. Taken together, these results suggest that walking tolerance is strongly purpose-specific and becomes more constrained under hot weather.

Table 3. Indicator responses

Latent Variable	Indicator	Percentage (%)					Mean	SD
		1	2	3	4	5		
Neighbourhood Satisfaction (SAT)	Overall, I am satisfied with living in my current neighborhood.	1.03	5.67	10.31	44.33	38.66	4.14	0.89
	I feel that my neighbourhood meets all my current needs.	1.03	11.86	16.49	42.78	27.84	3.85	1.00
	I would recommend my neighborhood as a place to live	2.06	7.73	17.01	42.27	30.93	3.92	0.99
	I feel a strong sense of belonging and connection within my neighborhood.	6.19	11.86	34.54	26.8	20.62	3.44	1.13
	I am satisfied with the cleanliness and maintenance of public spaces in my neighborhood.	4.12	7.73	11.86	38.14	38.14	3.99	1.09
Active Lifestyle (ACT)	It is important to me to be able to easily walk to daily needs like shops, schools, and parks.	1.03	3.09	8.25	40.21	47.42	4.30	0.83
	Staying physically active is an important part of my daily routine.	0.52	3.09	9.28	36.6	50.52	4.34	0.81
	I enjoy spending time outdoors walking, running, or cycling.	1.03	2.58	13.92	40.72	41.75	4.20	0.85
	I avoid using motorized transport for short distances.	2.58	13.92	17.53	34.54	31.44	3.78	1.11
Social Lifestyle (SOC)	I value local events and community activities in my neighborhood	1.03	3.61	23.2	46.39	25.77	3.92	0.85
	I like knowing and interacting with my neighbors.	2.58	7.22	29.9	38.14	22.16	3.70	0.98
	I prefer neighborhoods where people look out for one another.	0.52	1.03	21.65	41.24	35.57	4.10	0.81
	I actively participate in activities that involve my local community.	7.73	14.43	34.02	25.77	18.04	3.32	1.16

The rankings (Table 4) reveal a clear hierarchy in perceived accessibility priorities. Groceries and work/school dominate the upper part of the ranking. Groceries is the most frequently top-ranked purpose, and Work/school shows a similar, though slightly more dispersed, pattern. At the other end of the ranking, worship is most commonly assigned to last place, where it appears for 40.2% of respondents.

Table 4. Ranking responses

Purpose	Rank1	Rank2	Rank3	Rank4	Rank5
Work/School	36.6%	19.1%	18.6%	14.4%	11.3%
Groceries	37.6%	37.1%	15.5%	5.7%	4.1%
Worship	12.9%	13.9%	12.9%	20.1%	40.2%
Retail/Errands	1.0%	11.3%	30.4%	35.6%	21.6%
Outdoor/Social	11.9%	18.6%	22.7%	24.2%	22.7%

3. MODEL FRAMEWORK

This chapter presents the conceptual and modelling framework used in the paper. The study builds on the idea that local accessibility is not only a matter of proximity, but also of how individuals evaluate the importance of different activities, the conditions under which they are willing to reach them, and the broader attitudes and lifestyles that shape those evaluations. To capture these dimensions, the framework combines a ranking-based choice structure with latent variables, allowing the analysis to account jointly for observed characteristics, purpose-specific accessibility preferences, and unobserved psychological factors that may influence how residents prioritize nearby opportunities.

When respondents are asked to rank a set of alternatives, the outcome is richer than a simple choice as it reveals the order of all alternatives. To exploit this information efficiently, the modelling is based on an exploded logit model, which treats the observed ranking as a sequence of conditional choices. Suppose the observed ranking for respondent n is

$$\pi_n = (j_{n1}, j_{n2}, \dots, j_{nR}) \tag{1}$$

where $j_{n1}$is the first-ranked alternative, $j_{n2}$is the second-ranked alternative, and so on. The exploded logit expresses the probability of observing this ranking as the product of conditional probabilities across ranking stages:

$$P(\pi_n) = \prod_{r=1}^{R} \frac{\exp(\mu_r V_{nj_{nr}})}{\sum_{k \in \mathcal{C}_{nr}} \exp(\mu_r V_{nk})}, \tag{2}$$

Where $\mathcal{C}_{nr}$denotes the set of alternatives still available at ranking stage r, and $\mu_r$is an rank-specific scale parameter. At the first stage, all alternatives are available. Once the first-ranked alternative is selected, it is removed from the choice set; the second stage then conditions on the remaining alternatives, and so forth.

For estimating the latent variables, we formulated a MIMIC (multiple indicator multiple cause) model, which has two components (Bollen, 1989): (i) a set of *structural equations*, which relates latent variables to observed respondent characteristics, and (ii) a set of *measurement equations*, that links the latent variables to the attitudinal indicators. Then, the choice model and the latent-variable MIMIC model are estimated jointly.

For the structural equations, let $LV_{\ell n}$denote latent variable ℓ for individual n. The structural equation specifies the latent variable as a function of observed characteristics:

$$LV_{\ell n} = \mathbf{z}_n \boldsymbol{\gamma}_\ell + \eta_{\ell n} \tag{3}$$

Where $\mathbf{z}_n$is a vector of observed characteristics; $\boldsymbol{\gamma}_\ell$is a vector of structural coefficients; $\eta_{\ell n}$is the error term.

For the measurement equations, Let y_{mn} denote the observed response of individual n to indicator m. The modelled indicator response y^*_{mn} is calculated as:

$$y^*_{mn} = \zeta_m LV_{\ell(m)n} + \nu_{mn} \tag{4}$$

Where $LV_{\ell(m)n}$ is the latent variable associated with indicator m; ζ_m is the factor loading or measurement coefficient; ν_{mn} is a random error term. Then, the observed ordinal response is generated by threshold crossings:

$$y_{mn} = c \text{ if } \tau_{m,c-1} < y^*_{mn} \leq \tau_{m,c}, \tag{5}$$

where $\tau_{m,c}$ are indicator-specific thresholds.

Figure 1 presents the structure of the model and reports the variables included in the choice model (CM) and structural equation model (SEM).

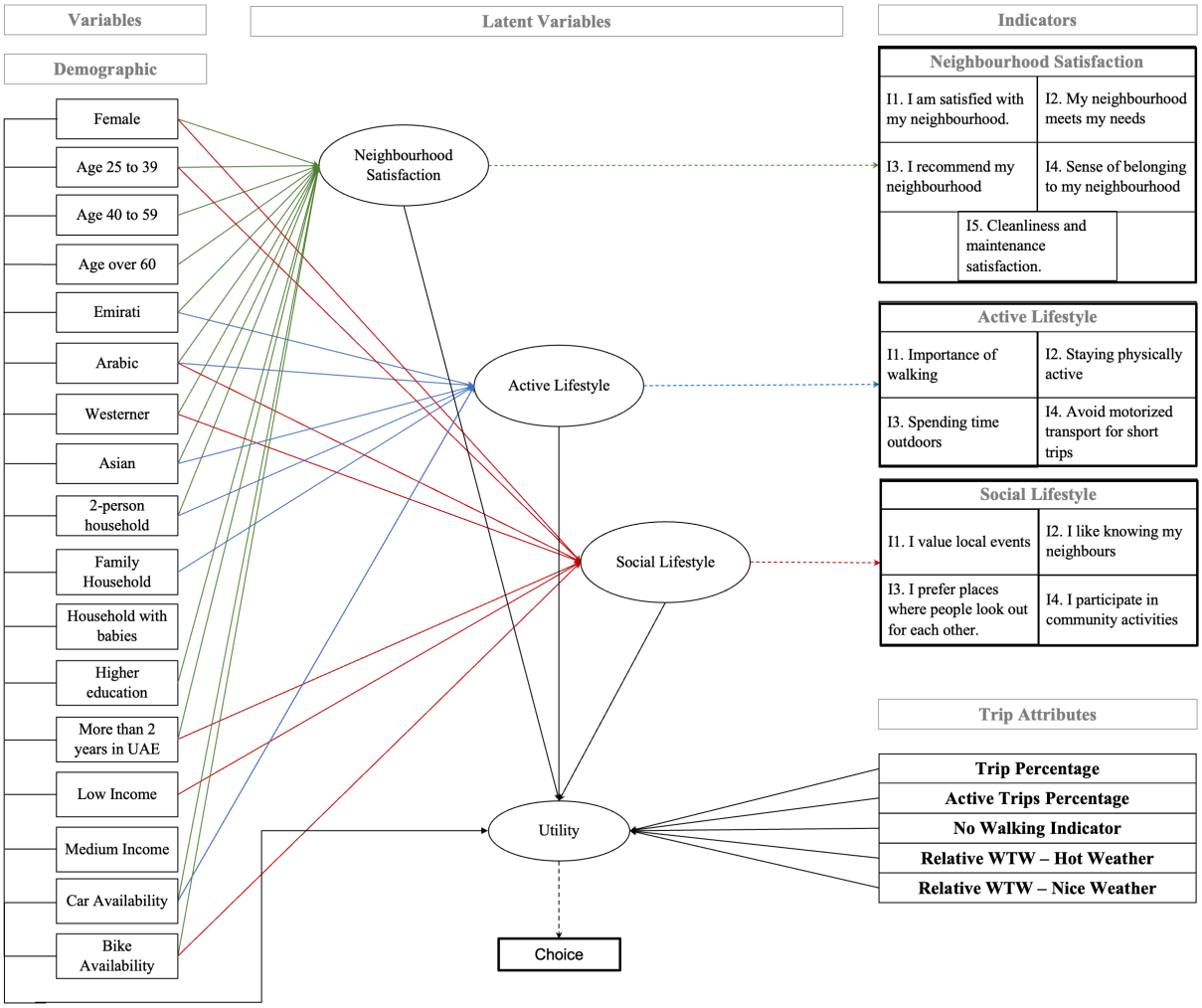


Figure 1. Model Framework

4. RESULTS

Table 5 reports the hybrid choice model estimated as an exploded logit with latent variables. First of all, the rank-scale parameters decline monotonically from the first to the fourth explosion stage (ranging from 0.57 to 0.12, with Rank 1 fixed to 1), indicating that respondents discriminate most clearly among their top priorities, while lower-order positions in the ranking contain progressively noisier preference information. The alternative-specific constants indicate that, after controlling for observed and latent covariates, groceries are statistically indistinguishable from work/school in their probability to be ranked highly, while worship and social/outdoor activities have lower average baseline utilities. Retail/errands also does not differ significantly from the reference in baseline terms.

A first important finding is that the desire to have an activity nearby is linked more strongly to actual walkability practice than to activity frequency. The generic "trip percentage" variable is not statistically significant, whereas "walk percentage" is positive and significant and the no walking indicator is strongly negative. In other words, the activities respondents most want nearby are not simply the ones they do most often, but the ones that already belong—or could belong—to their walkable activity space.

The weather variables require a more careful interpretation. For each purpose, the relative willingness to walk variables were constructed as the respondent's stated number of minutes willing to walk to that purpose under the respective weather condition, divided by that respondent's maximum willingness to walk. The no walking dummy equals one when the respondent is unwilling to walk to that purpose under either condition. The negative coefficient on walking in nice weather implies that when respondents are comfortable walking relatively farther to an activity in pleasant conditions, the urgency of having that activity immediately nearby declines. By contrast, the positive coefficient on walking in hot weather indicates that the activities respondents still consider worth walking to under thermal stress are precisely those they prioritize most strongly for nearby provision. This does not mean that heat encourages walking. Rather, it suggests that hot weather helps differentiate between trip purposes that remain essential, even in difficult weather, and those that can more easily be reached by other means.

Respondents aged 40 to 59 are less likely to prioritize groceries, worship, and social/outdoor activities nearby. By contrast, respondents over 60 are more likely to prioritize groceries and worship. This pattern suggests a more work centered local accessibility profile for mid-life adults, and indicates that respondents want different types of accessibility at different life stages.

Regarding the latent variables add in the choice model, neighbourhood satisfaction increases the utility of ranking work/school highly, active lifestyle increases the priority attached to groceries and social/outdoor activities, and social lifestyle has a positive influence with worship. These suggest that local accessibility priorities are also influenced by attitudes toward neighbourhood life and daily activity. The structural equations results are shown in Table 6. Neighbourhood satisfaction is higher among women, higher educated respondents and households with car availability. However, it is lower among two person households, respondents with longer residence in the UAE and several nationalities. Active lifestyle is strongly associated with bike availability, while social lifestyle is higher among women and respondents with bike availability.

Table 5. Choice model results

Model Framework		**ICLV - Exploded Logit**				
Generic Attributes		**Coefficient (t-test)**				
Trip percentage		0.6 (1.28)				
Walk percentage		0.85 (3.32)				
Walking - Nice Weather		-0.98 (-2.54)				
Walking - Hot Weather		0.82 (2.72)				
No Walking		-2.88 (-3.06)				
Scale	**Rank 1**	1 (Fixed)				
	Rank 2	0.57 (5.53)				
	Rank 3	0.31 (3.49)				
	Rank 4	0.12 (2.58)				
Purpose-Specific Attributes		**Work/ School**	**Groceries**	**Worship**	**Retail/ Errands**	**Outdoor/ Social**
Constant		-	-0.04 (-0.04)	-4.59 (-1.92)	-1.33 (-1.17)	-3 (-1.98)
Work frequency		0.18 (0.81)	-	-	-	-
Gender	**Female**	-	-	-1.33 (-2.77)	-	-
Age	**25 to 39**	-	0.64 (1.82)	-	-	-
	40 to 59	-	-1.17 (-2.53)	-3.22 (-3.71)	-0.98 (-1.47)	-1.67 (-2.99)
	Over 60	-	2.3 (2.19)	5.23 (1.74)	-	-
Nationality	**Arabic**	-	-	-	-1.52 (-1.81)	1.28 (1.89)
	Western	-	-	-9.7 (-2.17)	-	2.52 (3.66)
	Asian	-	-	-0.82 (-1.72)	-	1.91 (2.78)
Household Size	**2**	-	-	1.64 (2.06)	-	-0.99 (-1.64)
	More than 2	-	-	1.14 (1.63)	-	-1.12 (-1.99)
	With babies	-	-	-	-	1.63 (2.74)
Higher Education Dummy		-	-	-	-	1.21 (1.91)
Income	**Low (<10k AED)**	-	-	4.37 (2.18)	-	-
	Medium (10k - 50k AED)	-	-	4.77 (2.35)	-	-0.82 (-1.89)
Availability	**Bike**	-	-	0.75 (1.41)	-	-
	Car	-	-	-	-	-
More than 2 years in UAE		-	0.89 (1.95)	-	-	1.53 (2.2)
Dwelling Type: Villa		-	1.21 (1.33)	-	2.1 (2.02)	-
Latent Variables	**Neighbourhood Satisfaction**	0.32 (1.98)	-	-	-	-
	Active Lifestyle	-	0.37 (2.16)	-	-	0.49 (2.12)
	Social Lifestyle	-	-	0.42 (1.74)	-	-
LL Full Model		**-3367.02**				
LL Choice Model		**-723.28**				

Table 6. Structural equation results

Variable		Neighbourhood Satisfaction	Active Lifestyle	Social Lifestyle
		Coefficient (t-test)	Coefficient (t-test)	Coefficient (t-test)
Gender	Female	0.41 (2.66)		0.45 (3.03)
Household size	2	-0.53 (-2.49)	-0.2 (-1.06)	
	More than 2		-0.31 (-1.62)	
Age	25 to 40	-0.38 (-1.81)		-0.3 (-1.61)
	40 to 60	0.34 (1.45)		
	Over 60	0.76 (1.24)		
Years in UAE	More than 2	-0.68 (-2.29)		-0.29 (-1.34)
Availability	Car	0.26 (1.53)	-0.18 (-0.97)	
	Bike	-0.2 (-1.07)	0.52 (2.3)	0.53 (2.59)
Nationality	Western	-0.75 (-2.62)		-0.72 (-2.94)
	Arabic	-0.67 (-2.56)	-0.52 (-2.02)	-0.25 (-1.32)
	Asian	-0.5 (-1.97)	-0.4 (-1.86)	
	Emirati	-0.95 (-3.3)	-0.87 (-2.44)	
Income	Low (<10k AED)			-0.2 (-1.1)
Education Level	Higher Education	0.28 (1.22)		

5. DISCUSSION AND CONCLUSIONS

The findings suggest that the 15-minute city should be interpreted through perceived accessibility rather than through fixed proximity thresholds alone. In our case, what people want nearby is not a uniform set of amenities, but a purpose-specific hierarchy shaped by walking practice, weather conditions, life stage, household structure, and latent lifestyle orientations. This means that local accessibility planning should move beyond standardized amenity checklists and pay greater attention to which functions different groups consider most important to access close to home.

The results also show that climate is an important part of the mechanism through which residents define local necessity. In hot-arid settings, a climate-neutral walking threshold can therefore misrepresent lived accessibility. Planning for local living should account for thermal conditions, route comfort, and weather-specific willingness to walk, rather than assuming that the same travel-time threshold applies equally across seasons.

More broadly, the latent-variable results indicate that local accessibility is tied not only to urban form, but also to neighbourhood experience and everyday lifestyles. This reinforces the need for people-centered planning approaches that combine land use, pedestrian conditions, and behavioural differences when operationalizing the 15-minute city.

The main contribution of the paper is to show that nearby accessibility is simultaneously purpose-specific, socially differentiated, and climate-conditioned. In particular, the results highlight the importance of distinguishing between general proximity, actual walking practice, and willingness to walk under hot weather conditions. This is especially relevant for hot-arid cities, where the practical meaning of a walkable neighborhood cannot be separated from thermal exposure. Overall, the paper argues for a more nuanced

interpretation of the 15-minute city: one that reflects what residents actually value nearby, how those priorities vary across groups, and how climatic conditions shape the feasibility of local access.

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