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A Comprehensive Study of Travel Mode Captivity: A Nuanced Perspective on Car Captivity in New Cairo, Egypt

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ABSTRACT

The distinction between 'captive' and 'choice' user categories has long been a prevalent framework in transportation literature and planning circles. While 'captive' users rely on a sole mode, 'choice' users intentionally choose a particular mode based on perceived benefits. However, this binary classification is increasingly critiqued for its failure to capture the complexities of non-transit users. Not all individuals reliant on cars necessarily fit the traditional definition of "captive" users. This study delves into a nuanced perspective on car dependency, focusing on the degree of attachment to cars, and aims to categorize car-captive individuals beyond traditional definition. Examining the feasibility and implications of such categorization, this research adopts a tailored approach within the context of New Cairo, Egypt. An online geo-referenced survey was employed to measure car dependency potential clustering. The survey encompassed demographic information, travel behaviours, car dependency motives, and experimental travel mode change scenarios. Participants were deliberately selected from a comparable built environment to mitigate external factors' influence. The analysis encompassed both descriptive and inferential statistics, employing IBM SPSS Statistics 22 for a two-step clustering approach. This method, utilizing log-likelihood, revealing inherent groupings in the dataset, elucidating unique clusters related to car dependency. Iterative attempts were made to create a cohesive model, focusing on key variables such as dependency extent, time, and distance. In conclusion, the study findings proposed two other clusters, 'car reluctant' and 'car inclined' which differ in their level of attachment to car and level of intervention. By exploring potential categorizations beyond the conventional binary, this research contributes to urban planning and transportation design, fostering a more sustainable and user-centric mobility system. Also, it offers insights into the choice dynamics and the rigid concept of 'car captivity'.

Index-words: *Car dependent users, Car captivity clusters, and Two-step clustering method.*

I. INTRODUCTION

The categorization of travellers into 'captive' and 'choice' groups has long been a prevalent terminology in transportation literature and planning circles. 'Captive' users rely on a singular mode option. For example, car captives feel obligated to use automobiles due to insufficient transit choices or specific circumstances or simply because they have a personal preference for using cars. Conversely, 'choice' users have various options at their disposal but intentionally opt for a specific mode due to perceived benefits. This dichotomy is facing growing scrutiny, given its limited ability to capture the complexities of individuals' travel behaviours and preferences. Dividing travellers into just two categories, namely 'captive' or 'choice,' is overly simplistic and fails to provide an accurate and nuanced representation. The definitions associated with these labels often lack the necessary precision and consistency, casting doubts on their practical applicability in real-world scenarios.

In the realm of public transportation, mode captivity has emerged as a crucial term influencing decisions regarding transit planning, services, and investment. Transit ridership models tended to underestimate the diversity or range of transportation choices available to captive users. In other words, they may oversimplify the options or assume that everyone in this category uses the same mode of transportation, has the same preference and the same quality of transportation service.

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Reconsidering the concept of mode captivity, and recognizing its significance in segmentation is important to address market requirements and anticipate future demands. However, the challenge of making suitable definitions for mode captivity that seamlessly integrate into the transportation choices of individuals poses difficulties. This prompts a comprehensive investigation of the mode captivity concept, highlighting the significance of including motives, preferences and circumstances around mode dependency.

The existing literature in this field suffers from limitations, being either too scarce or overly reliant on rigid, established terminology. To address this issue, some researchers have introduced an intermediary concept that falls between the two extremes of 'captive' and 'choice' users, known as 'potential riders.' These are individuals who may consider using public transit under specific conditions and might abstain from car usage. Also, the concept of categorizing 'choice' users into different segments based on the nature of their transportation choices has been explored to some extent. However, there remains a notable gap in the literature regarding the categorization of 'captive' users, particularly in the context of 'car captivity.' Additionally, the transfer of research findings from developed countries to developing ones often lacks the necessary contextual adaptation. This underscores the importance of conducting studies that are specifically tailored to the unique settings and conditions of a given region. As exemplified by the focus of this paper on New Cairo, Egypt, it is essential to account for the local context and circumstances when conducting transportation research.

This study aims to examine captive users' segmentation, believing that segmenting the captivity into more categories enhances the accuracy of decision-making strategies and interventions, focusing on car captivity. The study delves into the possibility of categorizing individuals based on the degree of attachment they have to their cars and their willingness to shift to alternative modes of transportation. Not all car-dependent users may neatly align with the conventional understanding of "captive" users. This complexity prompts the researchers to embrace a precise outlook on car dependency and the underlying reasons for this dependence. This becomes crucial as the researchers delve into understanding their requirements for shifting to alternative modes. The implications of such categorization are particularly noteworthy for urban planners and designers, especially in a context that embraces automobile-oriented planning. The study also examines the factors and motives affecting car dependency in order to deeply understand the decision-making criteria and justify their degree of attachment to the car.

To delve into this exploration, the research utilized an online geo-referenced survey to explore the travel patterns and motives for car reliance and the potential categorization within the community of New Cairo. The selection aimed to include participants from a similar built environment to mitigate the influence of factors like built environment, travel mode options, and accessibility. The analysis employed descriptive and inferential statistics, including Chi-Square tests due to categorical data. IBM SPSS Statistics 22 was used for two-step clustering. This method was used to reveal inherent groups within the dataset based on key variables such as dependency extent, time and distance. The outcome clusters were then verified with the degree of change that is discussed later in the study.

In summary, this study explores travel decision behaviours, by shedding light on car dependency while delving into the concept of "car captivity" and its potential categorization. This study helps to provide valuable insights into the nuanced levels of captivity driven by personal preferences and motives, offering a profound understanding that can be instrumental in meeting market demands and effectively motivating specific segments of individuals who heavily lean on automobiles. This reliance often arises from their discontent with transit services or the limited availability of practical alternatives that meet their needs. The researchers aspire to enrich understanding of car dependency dynamics and the factors influencing it. Ultimately, the findings could contribute valuable insights to guide urban planning and transportation design, fostering a more sustainable and user-centric mobility

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system.

A. Background

The transportation literature broadly categorizes users into two main groups, 'captive' and 'choice' users. These terms have been widely used in academic literature and in professional transportation planning circles for many years such as Brown (1983), Polzin, Chu, and Rey (2000), Peng, Yu, and Beimborn (2002), Beimborn, Greenwald, and Jin (2003), Krizek and El-Geneidy (2007) among others as cited in Jacques et al. (2012). In the public transit industry, transit captivity has long been a fundamental factor influencing transit planning, service, and transport investment decisions (Polzin et al., 2000). In light of this context, it is essential to re-examine the concept of captivity, given its importance in decision-making and in exploring potential strategies for promoting more sustainable travel choices. Despite the ambiguity associated with these terms, the definitions of captive and choice remain vague and have a lot of variations. The absence of a precise and consistent definition for captive and choice users of a particular mode creates confusion regarding their practicality (Polzin et al., 2000).

The American Public Transportation Association defined captive riders as individuals "who lack access to a personal vehicle or the ability to drive (for any reason) and rely on transit for their intended trips" (2002). Captive users predominantly depend on transit as their primary mode of transportation (particularly for specific locations, like work). On the other hand, choice users (also termed discretionary riders) have alternative transportation options to reach diverse destinations but opt for transit for specific reasons (Beimborn et al., 2003; Krizek and El-Geneidy, 2007). Beimborn et al. (2003) described individuals who have no other option available to them as captive users. Transit captives are those individuals who do not have a driver's license or do not own a car while car captives feel compelled to use cars due to inadequate transit options or specific circumstances. Conversely, choice users are those who possess multiple options but deliberately choose a particular mode due to perceived advantages. However, the rigid distinction between these categories fails to encompass all scenarios (Krizek and El-Geneidy, 2007; Jacques et al., 2012).

Increasing ridership represents a substantial goal within transportation sector development, yet it often fails to target an understanding of non-transit riders' preferences (such as car captive users). The literature frequently uses these two terms, failing to make an effort to comprehend individuals' inclinations and preferences concerning their levels of captivity (El-Badawy et al., 2021). Changes in captivity status are not correlated with preferences (enjoyment), and circumstances such as finding satisfaction in using transit despite owning a car or experiencing shifts in income can lead individuals to shift from being captive riders to becoming choice riders (Singleton, 2019). Cervero and Radisch (1996) emphasized that the built environment significantly shapes decisions regarding travel modes. In this context, nothing aligns more seamlessly with car-oriented planning than the car itself. In this situation, it is merely a necessity, but their preference varies.

Discerning various levels of captivity based on preferences holds significance in catering to market needs and motivating specific groups of individuals who heavily rely on cars, either due to dissatisfaction with transit service or the absence of viable alternatives. A study on the opening of the Orange Line in Chicago revealed that a portion of transit users were former automobile commuters who switched to transit (Krizek and El-Geneidy, 2007). This hints at the existence of a latent demand for new transit users. However, there is limited research on the characteristics of the two users. Non-users can be categorized as potential riders and auto captives, as cited by Krizek and El-Geneidy (2007). Potential riders are individuals who might consider using transit under specific circumstances, while auto captives are exclusively automobile users who do not realistically consider transit as an option.

The transit sector primarily targets potential riders to increase ridership, emphasizing the importance of understanding the factors that encourage potential riders to become choice riders while disregarding car captive. Challenges arise when attempting to categorize individuals who engage in transportation modes other than car ownership or opt for transit, irrespective of the options available to them, their preferences, and circumstances. As a result, relying on the

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captive and choice labels becomes uncertain, as these classifications cannot be generalized and instead must be understood within specific contexts.

The application of literature from developed countries to developing countries is limited and lacks contextualization (Fang et al., 2021). For instance, while car usage is a choice in developed countries, it plays a significant role in developing countries due to insufficient public transportation and limited alternatives located in car-oriented planning like the study area. This highlights the need for studies tailored to specific contexts. In Cairo, Egypt, old neighbourhoods with crowded streets and grid street patterns discourage the use of public transport, leading residents to opt for private alternatives. In contrast, modern neighbourhoods with lower density and distinct land use make public transportation less feasible, resulting in a similar reliance on private alternatives and the associated negative consequences (Ghonimi, 2017). Although Egypt is a developing country, the number of car ownership is increasing rapidly. When individuals' income gets higher, they tend to choose private car ownership, whether paid in full or through instalments, rather than using public transportation. This preference is reinforced when public transport modes are perceived as unsafe, unreliable, uncomfortable, and of subpar quality (Abdel Wahed Ahmed and Abd El Monem, 2020). In the literature concerning the Egyptian context, the focus is primarily on identifying the variables influencing travel patterns and choices, with an emphasis on understanding the reasons for car dependence. However, these discussions often overlook individuals' preferences and their willingness to consider alternatives or abandon car usage if other viable options that meet their needs are offered. This underscores the significance of this paper in addressing these aspects and emphasizes the necessity for further studies specifically tailored to the Egyptian context. Such research is crucial for advancing mobility solutions with a user-centric approach.

B. The Case Study 'New Cairo'

New Cairo was founded in the late 90's to ease downtown congestion and extend the borders of Cairo's capital. It was one of the new urban communities (NUCs) that emerged in the east to counter the swift urbanization occurring nationwide and address persistent challenges. Although the initial vision for New Cairo aimed at fostering inclusive urban development, its actual evolution led to social exclusion, largely attributed to the emergence of enclosed gated communities and social segregation. As analysed from the fieldwork of the study, the gated compounds constitute 31% of the entire built-up area, in contrast to 0.05% of the social housing. Consequently, New Cairo became a magnet for affluent and upper-middle-class segments of society. New Cairo is vital for connecting old and new capitals, becoming a transit hub through projects like monorails, metro expansions, and the BRT system (see Figure 2) (Hegazy et al., 2019).

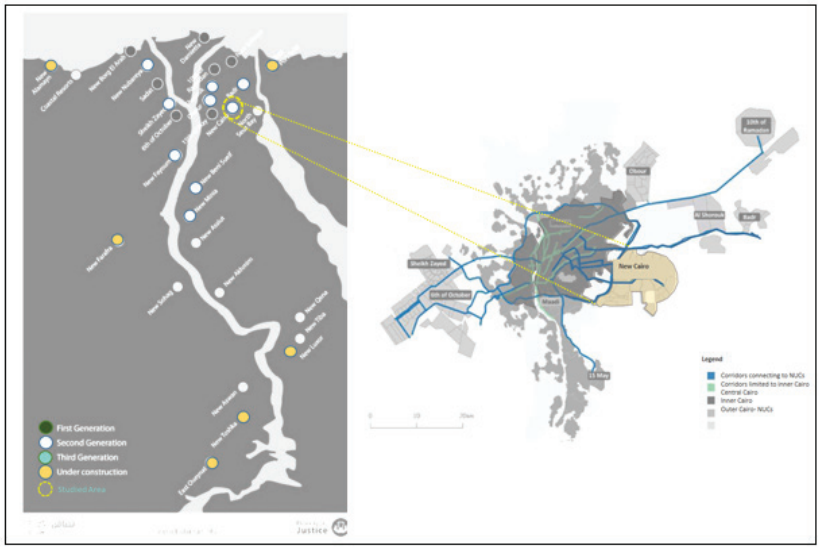

Fig. 1. New Cairo (the study area)
Source: www.Tadamun.info and TFC Report

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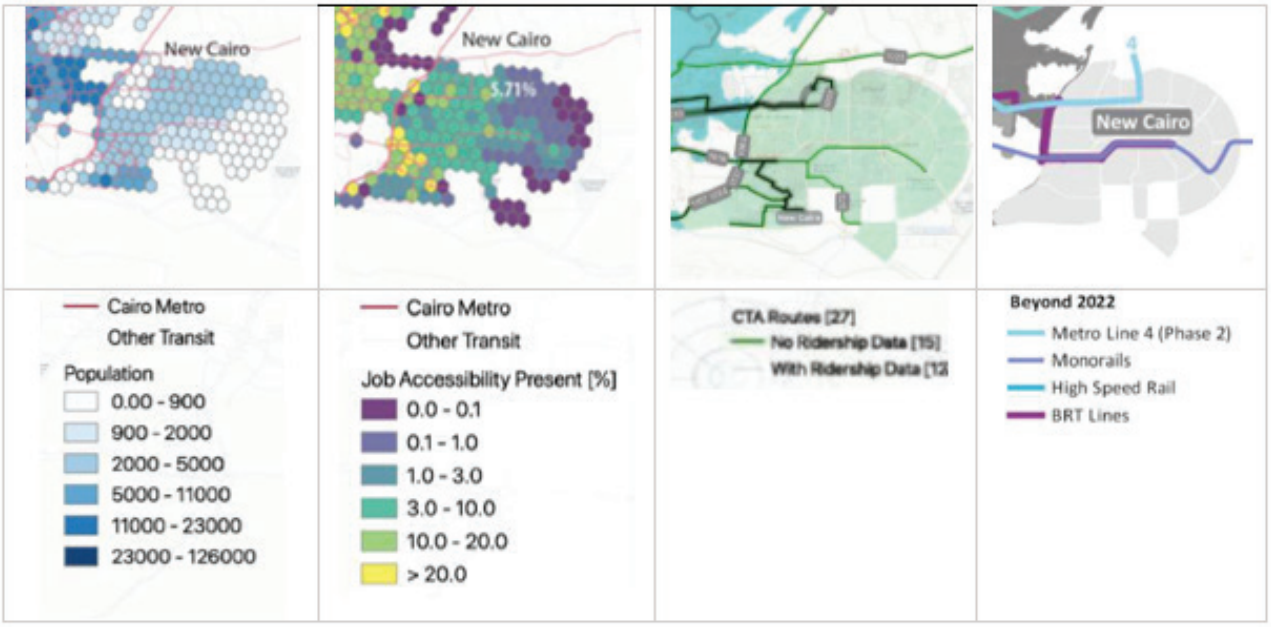

Fig. 2. Population distribution, job accessibility and public transport routes
Source: TFC Report

Population density within the region exhibits an uneven distribution, with the north-western sector boasting a higher concentration of residents (see Figure 2). This phenomenon can be attributed to several factors. Firstly, this area offers affordable housing options, making it an attractive choice for many. Secondly, its close proximity to the ring road, facilitating swift connections to the city centre and neighbouring districts, contributes to its popularity. Additionally, the presence of public transportation buses, shuttling passengers from New Cairo to the city centre. On the contrary, the eastern part of the region remains less developed, characterized by a prevalence of gated compounds and pockets of vacant land interspersed throughout (see Figure 3). The availability of public transportation in this area is comparatively more limited, underscoring the disparities in development and accessibility. The substantial distances between destinations and the homogeneity of land use patterns in this area have amplified the reliance on cars, making it less conducive for residents to opt for pedestrian travel to access nearby services. Especially given the absence of shaded streets, which renders walking during the summer months particularly challenging (see Figure 3). The primary mixed-use hub is strategically positioned at the heart of the plan, aligning with the two main arterial roads. In addition, local commercial zones are thoughtfully distributed within the core of each neighbourhood, ensuring accessibility and convenience for residents. As seen in Figure 4, the road network begins with main arterial roads, which typically have widths ranging from 70 to 90 meters. These primary roads then branch out into almost a grid system, dividing the overall plan into distinct zones (neighbourhoods) where local streets are situated. Unfortunately, the pedestrian network in this area is inadequate as the car is prioritized due to the streets' width and the absence of safe crossing areas. Public transport is primarily available on the primary roads. As a result, there is a significant challenge when it comes to covering the first and last mile distances, as there are no transportation options readily available for these short distances.

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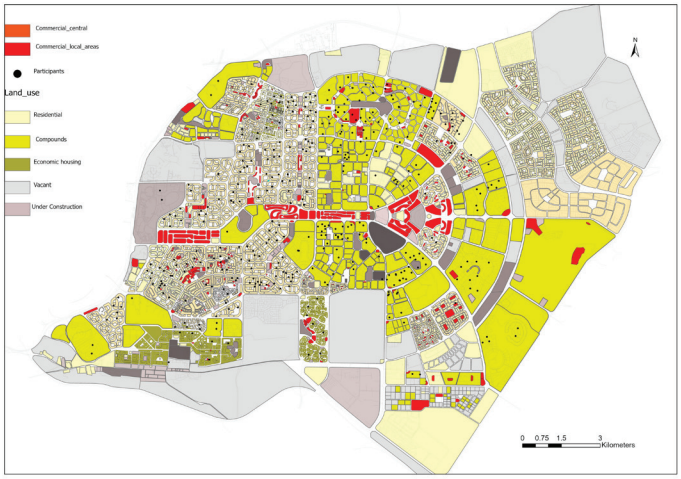

Fig. 3. Land use distribution New Cairo
Source: The authors

Fig. 4. Sample distribution, road hierarchy
Source: the authors

II. METHOD AND PARTICIPANT SELECTION

The study relied on an online geo-referenced survey. The survey was carried out online (voluntary and anonymous) across multiple platforms associated with the New Cairo residents. Participants who willingly responded to the survey were requested to share the survey with people residing in the designated study area. The study intended to choose participants residing within the similar built environment, in order to mitigate the effects of factors of the built environment itself, available travel mode options, and the degree of accessibility to services.

In order to attain a strong 95% confidence level while maintaining a 5% margin of error in the survey outcomes, the sample size was calculated employing Cochran's sample size formula (Megahed et al., 2020). The population was estimated to be 300,000 as per the estimations of the New Cairo Authority 2020, resulting in the identification of a representative sample comprising 384 respondents as the intended target (Governorate, 2022). As seen in Table I, the sample demonstrated a relatively even distribution across age and gender groups. However, owing to the predominantly high socio-economic status of New Cairo's residents, the sample exhibited a bias towards certain economic level, residential block type, and primary mode of travel. The high percentages of travel intensity is also noticed due to the low densities and the long distances of the studied area.

$$n = \frac{x^2 \times P(p-1)}{e^2}$$ *Cochran's sample size formula*

The presented study relied on 351 participants out of 400, all of whom indicated that their primary mode of transportation is the car. This purposeful selection is intended to align with the study's aim of classifying car-dependent users into clusters according to their level of attachment to their cars. This classification, when combined with the attitudinal section of the survey, seeks to achieve a more profound understanding of the reasons behind the attachment to cars.

TABLE I: SOCIO-DEMOGRAPHIC DISTRIBUTION OF THE SAMPLE

- Gender	***F*** *(57%)*	***M*** *(43%)*		
-Age	***18-24*** *(6%)*	***25-40 Year*** *(48%)*	***40-60 Year*** *(35%)*	***>60 Year*** *(10%)*
-Employment	***Employed*** *(63%)*	***Not/employed*** *(4%)*	***Freelancer*** *(15%)*	***Other*** *(17%)*
Economic level	***High*** *(56%)*	***middle*** *(41%)*	***Below middle*** *(3%)*	

-Walkability of Neighbourhood* *(WN)*	***Highly WN*** *(27%)*	***Moderate WN*** *(53%)*	***Low WN*** *(20%)*	
-Residential block Type *(RB)*	***Gated Compound*** *(47%)*	***Social RB*** *(9%)*	***Upper RB*** *(44%)*	
-Travel Intensity *Mobile user (MU)*	***High MU*** *(53%)*	***Moderate MU*** *(38%)*	***Low MU*** *(9%)*	
-Primary Travel Mode	***Car*** *(88%)*	***Carpooling*** *(1%)*	***PT*** *(8%)*	***Ride-hailing apps*** *(3%)*

**The measurement of walkability was conducted by the participants to explore their perceptions of the surrounding built environment. It utilized a 5-point Likert scale addressing three primary aspects: promotion of active transportation modes, accessibility of shops and services within walking distance, and safety.*

A. Survey Design and Data Analysis

The survey was structured into four primary sections: the initial section aimed at gathering demographic information (such as Age, Gender, Economic level, and Employment status). The subsequent section concentrated on travel behaviours, patterns, and preferences. The third segment delved into the factors influencing the persistence of car dependency, encompassing an attitudinal section discussing the reasons for this dependency (von Behren et al., 2018). Lastly, the survey concluded with an experimental component that examined the potential for altering travel modes. This involved presenting new travel options and comparing them against the use of cars (see Figure 5).

1. Degree of Change

The degree of change was based on the willingness of the participant to change their primary mode to other sustainable choices. The participant has to choose one for short trips and one for long trips, which makes the Degree of Change index out of 2.00. As 1.00 for making one change in either the short or long trip, 2.00 for making a change in both designated trips, and 0.00 for no change. This helps in comparing car captivity clusters to the degree of change and the participant's willingness to change their primary mode.

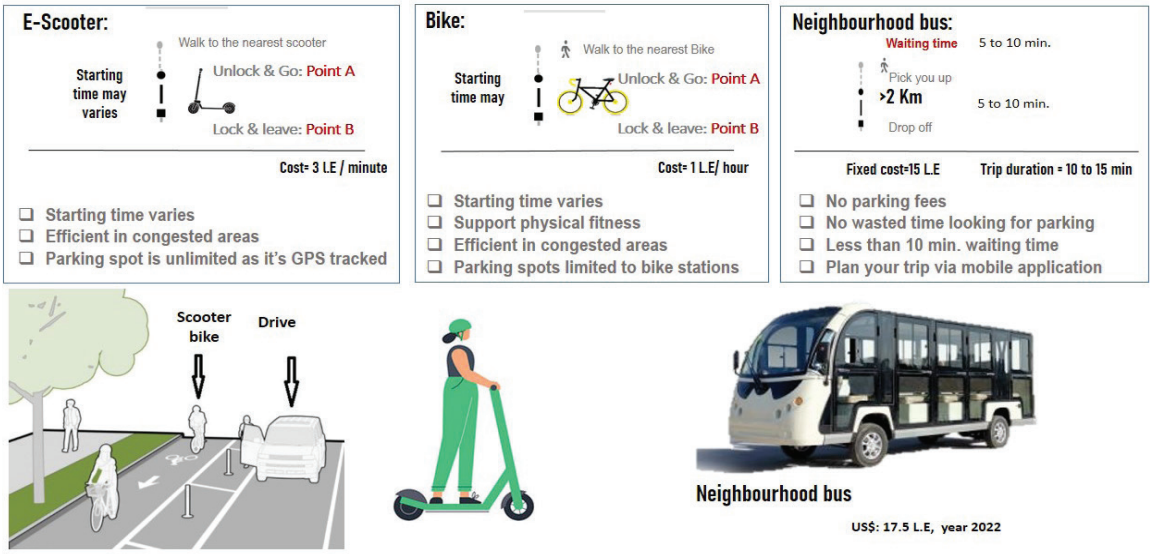

Fig. 5. Experimental model offering other sustainable choices (source: author)

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The study used descriptive and inferential statistical methods to analyse questionnaire responses. Descriptive statistics were used to organize and summarize the data, including frequency distributions for individual questions. Inferential statistics, particularly Chi-Square tests due to the categorical nature of most variables, were used to investigate the significance between variables.

Two-step clustering was done using the log-likelihood measure to reveal natural groupings in the dataset, using IBM SPSS Statistics 22 (Rundle-Thiele et al., 2015). The datasets originated from the survey in which respondents were presented with a series of questions concerning their reliance on cars and the potential for transitioning to alternative modes of transportation. The variables were categorical with an ordinal nature. V1:Car_dependency, V2:Try_another_moder, and V3: Change_mode_Commuting_time. As seen in Table II, (V1 and V2) answers relied on a Likert-type scale designed to measure the degree to which individuals perform certain actions or could do some changes. V3 inquires about the circumstances under which individuals would opt not to use their car, whether it is for local trips or for regional travel outside of New Cairo. As indicated in Table II, V1 assesses the degree of dependency, V2 examines the impact of time, and V3 evaluates the effect of distance on car dependency. Numerous attempts were undertaken to achieve a successful model with a cohesion measure surpassing 0.0; in our case, it recorded 0.4, which stands as a reliable benchmark for evaluating the model, coupled with a good cluster ratio of 1.08.

TABLE II. VARIABLES QUESTIONS IN THE SURVEY
(Source: the authors)

Variables	*Questions in the Survey*
V1 $_{Dependency}$	*'I depend on the car as the only travel mode' to what extent it is true?*
V2 $_{Time}$	*Do you change your primary mode (car) if you have regional trips (long commuting time)?*
V3$_{Distance}$	*In which of the following cases, would you leave your car and try another mode?*

2. Study's Limitation

The study's limitation lies in the socio-economic makeup of the sample, predominantly comprising individuals from the upper-middle to upper social class. This composition might not fully capture the diversity of the broader population. However, this bias could be advantageous for the study's purpose, given that the focus is on car dependency, a capability more prevalent in this socioeconomic stratum.

III. RESULTS AND DISCUSSION

It was found from the survey that there are several factors that influence car dependency. Some of them were found to be statistically significant using the Chi-Square test. The "strongly true" and 'true' statements that indicate high agreement with the statement mentioned in Table II, 'I depend on the car as the only travel mode', are remarkably high among the "high mobile users" group, whose total trip duration per day is around 1 hour or more. They resemble more "lonely commuters" and "Drop off" companions. The age range varies from 25 to 60 years old, with a moderate to high economic status. Disagreement with the statement was negligible across most of the variables. This could be due to a consistent trend shared among the participants (see Figure 6).

TABLE III: P-VALUE TEST WITH RESPECT TO THE 'CAR_DEPENDENCY ' VARIABLE

Variable	P-value
Age	**<0.00**
Gender	**<0.20**
Economic level	**<0.75**
Traveller's Characteristics	**<0.00**
Degree of Change	**<0.11**
Total trips duration	**<0.03**
Travel Intensity	**<0.10**
Change mode commuting time	**<0.00**

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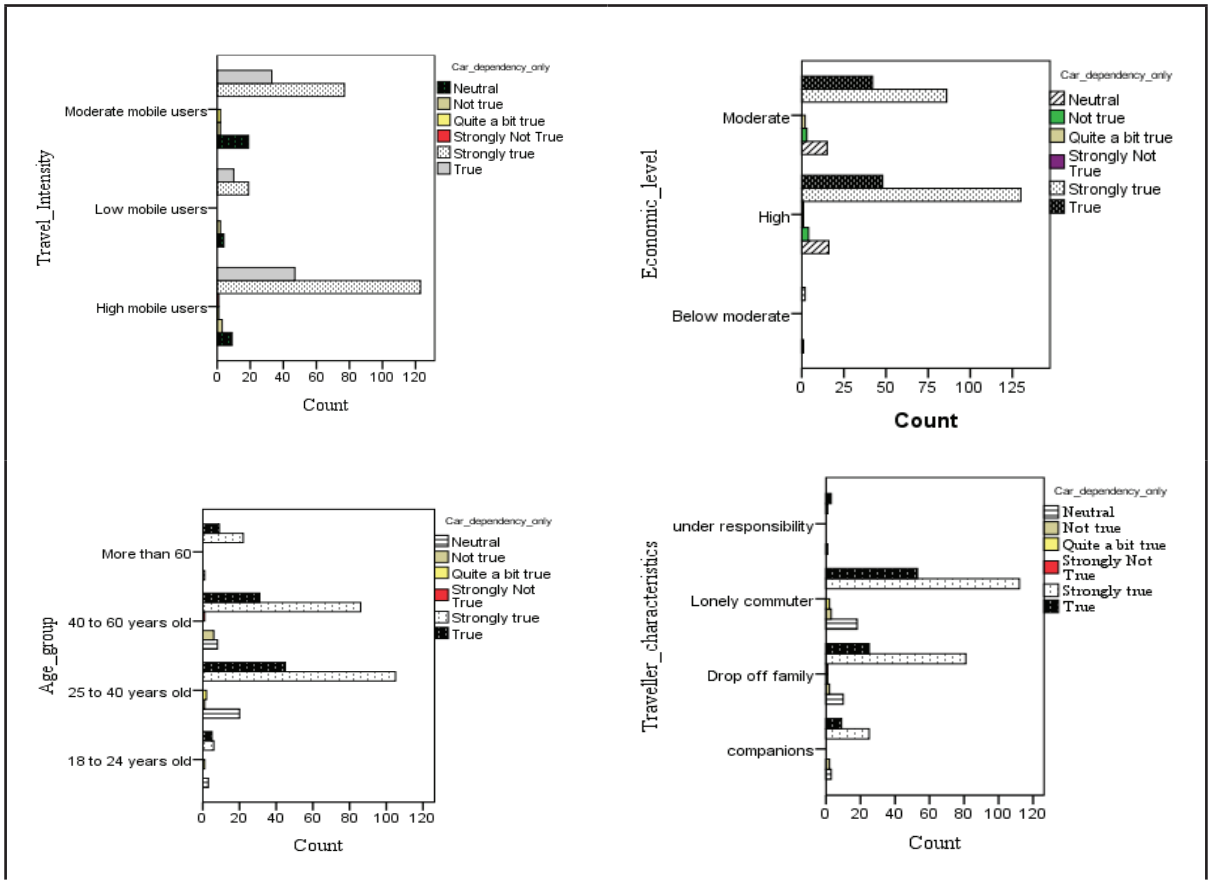
The variables underwent testing for significance with respect to 'Car_dependency.' Among these variables, 'age,' 'traveller's characteristics,' 'total trip duration per day,' and 'change mode according to commuting time' exhibited a high level of significance. However, 'Economic_level' did not show significance, which could potentially be attributed to the non-representative nature of the sample across the three economic groups (see Table III).

Regarding the attitudinal section, as shown in Table IV below, 42% of participants reported experiencing a sense of excitement when using cars. The car provided them with the luxury of increased flexibility, companionship, reduced waiting times, and the convenience of using the vehicle as storage for personal items. 77% of participants mentioned that challenging weather conditions during summer and winter, coupled with a lack of shaded streets, discouraged walking. This observation corresponds with their perception of the neighbourhood's walkability, as presented in Table I, where only 27% indicated high walkability. This situation might be attributed to the low-density built environment of the studied area, characterized by leapfrog development. The absence of integrated mobility solutions, along with deficiencies in public transport autonomy and smart modes, accounted for 37%, 33%, and 20%, respectively. These percentages underscore the transportation sector's failure to adequately address the requirements of New Cairo's intended residents. These individuals seek smart technologies such as online tracking and ticketing, as well as intermodal digital platforms. In terms of the built environment, they express a need for secure bike lanes and versatile unconventional transit hubs. Furthermore, in the realm of transportation modes, there is a demand for innovative mobility options like scooters and electric vehicles that align with their convenience preferences.



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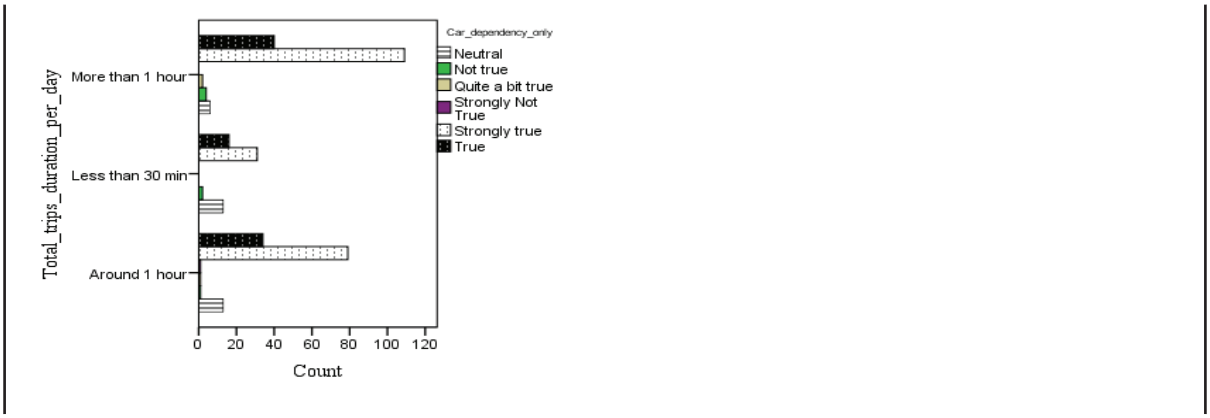

Fig. 6. Car dependency in relation to other variables
Source: the authors

TABLE IV: THE RESULTS OF THE ATTITUDAL FACTORS: REASONS FOR CAR DEPENDENCY

Car Excitement	***CE***
▪ *Driving my car makes me move around freely* ▪ *Pick up others and drop them* ▪ *Carry things that make my car as my bag* ▪ *A tight schedule makes me sensitive to waiting time*	*42%*
Integrated Mobility Deficiencies	***IMD***
• *Need Safe bike lanes* • *Need tram line that connects new Cairo main commercial centers* • *Need a transportation hub that has facilities like parking, commercial shops and banks* • *Need fixed route private buses* • *Need continuous maintenance within a high-standard interface* • *Need light rail that is well networked all over New Cairo*	*37%*
Public Transport Autonomy	***PTA***
• *No efficient and quick mobile app. that offers the best travel options* • *No online tracking of arrival/departure* • *No inter-modal digital platform*	*33%*
Weather Resistance	***WR***
• *Tough weather in summer & winter prevents using PT* • *Shaded streets for walking*	*77%*
Smart Modes Absence	***SMA***
• *Need unlock and go scooters* • *Need unlock and drive electrical vehicles*	*20%*
Privacy and Safety in Car	***PSC***
• *Feel more safe when I am in my car* • *Privacy issue, I don't feel comfortable in public transport* • *Sensitive to physical movement so car is the best option*	*24%*

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In summary, the absence of comprehensive integrated mobility solutions seems to play a role in fostering heightened car dependency among New Cairo's residents. Their preferences for smart technologies, improved built environment features, and innovative transportation options underscore their desire for more convenient choices. Addressing these elements in a comprehensive manner has the potential to diminish reliance on cars and promote a more sustainable and diverse mobility environment in the region.

A. Car Captivity Clusters

As a consequence of the Two-Step clustering process using the log-likelihood measure, depicted in Figure 7, which is a recognized method for handling categorical variables (Norusis, 2009), distinct groups of individuals reliant on cars were identified using pivotal variables derived from the survey outcomes (dependency, time and distance, see Table II). As presented in the figure, the model outcome was four clusters, but the researchers combined Cluster (1) and Cluster (2) due to their similar characteristic of displaying strong agreement regarding the lack of willingness to replace the car. The outcome of this analysis concluded in the formation of distinct clusters, subsequently inspiring an alternative approach to transportation market segmentation. This involves three distinct market segments; namely, car captive users, car inclined users, and car reluctant users, ranked in a descending order of attachment strength from the highest to the lowest.

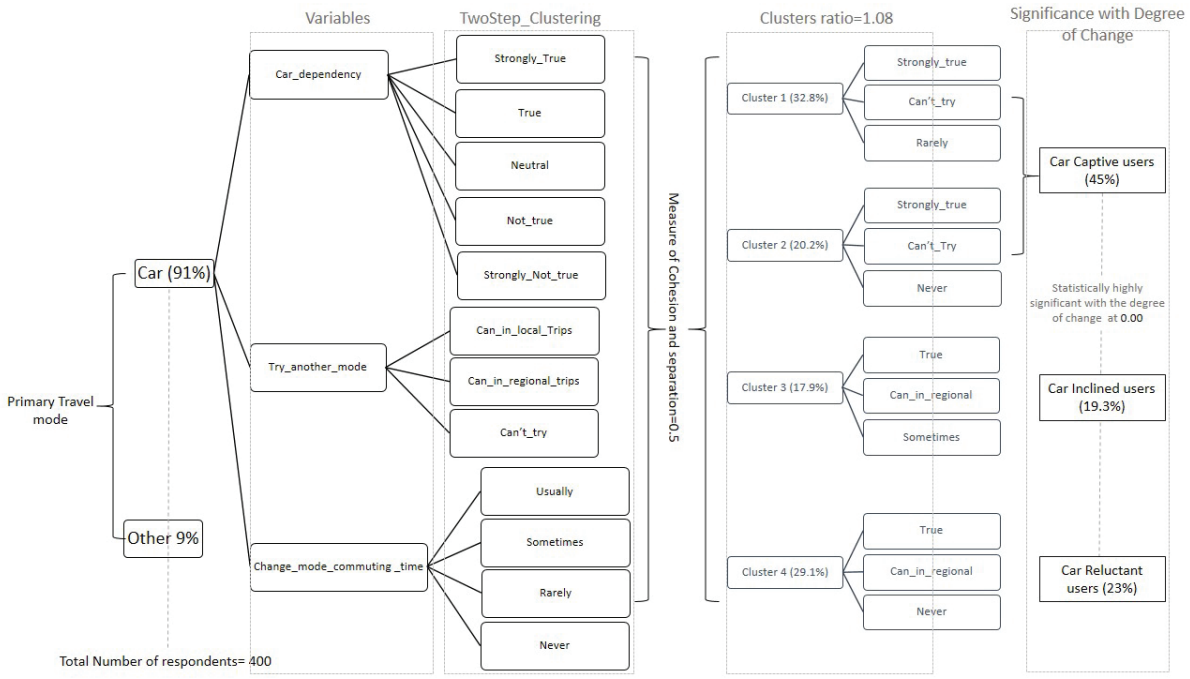

Fig. 7. Two-step Clustering for V1, V2, V3 to segment car dependency using SPSS
Source: the authors

To validate the clustering results, following Norusis (2009), Pearson's chi-squared test was applied to confirm significant differences among the clusters across the segmentation variables. The test yielded a p-value of <0.05, indicating high significance. After validating the clustering, One-way ANOVA was utilized to assess the relationship between the clusters and the degree of change variable.

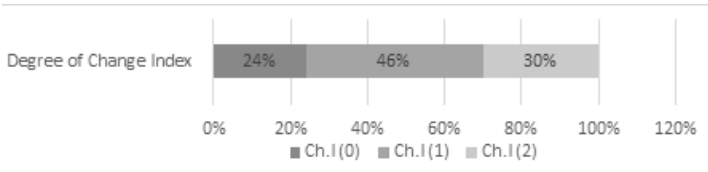

Fig. 8. Degree of change for the experimental section
Source: the authors

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The results, as shown in Table V, indicate that there are indeed differences among clusters in relation to the (Degree of Change) variable. The results of the One-way ANOVA analysis revealed statistically significant differences among the clusters concerning the degree of change variable. This implies that the clusters are not uniform in terms of their responses to changes, and there are distinct variations in how they respond. The high level of significance suggests that the observed differences are unlikely to occur by random chance alone. These findings strengthen the validity of the clustering results and underscore the importance of the identified clusters in relation to the degree of change variable.

TABLE V: SIGNIFICANCE BETWEEN CLUTERS AND DEGREE OF CHANGE USING ANOVA

ANOVA

Degree_of_Change

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.769	3	2.256	4.305	.005
Within Groups	181.853	347	.524		
Total	188.621	350			

1. Interrelationships between car captivity clusters and other variables

The analysis revealed a statistically significant relationship between car captivity clusters and walkability of the neighbourhood ($p < 0.05$). Also, the relation between car captivity clusters and traveller's characteristics was found to be statistically significant at ($p<0.05$). As shown in Figure 9, the group of lonely commuters exhibited the highest representation within the captive and reluctant clusters. Interestingly, individuals who consistently drop off their family members displayed a fair inclination, prompting considerations about its feasibility. Those who exclusively rely on their own driving and do not have dependents are likely to find transitioning to alternative modes less feasible compared to those responsible for transporting others, which needs further investigation.

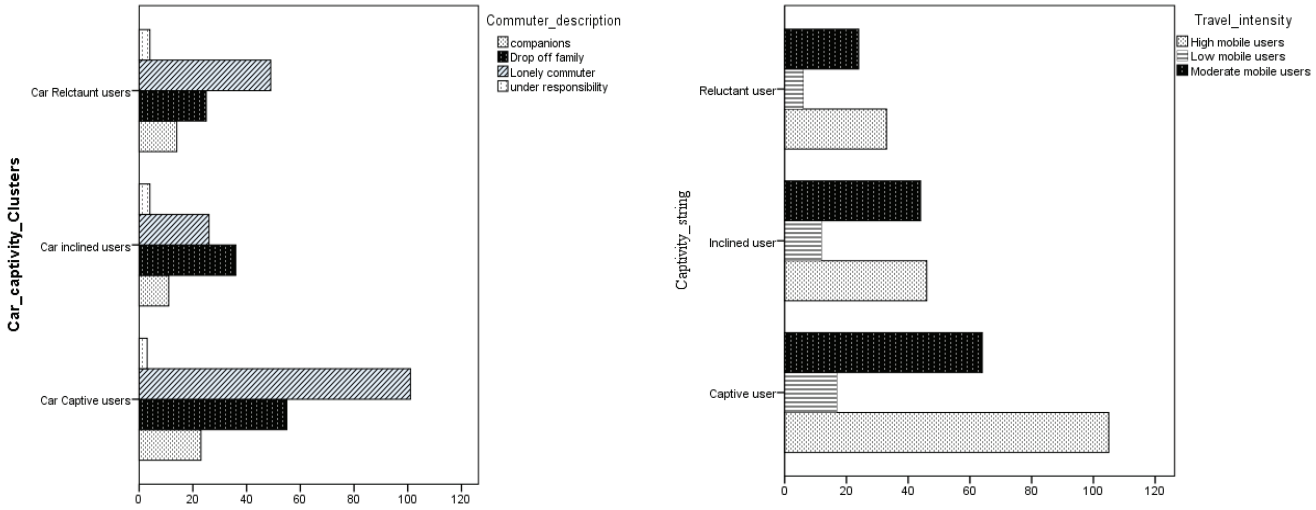

Fig. 9. Car captivity clusters with other variables

Travel intensity did not demonstrate statistical significance; however, the captive users prominently featured a substantial number of high travel intensities. In contrast, the inclined cluster exhibited an even distribution of both high and moderate mobile users. The results suggest a moderate influence of travel intensity on the degree of car captivity. As proposed by Jacques et al. (2012), the likelihood of individuals transitioning from automobile travel to other modes is diminished when confronted with potentially long travel distances, a circumstance applicable to the studied area.

Gender exhibited statistical significance with a significance level of $p < 0.05$. Tiikkaja & Liimatainen (2021) previously established a correlation between gender and car usage, noting that women often prioritize safety and privacy. This observation aligns with the

researchers' findings, as females displayed a greater tendency towards car captivity compared to males.

The relationship between car captivity clusters and age or economic level variables was not found to be statistically significant. However, this lack of significance does not necessarily imply the absence of an influence. As noted by Lansley (2016), car ownership and dependency have frequently been considered indicators in demographic assessments for gauging prosperity or societal status. This suggests the requirement for additional investigation.

The significance of this study is underscored primarily by its innovative methodology. The experimental section of the survey stands out for its efficacy in exposing alternative choices through the use of illustrative cards, strategically influencing participants' decisions in a positive direction. The introduction of illustrative cards during the survey induced a pronounced shift in the participants' decisions. This effect was especially prominent among those who were initially faithful proponents of 'car-dependency.' Remarkably, a substantial proportion of these participants exhibited a shift of 1.0 or 2.0 degrees in their preferences. This not only signifies a remarkable advancement in influencing perspectives but also underscores the critical importance of incorporating visual aids in survey design.

The study introduces a novel concept by challenging the conventional notion of treating "car captives" as a monolithic group. Instead, it innovatively segments this seemingly rigid category into clusters based on participants' varying degrees of attachment to their cars. This strategic approach not only breaks down a complex term but also refines interventions by tailoring them to the specific needs of users. The brilliance of this approach lies in its ability to capture the nuanced spectrum of individuals' attachments to their cars. By recognizing and categorizing different levels of attachment, the study provides a more granular understanding of user preferences and behaviours. This segmentation, in turn, enhances the precision of interventions, ensuring that strategies are finely tuned to address the distinct needs of each cluster within the broader category of "car captives."

In summary, the study utilized a comprehensive methodology, integrating survey data, an experimental approach, and advanced statistical techniques. This approach provided insights into participants' attitudes and behaviours related to car dependency and alternative transportation modes, contributing to a nuanced understanding of the factors influencing transportation choice.

B. Implications for Policy and Future Research

The study suggests a need for policy interventions that address the specific needs and preferences of different user groups, including gender-specific transportation solutions. Additionally, the findings highlight areas for further research, particularly in understanding the nuanced impacts of economic status and age on transportation preferences.

– **Towards Sustainable Urban Mobility:** Ultimately, the study advocates for a shift towards more sustainable, efficient, and inclusive urban mobility solutions. By acknowledging and addressing the varied reasons behind car dependency, New Cairo can pave the way for a more environmentally friendly and accessible transportation system, catering to the diverse needs of its residents.

– **Opportunities for Urban and Transportation Planning:** The findings present a compelling case for urban planners and transportation authorities to rethink and redesign the city's mobility landscape from a user-centric approach. Integrating smart transportation technologies, enhancing walkability, and developing comprehensive and integrated public transportation networks could significantly reduce car dependency.

IV. CONCLUSION

In summary, the survey results underscore a prevailing reliance on cars as the primary mode of transportation. Notably, 42% of respondents express excitement for car usage, aligning with the percentage observed for the 'car captives' cluster due to the convenience, comfort, and personal space it offers, as well as the social status it may confer. A clear correlation emerged between time and distance and an increase in car dependency, these relationships were found to be statistically significant. The

lack of comprehensive integrated mobility solutions and the absence of smart technology has proven to be discouraging factors for individuals heavily reliant on cars, inhibiting their willingness to embrace alternative modes of transportation. The absence of user-friendly and technologically advanced options could preserve car-centric behaviour, limiting the potential for sustainable mobility alternatives. Moreover, the presence of tough weather conditions during both summer and winter, coupled with a lack of properly shaded streets, contributed to the discouragement of active modes, as reported by 77% of participants. This observation was consistent with their perception of the low walkability of the neighbourhood. Regarding traveller characteristics, a significant association was discovered with car dependency. Individuals who consistently travel with companions, responsible for dropping off, exhibited a pronounced reliance on car usage, indicating challenges in substituting this mode of transportation.

Insights

- **Attitudinal Factors:** Residents cite excitement in using cars, and reduced waiting times as reasons for car dependency. Concerns about weather conditions discourage walking, while the lack of integrated mobility solutions and smart modes further push towards car usage.
- **Statistically Significant Variables:** Age, traveller's characteristics, total trip duration per day, and change mode according to commuting time are significant in relation to car dependency.

A. Captivity Clusters

The study's importance is presented in the innovative two-step cluster analysis approach designed to segment car-dependent users. This method proves highly effective in aligning with market demands and precisely targeting distinct user groups. Stratifying the segment of car captive users based on their tendency to adopt alternative modes are tested with time, distance and level of dependency variables, had unveiled two pivotal clusters: the 'inclined car users' and 'reluctant car users'. These groups hold significance due to the potential efficacy of transportation interventions in effecting a reduction in car dependency. The clusters identified in this study displayed a statistical significance with the degree of change variable, affirming the robustness of the segmentation process and highlighting the presence of distinct groups with closely aligned characteristics. First, there are the 'car captives' who see their cars as symbols of luxury and value the flexibility, companionship, reduced waiting times, and storage convenience they provide. Additionally, they may associate social status with their cars. On the other hand, 'car inclined' individuals maintain a positive view of cars, considering them essential for daily activities but are willing to explore alternative options for short trips if they come with smart technologies and luxurious transportation means. Lastly, the 'Car Reluctant' group harbours a generally negative attitude towards cars, yet they do not find convenient alternatives. For them, transportation network coverage, inter-modality, and fare system practicality are key factors in making travel decisions. These insights can inform tailored transportation solutions for each group, addressing their specific needs and preferences.

Insights

- **Walkability and Traveller Characteristics**: There is a significant relationship between car captivity clusters and the walkability of the neighbourhood and traveller characteristics.
- **Travel Intensity and Gender**: Travel intensity showed moderate influence, with captive users having high travel intensities. Gender was significant, with women showing a greater tendency towards car captivity.
- **Age and Economic Level:** These variables were not statistically significant, suggesting a need for further investigation.

In conclusion, this study does not only provide a detailed understanding of the current state of car dependency in New Cairo, but also

offers valuable insights for shaping future urban mobility strategies that are sustainable, inclusive, and responsive to the needs of the residents.

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