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Sustainable Urban Mobility: Assessing Different Neighbourhood Models in Greater Cairo Region, Egypt

Islam Ghonimi, Hassan El Zamly

(Dr. Islam Ghonimi, Shoubra Faculty of Engineeing, Benha University – Cairo - Egypt)
(Ass. Prof.. Hassan El Zamly, Shoubra Faculty of Engineeing, Benha University – Cairo - Egypt)

1 ABSTRACT

Sustainable urban mobility aims to encourage movement behavior that reduce automobile dependency and induce non-automobile and public mobility. As cities continue to change, planners are facing the challenge of designing urban mobility systems that are sustainable on social, economic, and ecological levels. They aim to reduce transportation energy consumption; increase social interaction between residents; and increase subsidiary effects of side path through movement. There is a growing calls for planners to shift paradigm of urban mobility to enable economic activity, social connectivity, and ecology. Movement behavior is influenced by different factors, part of them due to socioeconomic variables, others due to urban form. Some neighborhoods seem to support alternative modes of movement of non-motorized or public motorized as feasible mobility solutions and meet resident's expectations and accordingly reduce the need for high level of motor vehicle ownership; Where other neighborhoods don't and encourages residents to depend on private alternatives accordingly increase fuel consumption, cost, and environmental pollution. Based on a case study of six neighborhoods that represent chronological development of neighborhood types in greater Cairo region, this research provides an understanding of how urban mobility was influenced by neighborhoods urban patterns. This research suggests that some specific neighborhood features can efficiently influence people mobility, demand and travel behavior than others, accordingly enhance achieving sustainable urban mobility and overall sustainability of development.

Keywords: Greater Cairo Region, Measuring urban form, Mode choices, Sustainable Urban Mobility, Movement Behaviour

2 INTRODUCTION

Sustainable urban mobility aims to achieve sustainability goals through movement behavior in environmental, economic and social level. Last decades, a massive scientific research worked to test the impacts of neighborhood patterns urban form on movement behavior as a way to achieve sustainability in the built environment. Different scholars concerned the role of public transportation, walking and cycling in achieving this goal, through using urban form that encourages such trends. This paper work on the way neighborhood pattern could achieve efficient public transportation and so achieve sustainable transportation and enhance built environment sustainability.

Old neighborhoods, the grid pattern, high density with crowded streets; make public transport is un-useful, undesirable, and uncomfortable for residents. So it encourages them to depend on private alternatives accordingly increase fuel consumption, cost, and environmental pollution. Modern neighborhoods with low density, separate use, large distance caused a low feasibility in public transportation so it also increases private alternatives; accordingly increase fuel consumption, cost, and environmental pollution. The overcrowded and low quality in old towns and the low feasibility in new towns are key factors for reducing the impact of on movement behavior.

Different neighborhood models can play a significant role in shaping individual travel behavior. Landuse pattern, housing income pattern, and street network pattern are factors that differentiate neighbourhood models and can affect movement behavior inside our cities. Neighborhood patterns impacts the type, quality and quantity of mobility facilities that can be used and accordingly shape residents travel choices of movement behavior (Giles-Corti et al., 2013). Mode choices depends on residents socioeconomic charachterstics like age, gender and socioeconomic level; at the same time, urban form characteristics creates conditions that can facilitate and encourge some kinds of travel behavior while discouraging other types of travel behavior. Most studies of movement behavior have focused on the impact of some neighborhood patterns like land use, housing income, and street network pattern and density.

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2.1 Research Aim

Some neighborhood patterns characteristics facilitate types of travel behavior and discourage other types, whereas other charachterstics do not do so. An understanding of the reason that some neighborhoods provide more chances of pedestrian, cycle movement and public transportation and improve trips distance and frequency than others is important to improve energy saving and reduce resource depletion and reduce environment pollution. The aim of this paper is to analyses current evidence relating to the impact of urban form patterns on travel behavior patterns, based on a case study in greater Cairo region. The article examines how travel behavior was influenced by urban form in six neighborhoods; The results suggest that urban form can mediate the impacts of movment behaviour on sustainability issues.

2.2 Research Hypothis

This research suggest that neighbourhood patterns can effectively influence people's mobility demand and travel behaviour towards achieving sustainable urban mobility in Cairo. And that traditional neighborhood is pedestrian oriented that discourages motorized travel and increase non-motorized one, and could reduce trip distance and trip frequency. on the other hand modern neighborhood is car oriented that encourage motorized travel and minimize the pedestrian one.

2.3 Research Method

An inductive analysis using comparative methods is used to test and compare the relation between neighbourhood pattern and movment behaviour. The research depends on two interlocking stages. First, literature review to introduce the two variables of the research, movment behaviour and urban mobility in terms of concept, historical development, and measurable variables. In addition, to introduce sustainable urban mobility in terms of concepts, types and measurable indices. Finally, Field study for sic neighborhoods in Greater Cairo Region to test the mutual relationship between the two variables. The field study go through three steps: Measuring neighbourhood patterns, measuring movment behavior and measuring resident's perception of sustainable development indicators, and testing the validity of their relations. The research based on spatial model for measuring land-use pattern and semi structured interview for measuring resident's satisfaction to urban development.

3 URBAN FORM AND SUSTIANBLE URBAN MOBILITY

This part intends to explore the meanning and factors of movment behaviou, the paradigm shift to sustainable urban mobility, and based on previous studies to review the relation between urban form and urban mobility.

3.1 Movement Behaviour

Movment behaviour is a social behaviour of residents, like any other behaviour it is based on demand, constraints and potentialities. Movment behaviour can be defined using different travel parameters, such as (trip frequency, trip distances, mode choices of travel, or overall vehicle ki¬lometers traveled, trip rates, overall traveling distances, traveling distances by mode, modal shares, and energy con-sumption.

The variable "Modal Choices" means whether and to what degree residents, welling to use certain travel modes (private versus public), (motorized versus non motorized), (motor, walking, cycling). To what degree they feel satisfied with public transportation, private car, walkability, cycling. For what degree they depend on each travel mode during day hours, during night hours, till late night. Percentage of Each mode trip per total trips.

The variable "Public Transportation" refer to available public transportation and their sutability. Residents satisfaction with quality of public transportation, and the degree of proximity and accissibility of to public transportation, and the main reason of using or not using publc transportation (expense, availability, quality, safety, comfortability, flexibility).

The variable "Private vehcile" refere to no. of car ownership. Times of using private car per day, and the main reason of using or not using priavte car (available parking spaces, traffic jam, traffic information, safety, comfortability, flexibility, accedents risk, fuel cost due to distance and frequency, mintatnce cost).

The variable "Cycling" refere to no. of cycle ownership. Times of using cycle per day, and the main reason of using or not using cycling (available cycle lanes and their quality, traffic jam, safety, comfortability, flexibility, accedents risk, effort due to distance and frequency).

The variable "walkability" refers to times of using walkability per day, and the main reason of using or not using walkability (available walk ways and their quality, safety, comfortability, flexibility, accedents risk, effort due to distance and frequency).

The variable "Trip Frequency" includes the times residents can repeat this trip per week; it probe the degree to which resident found it easy to repeat the trip. Trip frequency in traditional neighbourhoods is limited by car due to the lacke of parking area.

The variable "Trip Distance" includes the actual network distance travelled by the residents from their own residence to various destinations. It measures residents weeling to drive long or short distances.

The Variable "Travel Obsticals" was measured whether and to what degree their is a physical and pschycological conditions that limit traveling by certain modes at certain times of the day.

The variable "Car Ownership" (vehcile ownership is high in high income neighbourhoods, and bycicle is high in traditional neighbourhoods). In traditional neighbourhoods residents can aford cars but due to the unavailability of parking area they prefere to reduce car ownership and reduce depending on them.

The variable "Parking Area Availability" include Questions regarding available public transportation and their sutability.

3.2 Sustainable Urban Mobility

UN- habitat in the global report of human settelments, reported a paradigm shift in transportation planning. It diferentiated between two paradigm shifts in movment, the first that found effeceincy in increasing traffic flow effeceincy based on the speed, affordability and convenience of motorized transport. On the contrary, current paradigm strives for sustainavbile mobility through accessibility based on minimizing the need for extended movment, Reducing the need for motorized demand, Reducing the Number of Motorized Trips, Reducing Travel Distances in Cities, and Changing the Modal Split. As cities continue to change, planners are facing the challenge of designing urban mobility systems that are sustainable on social, economic, and ecological levels.

The development of sustainable mobility starts with the organization of urban form to reduce the need for mobility, reduce travel distnaces and reduce travel frequency in the first hand, and to concern mode choices to pedisterian and public transportation and shared modes instead of private alternatives. Accordingly, better impact of urban form on movement behavior could enhance social, economic, and environmental impacts of sustainable development. Their is a growing calls for planners to make paradigm shift in mode choices to enable economic activity, social connectivity, and ecological sustainability.

This shift put fourward an interst to urban planners. To develop urban form that impact well on movement behavior and acheive sustainable urban mobility in term of social, economic, and environmental levels. Their is a growing call for planners to make paradigm shift in mode choices to enable economic activity, social connectivity, and ecological. Traditional neighbourhood by mixed use between residential units and commercial, compaction, high community size, may encourges non-motorized communiting modes and reduce travel distance and. On the contrary modern neighbourhoods by separate use, low density, low community size, may encourge the reliance on private car, increase travel distance, trip frequency, the need for motorized demand, Reducing the Number of Motorized Trips, Reducing Travel Distances in Cities, and Changing the modal Split.

Sustainable urban mobility should Enhance Movement behaviors in term of mode choices, trip distance, trip frequency and reduce pollution and traffic cognition and transportation cost including energy consumption, mintance, time and effort. It should acheive the following criteria:

- Enhance Permeability increases the property of how easy it is to move through an environment and depends heavily upon the paths and objects placed within the space. There are two types of permeability: physical properties (e.g. a path) and visual appearance. For example although a path may exist in some environment, if it is not visually obvious it may remain unused (McCal et al, 2005). It meane to avoid restrictions that distort the continuity of city urban fabric, and distort traffic

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movement, and make the residents looking for alternative roads that could be longer which reduces the movement functional efficiency. “Freezes” the urban fabric forever.

- Enhance Accessibility by providing range of choices of safe routes, and removing barriers for movement to accessibility of residents to services, facilities, and urban spaces, reducing the degree to which "ability to access" and possible benefit of services, amenities and urban environment is accessible by as many people as possible. Hence it affects the urban, economic and social mutual and exchange benefit of the community in this urban fabric.
- Enhance Connectivity and Integration through promoting external dependency to connect people with each other and to facilities with a range of choices of save routes.
- Encourge Movment Behavior by reducing travel distances, travel frequency, and accordingly avoids travel time and cost and reduce traffic volumes. In addition don't isolate people without vehicles, create efficient “day” and¬¬¬ “night” districts (Masnavi, 2000).
- Encourge Alternative movement systems by increasing the degree that urban form could encourage potential for alternative movment options (pedestrian, cycling, public transport) and discourge car dependency and improve pedestrian oriented public realm. In addition, it refers to transit, pedestrian, and bicycle systems should maximize access and mobility. It refers to a framework of streets and urban spaces to be easy, safe, and pleasure (Urbed 1997).
- Improve public transportation: Refer to critical mass of activity and sufficient densities, and micro and macro connected street network (Frey 1999, Newton 2000, Buxton 2000). The public modes proved to achieve maximum sustainability in saving fuel consumption, and co2 pollution reduction. Metro, bus, minibus, tram are alternative public transportation options that move large no. of people in one trip, otherwise each of them would have his own car, and accordingly it will be replaced with a large no. of private cars that could consume more fuel consumption and increase co2 emission and accordingly environmental pollution. This research work on linking the relation between public transportation and neighborhood pattern. To how extent the neighborhood pattern can affect the efficiency of sustainable public transportation.
- Encourage walkability: Refer to ensuring that most people's needs are within walking distance, and providing an environment which is safe and pleasant for pedestrians.

3.3 The Impacts of Neighbourhood Patterns on Movement Behaviour

The Correlation between urban form and movment behaviour has found in numerous studies. Some scholars found that urban form could facilitateate movement behavior using different factors including density (Cervero, 1996), better street connectivity (Boarnet and Crane, 2001), and the presence of mixed land uses (Cervero, 1996; Moudon et al., 1997; Saelens et al., 2003). A current debate exists between scholars for the role of modern versus traditional patterns in their impacts on acheiving sustaiable urban mobility. The paper rests on four charachterstics of neighbourhood to test their impact on residents movement behaviour. They have a continuing effect on transport demand, in terms of the number of trips, mode choice and trip lengths.

3.3.1 Regarding Density:

Scholars consider desnity as the main factor that could impact movment behaviour. They found a relative dependancy on private car in low density communities compaired to high density communities. They put four reasons how density impacts travel patterns (Banister, 2005, p:106). They found high population densities widen the range of opportunities for the development of local personal contacts and activities, and services that can be maintained without resort to motorized travel, and reduce avarage distances between homes and services, reducing the need to travel and reduce travel distance. In addition high densities may be more amenable to public transport operation and use and less amenable to car ownership and use which have implications for modal choice. On the other hand, low density could impact modal choices, since residents's forced to cut long distance trips, they mostly depend on motorized mode choices. The public motorized modes are unpractical in case of low densities and low community size, so residents's mostly depend on private motorized mode choices. In addition, density could impact trip frequency.

3.3.2 Regarding Socio-economic Level.

Scholars argued that socioeconomic patterns could be more significant in their impacts on movment behaviour, communitng behaviour among various income groups, income status is highly associated with certain commuting patterns. High income residents mostly depend on private cars and neglect the public aternatives, they also depend on long distance trips with high frequency with private cars (Hanson,1982). The higher the residents income, the more likely to choose faster and more comfortable and more flixble modes.

3.3.3 Regarding Street Network Pattern:

Some street layouts can be more environmentally sustainable to travel patterns than others. Street network pattern can impact the visibility of achieving public transportation. Grid pattern can increase the intersections and so increase the alternative ways so increase. Not only regarding conditions of individual streets, ranging from the dimensions and design of sidewalks to the prevailing levels of environmental comfort that may encourage pedestrian movement (Gehl et al., 2006), but also the structure of street networks and street connectivity that encourage such behavior.

Figure 1: Street network patterns

Grid-like patterns have high intersection and access points that provide greater connectivity and permeability and promotes short and direct routes that offers shorter trips and reduces travel distance, It provide different pass alternatives and chances. It highly encourages public transportation as it allows more direct access to public transport. It can be more transit friendly to the extent that they may allow greater penetration of an area by transit services. It is expected to enhance walkability, and increase trips frequency by foot and reduce trip frequency by private cars especially with low parking area.But at the same time it could facilitate private car trips. On the other hand, tree like patterns have very low noumber of intersections and access points that reduces permiability, connectivity and accessibility, it promotes very long distances and increases travel distance, and reduce alternatives public transportation options. It is expected to increase private car dependancy, high frequent trips by cars.

3.3.4 Regarding landuse pattern

Moving from mixed to separate landuse probably impact nonwork - travel behaviour regarding modechoices, trip distance, trip time and and frequency. Landuse pattern affect the relation between residential and commercial uses, it could cause a separation between residents and services, accordingly impacts travel demand. Schoolars found mixed use is determenant for travel behaviour and mobility. It could make mode choices depend on walkability than on cars. In addition it reduce avarage trip distance by cars, and the frequency of their use. On the other hand it could increae less energy intensive comuting modes, namely walking and cycling. It impacts its trip frequency and donot affect trip distances.

The literature defined the favorable neighbourhood configuration to achieve sustainable urban mobility. Some of them are contradictory between studies according to difference contexts, this paves the way to test such hypotheses in local context. These litrature will form guidline to assess the selection of neighbourhood in Cairo, Egypt.

4 THE CASE STUDY OF SIX NEIGHBORHOODS IN CAIRO

The objective of this research is to trace any statistical significant differences in responses to resident's movment behaviour across different categories of neighborhoods, starting from the traditional, to the sprawled contemporary. Shoubra and Abasia represent early developed urban growth, Masr Elgdida and Nasr City represent early planned urban growth, and 1st district, and Jasmin in new cairo represent new planned growth. They represent three different chronological ages of cairo development ranging from

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traditional, mixed-use, pedestrian-oriented neighborhood to the contemporary, separate use, car-oriented neighborhood.

4.1 Selection of Case Studies

Six neighborhoods were selected to present different categories of physical and social attributes, as shown in Figure 2. They should be developed as public property, not a private. They should satisfy variables incorporated within the study regarding configuration difference in urban form including the historical development, street network patterns, land-use pattern, housing patterns, population demographics and household characteristics ranging between traditional and contemporary.

Early Developed	Early planned	New Planned
1) Shoubra 1850 (Early planned)	3) Masr EL-gdida 1900	5) 1st district 1985 (New Cairo)
2) Abasia 1850 (Early planned)	4) Nasr City 1960	6) Jasmin 2000 (New Cairo)

Figure 2: Case Study Selection (Greater Cairo Region)

Figure 3: different spatial configuration in cairo development stages NUCA 2008

Cairo urban form revealed deferent typologies of adopted urban development patterns that are different in density, land-use pattern, housing income pattern, and street network pattern. Four typologies of urban form are traced starting from Fatimid old Cairo. Followed by early developed districts that informally grow over green land and adjacent to the planned settlements, like Shoubra, Abassia, Sharabia and others. Followed by early planned by private developers in end of18th and the early 19th century like Khedewi Cairo, Maadi, EL Muhandssin, and Heliopolis and early planned by government like Nasr city. Finally, the latest modern new planed Egyptian settlements surrounding Cairo like new Cairo, Shorouk and El Obour to the east and six October and Sheikh Zayd to the west.

The Fatimic traditional urban form will be excluded from the analysis due to deep socio-economic changes take that place along 1500 year from the establishment to now; and due to unconsiderable design trend for considerig automobile as it was not a exist mobility solution. Accordingly the research will depend on three typologies the early developed, the early planned, and the new planned. In most of the following analysis, the neighborhood arranged according to such categorization to present the movment behaviour moving between these categorize. Six neighbourhood are selected to present different chronological patterns in cairo development.

- Early developed: Abasia and Shoubra are selected to present the early developed neighbourhoods.

- Early planned: Masr EL-Gdida and Nasr City are selected to present the early planed neighbourhoods.
- New planned: 1st district and Jasmin are selected to present the new planed neighbourhoods.

4.2 Data collection and classification:

The purpose is to measure the impact of neighborhoods urban form on resident's movment behaviour and accordingly on sustainable urban mobility. Two forms of data collection were used – the first to measure urban form patterns, and the other to measure resident's movment behaviour in their neighborhood in term of behaviour and satisfaction. Finally, the correlation between both is measured.

4.3 Measurements of Neighborhood urban configuration patterns:

Urban form data were collected using surveying maps, observation, satalite maps, photographic images to document and explore neighbourhoods urban configuration patterns including land-use pattern, housing income pattern, and street network pattern including density.

(1) Street network pattern can be classified under three categorize between the grid to the herarchial as (grid, loop, and cul-de-sac) patterns. Their spatial structure can be classified under heading of type of street, linear meter of streets, No. of blocks, Intersections density, No. of access point, No. of cul-de-sacs, percentage of streets area per community area, and the no. of continous routes (Ghonimi 2014).

(2) Land use pattern can be classified under heading of landuse type, variation and density. They can be measured using the length in meter of (dividing vs. connecting) line between different land-use represents the degree of landuse mix vs. separation (Ghonimi et.al, 2011).

(3) Housing pattern can be classified under heading of housing type, variation and density; They can be measured using the length in meter of (dividing vs. connecting) line between different housing types represents the degree of housing exclusion vs. segregation (Ghonimi et.al, 2010).

(4) Community density range between low density (60 -150 Person/Fedan), Middle density (300 -600 Person/Fedan) and High Density (800-1500 Person/Fedan). Also community size is measured and ranged between small, medium and large community size.

The urban form analysis results, for each case study, are gathered, measured and scored in Table 2. It is categorized starting from the traditional type ending with the modern type. The traditional pattern is higher in percentage than the modern pattern.

		(Early Development)		(Early Development)		(New Planned)	
		Abasia	Shoubra	Masr El Gedida	NASR CITY	1st District (New Cairo)	Jasmin (New Cairo)
							
Street Pattern	Entrances	27	27	11	12	10	7
	Intersections	85	85	46	49	39	18
	Length	12344.9434	12344.9434	11467.1854	57610.8395	13623.6725	8070.7919
	Street network	Grid ouward oriented	Grid ouward oriented	Treed inward oriented	Treed inward oriented	Treed inward oriented	Treed inward oriented
	No. of intersections	High	High	Mid	Low	Low	Low
	L. of grid	16166.5529	16166.5529	14736.7059	58309.2754	613.5728	
		Low	Low	Mid	High	High	High
	L. of loops					1878.2703	6958.8716
		Low	Low	Mid	High	High	High
	L. of cul-de-sacs					7739.3594	
		Low	Low	Mid	High	High	High
	No. of blocks						
		High	High	Mid	Low	Low	Low
	Street network	(A): Connected fine grained public urban form Transit oriented Development Fine grained with high no. Of intersections, egrees points, and street length.	(A): Connected fine grained public urban form Transit oriented Development Fine grained with high no. Of intersections, egrees points, and street length.	(B): Connected fine grained public urban form Transit oriented Development Fine grained street network	(B): Connected fine grained public urban form Transit oriented Development Fine grained street network	(C): Connected fine grained public urban form Treed inward oriented Super block with high intersection density, egrees points, and street length.	(C): Divided Super block public urban form Treed inward oriented Super block with high intersection density, egrees points, and street length.
	No. of intersections						
Land use Pattrn	Type						
		Diverse - Residential, Commercial, and crafts	Diverse - Residential, Commercial, and crafts	Mixed – Residential and Commercial	Mixed – Residential and Commercial	Single -Residential	Single - Residential
	Density						
		High	High	Mid	Mid	Low	Low
	Mix	7091	6543	3951	2627	561	250
		Highly mixed	Highly mixed	Mixed	Mixed	Separate	Separate
Housing Pattrn	Type						
		Low, Mid and High income	Low, Mid and High income	Mid and High income	Mid and High income	High Income	High Income
	Density						
		High	High	Mid	Mid	Low	Low
	Mix						
		Mixed	Mixed	Moderate	Moderate	Separate	Separate

Table 1: Main Socio-Spatial Characteristics of Case Study Areas.

4.4 Measurements of sustainabilty of Movment behaviour:

Two forms of data collection, the first objective quantitiative data concerns resident's movment pattern and behaviour. The second is subjective qualitative data concerns resident's satisfaction to movment.

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4.4.1 Measuring urban mobility in term of Bahaviour:

The study of movment behaviour is based on a questionnaire administered to district residents. The questionnaire was designed to explore the influence of urban form to residents' movement behavior. Sample selection and characteristics depends on 40 residents per each neighborhood with total 240 questionnaires. They are randomly selected in each case study area, to represent different socio-economic characteristics age, gender, education, income level and to measure key factors of travel behavior indicators (Table 2):

The variable "Sustainable Mode Choices Measure": Questions regarding modal choices of certain travel modes (private versus public) (motor, walking, cycling). And Percentage of each mode trip per total trips. The larger percentage depending on public transportation and walkability will be more sustainable.

The variable "Sustainable Trip Distance Measure": Questions regarding avarage travel distance per week for differen uses including work, shop, school, collge, health facilities, restaurant, garden, the smaller distance will be more sustainable.

The variable "Sustainable Trip Frequency Measure": Question regarding no. of trips per week using each mode choice trips, the lower frequent trips by cars will be more sustainable; in addition the high frequent trips by public transportation and cycling, and walkability will be more sustainable.

A five points Likert scale (1 to 5) were used to compute each indicator score from the household survey and the average scores have been converted into percentage scale. These dependent variables were measured as described in the following paragraphs:

Movment Behaviour Assesment Factors		NH1	NH2	NH3	NH4	NH5	NH6
Car Ownership		0-1	0-1	1	2	2-3	3-4
Public Transportation		80%	80%	60%	40%	20%	10%
Parking Area		20%	20%	40%	60%	80%	80%
Mode Choices	Private car	20%	20%	30%	40%	60%	80%
	Public transportation	40%	40%	40%	30%	20%	10%
	Walkability	40%	40%	30%	30%	20%	10%
Sustainabile mode choice index		80%	80%	70%	60%	40%	20%
Trip Frequency	Private car	10%	10%	30	50	70	80%
	Public transportation	20%	20%	30	30	20	10%
	Walkability	70%	70%	40	20	10%	10%
Sustainabile low Trip frequency index		80%	80%	70%	50%	30%	20%
Trip Distance	Private car	20%	20%	30	50	70	80%
	Public transportation	20%	20%	20	30	20	10%
	Walkability	60%	60%	40	20	10%	10%
Sustainable low trip distance index		80%	80%	60%	60%	30%	20%
Sum Percentage		80%	80%	65%	60%	35%	20%

Table 2: Measured Neighborhood Urban Mobility in term of Behaviour (in percentage).

4.4.2 Measurements of urban mobility in Term of Satisfaction:

Satisfaction is measured using 5 Lkirte scale is to measure resident's attitude and preferences of their neighbourhood. Questions first explore resident's socio-economic characteristics then it investigates their satisfaction to movment including: Functional aspects (parking space, crowding, delay, travel accessibility; services accessibility), Social aspects (safety, attractiveness, interaction) Environmental aspects (air polution, noise polution, resource consumtion and traffic cognition), Economic aspects (commuting cost, mentance).

Movment Satisfaction Assesment factors		NH1	NH2	NH3	NH4	NH5	NH6
Functional	Accessibility	80	80	60	50	30	20
	Walkability	80	80	60	40	20	10
	Delay	20	20	30	50	40	20
	Crowdness	70	70	50	30	20	30
	Parking requirments	10	10	20	50	40	30
Social	Safety	30	30	40	50	40	30
	Attractivness	20	20	30	40	60	70
	Interaction	70	70	50	30	20	10
Environmental	Air pollution	70	70	50	30	20	10
	Noise polution	70	70	50	30	20	10
	Resource consumption	20	20	30	40	60	70
	Traffic Cognition	70	70	50	30	20	30
Economic	Comuting Cost	20	20	30	40	60	70
	Mentanance Cost	20	20	30	40	60	70
Sum Percentage							

Table (3): Measured Neighborhood Urban mobility in term of resident's satisfaction (in percentage).

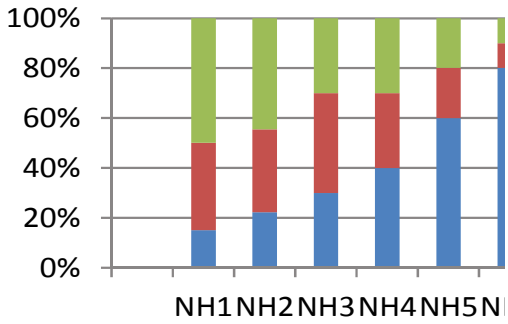
5 CONCLUSION AND DISCUSSION

This part aims to discuss two interloking issues, the first regaring the relation between neighbourhood model and urban mobility in term of behaviour including mode choices, travel distance, travel frequency, trip lengths to different destinations and to define how it varies across the neighbourhood categories. The second regaring the relation between urban charachterstics and urban mobility in term of behaviour and satisfaction.

5.1 Sustainability Mobility Measure in Term of Behaviour

5.1.1 Mode Choices:

Figure (3) compaires different mode choics in the six case studies, it illustrates that traditional one recorded mostly non-motorized, and public modes and reduce reliance on private cars, this in comparison to modern neighbourhoods, that recorded private car dependancy and reject public transportation. High walkability is noted in traditional neighbourhoods where high mixed use and high density. People donot prefere to walk in contemporary neighbourhood due to great long distance trips. Public transportation does not depend on neighbourhood type. car trips are noted in modern car oriented neighbourhoods.



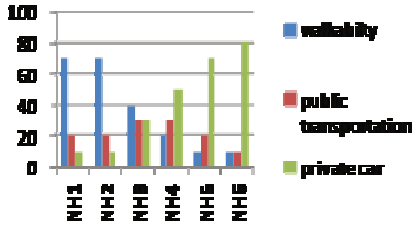


Figure 3: Mode Choices in Percenage. Figure 4: Trip Frequency (in percenage)

Private Car:

In traditional neighbourhoods, residents depend on public transportation due to their low cost, accessibility to their home; they will not take time, effort to get home from bus station, on the other hand other residents found it dirty, not comfortable, noisy, and crouded. On the other hand, modern neighbourhood, public transportation revaled that it do not fit to their needs, it is not flixble for their daily trips, they refuse to cut very long distance and consume time and effort from bus station to get their destiation in long distance, unsafe and environmentaly uncomfortable context; they found private car would be more flixble for them.

Public transportation:

Traditional neighbourhoods, associated with high dependency on public transportation due to their low cost, accessibility to their home; they will not take time or effort to get home from bus station. But some consider it as not welcomed due to it is dirty, uncomfortable, noisy, and crouded. On the other hand, modern neighbourhood associated with low dependency on public transportation, it do not fit to their needs, it is not flixble, they will cut very long distance and consume time and effort from bus station to get their distiation due to long distance and unsafe and environmentaly uncomfortable context. Private car would be more flixble and save for them.

Walkability:

Traditional neighbourhoods associated with public transportation and walkability. This is due to the short distance trips in livable, safe and attractive streets residensts need to walk in areas where residential parking is limited to retain their parking space. Residents seek to reduce the number of journeys and hence the number of times they have to search for a parking space on their return home. On the contrary, modern neighbourhoods associated with low walkability, due to the long distance trips and unsafe and unattractive streets make them depend mainly on private automobile alternative.

It is noted that traditional urban form makes useing motorized modes more difficult compaired to non-motorized modes such as walking and cycling that are easier in traditional communities on the other hand

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modern urban form tends to increase private motor vehicle use because it can provides travel options of a range of household activities.

5.1.2 Trip frequency:

Figure (4) Traditional neighbourhoods associated with high pedestrian frequent trips. Due to the short distance trips with safety. On the other hand it is associated low car frequent trips and hence the number of times they have to search for a parking space on their return home. Difficulties in finding a parking space may not necessarily deter car ownership or intentions to acquire additional vehicles even with increasing parking problems. On the contrary, modern neighbourhoods are associated with low frequent private car trips; residents try to avoid long trips with great effort and cost.

5.1.3 Trip distance:

Figure (5) Modern neighbourhoods are associated with high travel distances, residents are forced to cut long distance due to the low densities and small community sizes that lake to provide residents with suffeceint range of services and facilities, accordingly impacts residents's travel needs they are forced to cut longer distances to have required facilities and services.

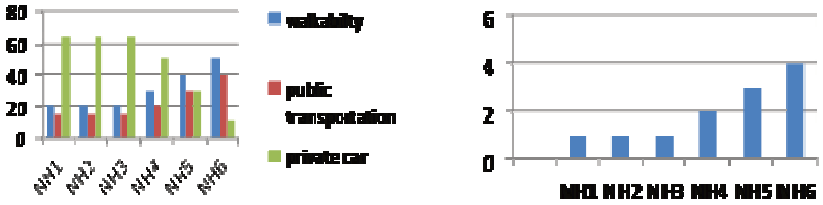

Figure 5: Trip Distance (in percenage). Figure 6 : Car Ownership (in percenage)

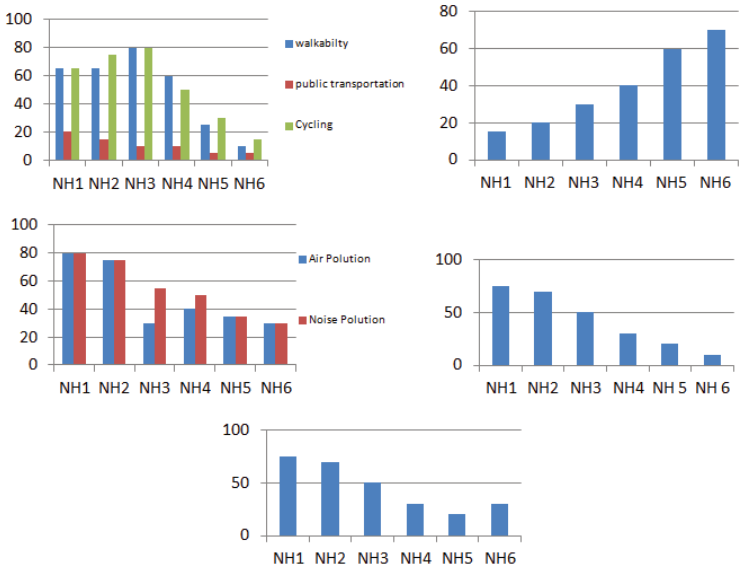

Figure 7: Modes Attractivness (in percenage). Figure 8: Travel Cost (in percenage). Figure 9 : Environment Polution (in percenage). Figure 10: Social Interaction (in percenage). Figure 11: Traffic Cognition (in percenage)

It is noted that traditional urban form redusces trip frequency and trip distance for private cars compaired to trip distance and frequency done by walking and cycling that are higher in traditional communities. On the other hand, modern urban form tends to increase trip distance using private car public transportation, and walkability; on the same time, it noted to reduce travel frequency for using private car public transportation, and walkability because it reduce residents willing to move due to the long distance trips that are associiated with cost and time, it may impact social engagement and interaction, an impacts residents health.

5.1.4 Private Car Ownership:

Figure (6) Modern neighbourhood associated with high rates of car ownership ranges between two to three car lot per family, compaired to traditional cities that revealed lower value of car ownership. Residents found their car very essintial for living, As stated by on of the residents. Accordingly they require large no. of parking lots, accordingly cause low effeceincy in meeting residents huge demand of car parking.

5.2 Sustainability Mobility Measure in Term of Satisfaction

perception measurement in reference to different parameters, socially (Safety, Attractivness, Social interaction, Accessibility, crowding, delay). Environmentaly (Air polution, noise polution, resource consumtion and traffic cognition), Economic (commuting cost, mentance cost,...).

5.2.1 Attractivness of mode choices:

Figure (7) all neighbourhoods are recorded lower attractivness for public transportation. Resident's starts to think twice to move to public transportation options. They only need to have good quality public transportation, to effectively discourage use of private cars and encouraged to public transportation. On the other hand walkability and cycling recorded lower attractiveness in modern neighbourhoods, residents found neighbourhoods unsafe for walkability. On the other hand it records highr values in Masr El-Gdida and Nasr City.

5.2.2 Travel Cost:

Figure (8) Modern neighbourhood is associated with high comute cost due to long distance that discourge walkability and increase dependency on private car with high frequent trips that consume more travel time, effort, and fuel consumpption cost to reach services in adition to cost of car mintance. Traditional neighbourhoods are associated with lower comuting cost, service in proximity to residents, they can walk, use public transportation, to get services. They donot have to use private car for every trip .

5.2.3 Environmental Polution:

Figure (9) Modern neighbourhood is associated with lower noise and air polution, due to low traffic density caused by low frequent trips with large green areas. On the contrary traditional neighbourhood associated with high noise and air polution due to the high traffic density caused by high frequent trips and high trafic jams, with minimum green area.

5.2.4 Social Interaction:

Figure (10) Modern neighbourhood is associated with lower social interaction, due to the long distances and low frequent trips using all travel modes, residents are not willing to move, to avoid travel cost, effort and waste time. They become unsocialized to meet thesir freind and neighbours. On the other hand traditional neighbourhood associated high social interaction.

5.2.5 Traffic Cognition:

Figure (11) Traditional neighbourhood is associated with high traffic cognition, it also associated with low parking requirments. Also traditional neighbourhood associated with high traffic cognition at main streets and high traffic cognition at peak hours greater than traffic cognition that take place in old traditional neighbourhoods.

Traditional communtities with high density and mixed housing types were livable communities encourge walking and biking. Communities where the users finds all services especialy daily one with walkable distance where more secure, livabile and attractive to residents to make all travel to be more depending on alternative transportation options, public transport, walkability, and biking; and discourge private cars.

On the contrary, modern neighbourhood isolate its residents away from everything, to go anywhere one must leaf the community and go on arterial road its boundaries just a wall, which pedestrian walks are long, inconvenient and unsafe, so residents should have their cars for any daily needs increasing car dependency, and generate traffic cognition in the outer city that should increase noise and air pollution and accordingly reduce sustainability. All these characteristics affected the movement behaviour that become less depending on alternative transportation options, public transport, walkability, and biking; versus encouraging private cars dependency.

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In modern neighbourhood, Walking or biking has become a main problem, daily needs are out of walking distance, to walk from a point to another it talks to longer pathes which consumes more distance and time. Even all passes turned into artaeil roads its boundaries donont have any use, only some fences which increae street. it is unsafe, unpleasent environment, and just walls. it encourge criminality and reduce sense of safety, In additions there is no motivations inside these streets to encourage walkabilbility, so make its residents depend mainly on private car as a primary mode of transportation.

Public transportation has become unpractical movement solution. Public transportation need connected permeable street network, and need accessibility to bus stop, which is not acceptable, hence public transportation is not a practical transportation option. Private car has become the available way for movement inside the city. unpracticality of alternative transportation options make private car becomes the only available choice for residents. No walking, biking or public or any alternative transportation options, Only private car. To go anywhere one must leaf and get out the gate and go on collector roads its boundaries become just a wall, where pedestrian walks, cycling are long, inconvenient and unsafe, and where public transportation, inconvenient, in visible.

Therefore, residents should depend on their private cars for all daily life needs, increasing car dependency. Even they use inside the or outside the community in the city streets or even on the regional roads that are connecting the city with Cairo. The approval for road closures in many cases depends on the nature of the roads, as well as the road layout. The closure of major through routes is not allowed. Bearing this in mind, it is usually neighborhoods designed on a closed road network system that are likely to be granted approval, since these have a limited number of traffic intersections (therefore less roads to close). Which affect pattern of movement (land man, 2002:9).

Traffic cognition has existed on city scale and regional roads that connect new towns to Cairo; it was a result of two reasons. The first is due to restricting public transportation and centering movement on private cars, make traffic volume increase especially in the major arterial roads networks. The second, as more residential roads are withdrawn from public use, the cars movement in the city are restricted and diverted to alternative adjacent roads, which are subjected to increased traffic volumes, that they are not originally designed for. This could affect the functional efficiency of local, regional street networks. Commuting cost was a result of two factors, the first due to increased car dependency and the other due to longer distances and increased travel time journeys that required to go anywhere. This could increase of commuting time and fuel cost for residents, visitors and other road users.

6 THE RELATION BETWEEN URBAN FORM AND SUSTAINABLE MOBILITY:

Deducing the correlation between uran form patterns in one hand and sustainable mobility represented in movment behaviour and movment satisfaction in the other hand.

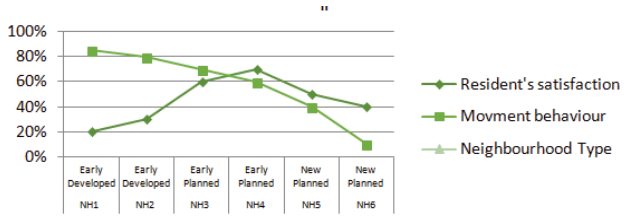

Figure (12): the relation between urban mobility on sustainability and satisfaction level.

Moving between different neighbourhood models, starting from traditional to modern one, reveals a negative relation between movment in behaviour level and movment in satisfaction level. It is clear that traditional neighbourhoods records high value of sustainable mobility on behaviour level, and lower level on satisfaction level. on the contray, modern neighbourhoods records loer sustainable mobility value in behaviour level and records midium value on satisfaction level. A moderate neighbourhood types will acheive obtimum sustainable mobility in term of both behaviour and satisfaction level.

6.1 The relation between Crime Prevention measure and Density pattern:

Figure (13) reveals that sustainable movment behaviour is acheived with moving from low density to high density community. This can be explained because increasing density causes a relevant increase in community size accoridngly widen the range of opportunities contacts, activities and services that can be

supported in neighbourhood, and reduce average distances between homes and services. Accordingly reduce the need for long distances trips, frequency and concern public and walkability and increase sustainable urban mobility. Density is inversly proportional with trip distance, private car ownership, comuting cost. Increasing density reduces trip distance and trip frequency by car and increase trip frequency by walkability, and reducing density increase trip distance.

On the other hand both high and low density community is associated with low satisfaction level, the first cause high traffic, croudness, delay, cognition, air and noise polution and unattractivness for public transportation and the second records high commuting cost and traffic cognition on arterial roads.

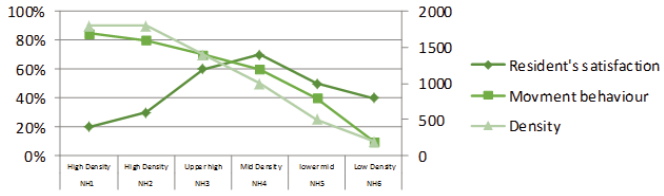

Figure 13: Relation between density and movment behaviour.

6.2 The relation between movment behaviour measure and streetnetwork pattern:

Figure (14) reveals that sustainable movment behaviour increases with moving from herarchial network to grid network. This can be explained because increasing access points and intersections density create fine graind spatial fabric that provide greater connectivity, permiability and accessbility connectivity and promotes short and direct routes that offers shorter trips and reduces travel distance, It provide different pass alternatives and chances. It highly encourages public transportation as it allows more direct access to public transport. It can be more transit friendly to the extent that they may allow greater penetration of an area by transit services. It is recorded to enhance walkability, and increase trips frequency by foot and reduce trip frequency by private cars especially with low parking area, accordingly increase sustainable urban mobility.

On the other hand, both extremely grid and herarchial street pattern is associated with low satisfaction level, the first increases the flow of private car and accordingly reduce safety and security of nodes and increase accedents, through traffic, and traffic jams and the second records high commuting cost due to the complete dpendency on private cars and lake of any other alternative.

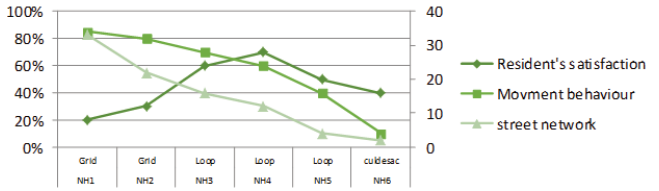

Figure 14: Relation between street network pattern and movment behaviour.

6.3 The relation between movment behaviour measure and landuse pattern:

Figure (15) reveals that sustainable movment behaviour increases with moving from separate to mixed landuse. This can be explored because it could cause a separation between residents and services, accordingly impacts their travel demand. Mixed use make neighbourhood more secure, livabile and attractive for residents to use all mode choices walkability and cycling than private cars. In addition it recorded low avarage trip distance by cars, with low trip frequency. On ther hand, it recorded less energy intensive namely walking and cycling. It impacts its trip frequency and donot affect trip distances. Accordingly increase sustainable urban mobility. On the other hand, urban mobility in term of satisfaction records lower values in both extremely mixed and extremely separate use, the first cause high traffic cognition, crowdness, and donot provide suffeceint parking areas, at the same time streets are full of strangers that make it unsafe for walkability and crouded, noisy, and recorded high cognition. The second cause reduces the existence of unknown persons and avoid shareing parking of residential area with non-residental users.

6.4 The relation between urban mobility and housing-income pattern:

Figure (16) reveals that moving from separate housing income to mixed housing income increase sustainable movment behaviour. This can be explored because it cause diversity of transportation options that meet

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different levels. Taken in mind the basic fact that, different mixed housing types generate different kinds and amounts of mobility standards. On the other hand lack of diversity reduces transportation standards, and reduces the diversity and choices of allowed transportation options. Accordingly reduce sustainable urban mobility. On the contrary, urban mobility in term of satisfaction revealed lower values in both extremely mixed income and extremely separate income. Both reduce the possibility of alternative travel choices to meet different income levels.

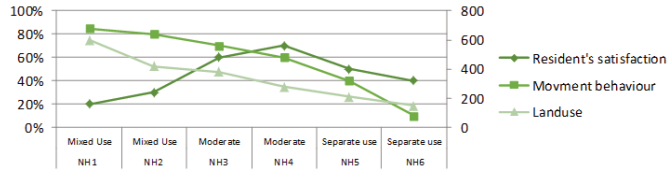

Figure 15: Relation between landuse pattern and movment behaviour.

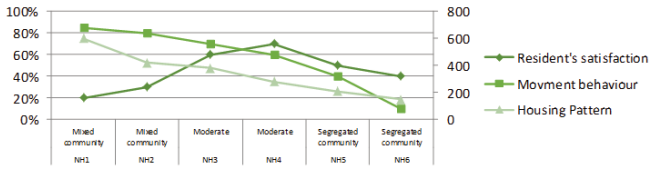

Figure 16: Relation between landuse pattern and movment behaviour.

7 CONCLUSION AND RECOMMENDATIONS:

This research suggest that the way we design our neighborhoods affects our movment behaviour and thus affects acheiving sustainability. This study gives evidence of the relation between travel behaviour and different urban forms to try and identify the current drivers of travel behaviour. It is hoped that this provides an understanding how to make future developments be more sustainable and be more low carbon-based in their transport activities. The results indicates three conclusions:

The first indicate that resedints movment behaviour does not coincide with their movment satisfaction.

The second that traditional neighbourhoods recorded lower value in carownership, trip distances, trip frequency by car, Its modal choice based on public transportation and walkability, high trip frequency by pedisterian, lower trip frequency by private car. Accordingly lower travel expenses. It recorded highest sustainability with lower satisfaction level for movment behaviour.

The third that Modern neighbourhoods recorded high value of carownership, modal choices by private car, with minimum share, high trip frequency, and distances by cars, lower public transportation and private car dependency. Accordingly, It causes high travel cost and consumption of resources. It recorded lower sustainability with high satisfaction level.

The fourth that moderate neighbourhoods like masr El-Gdida and nasr city, recorded moderst sustainability with moderst satisfaction level. The research found that traditional neighbourhood are sustainable in term of movment behaviour that depend on short trips, modechoices that encourge walkability and discourge private car, and low private car frequent trips. On the other hand they are not prefered in satisfaction level due to the high traffic cognition, noise and polution, and delay. on the contrary modern neighbourhood proved to be unsustainable in term of movment behaviour it consume more trip distance and more time and cost to get services, with complete dependency on private car; but they are unprefered in satisfaction level for residents due to different externalities, such as trafic cognition, high polution.

Accordingly planners and urban designers are recommends to take in their consideration the impacts of physical characteristics on movment behaviour and movment satisfaction.

(1) Good design should in one hand facilitate public modes and walkability to increase sustainability on the other hand should give resident's participation a great role in urban design, to found what is suitable for their movment satisfaction.

(2) Both high and low density could reduce sustainability. The first increase community size to an extent that facilitate sustainable mobility at bahaviour level but reduces comunity sustainble mobility at perception level it increase croudness, delay, cognition, air and noise polution. And the second reduce community size to an extent that reduce sustainable mobility by restricting travel modes to private motorized and increase trip

distance. A moderate community density and size values proved to be efficient to enhance movment behaviour and satisfaction.

(3) Both high mixed and high separate use community reduce sustainability. The first in one hand increas travel behaviour with reducing travel distance, private modes, and reduce trip frequencies by private car. On the other hand it reduces movment satisfaction, resdients donot find suffeceint parking areas, at the same time streets are full of strangers that make it unsafe for walkability and crouded, noisy, and recorded high cognition. The second in one hand reduce sustainable movment behaviour by increaseing travel demand and increase private mode and trip distance; on the other hand, it increase satisfaction level by reducing the existence of unknown persons and avoid shareing parking of residential area with non-residental users. A moderate community landuse mix could be sustainable on movment behaviour and satisfaction level.

(4) Both high income and low income residents could reduce travel behaviour and satisfaction. The first Reduce diversity of transportation options that meet different income levels. The second enables residents to interact with different social groups and encourage sense of trust and sense of connection between them. A moderate mix is recommended.

(5) Both grid and herarcial street network pattern could acheive sustainable mobility. The first increases permiability, connectivieity and accissibility that makes better behaviour of reducing trip distance, trip frequency by private car, and orint mode choices to discourge private car and encourge walkability; on the other hand it reduce resident movment satisfaction by increaseing flow of private car and accordingly reduce safety and increease traffic cognition. The second reduces permiability and increase trip distances that make residents seek private solution and discourge walkability on the other hand residents are satisfied with low carbon emmesion. A moderate value is recomended.

A further research with more case studies needs to be carried out to obtain clear conclusions of the relationship between movment behaviour and satisfaction and neighborhood patterns.

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