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Using Urban Carrying Capacity (Ucc) As A Tool for Evaluating Infrastructure of New Egyptian Cities to Promote Sustainable Development. Case Study: 10th of Ramadan City

استخدام القدرة الاستيعابية الحضرية كأداه لتقييم البنية التحتية للمدن المصرية الجديدة من أجل تعزيز التنمية المستدامه. دراسه الحاله : مدينه العاشر من رمضان

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KEYWORDS:
Urban growth, sustainable development, urban carrying capacity (UCC), infrastructure, 10th of Ramadan city.

الملخص العربي:- **يتزايد النمو الحضري بشكل مطرد في العالم النامي ، وفقًا لتقريرالأمم المتحدة للسكان في العالم لعام 2007. وتؤدى هذه الزيادة إلى تدهورالبيئة الحضرية بسبب عدم قدرتها على استيعاب متطلبات السكان. ويظهرهذا التدهوربشكل اكبرفى عناصرالبنيه التحتيه ، والتى تصبح بحاجة إلى الحماية والاستخدام الجيد لتستطيع استيعاب احتياجات الحاضروالمستقبل. يحظى مفهوم القدرة الاستيعابية لعناصر البيئة الحضرية باهتمام العديد من السلطات المعنية بدعم الاستدامة الحضرية على المستوى العالمي ، وتم تطويرمنهجية لتقييم القدرة الاستيعابية الحضرية (UCC) فى المدن ، حيث تتناول احد جوانبها تقييم حالة البنيه التحتيه فى البيئه الحضرية . لذا ، تهدف الورقة البحثيه إلى تسليط الضوء على هذه المنهجية ودراستها ، والتركيزعلى احد جوانبها الرئيسيه وهى ؛(البنية التحتية والخدمات الحضرية). ودراسة إمكانية تطبيقها على المدن المصريه الجديده كوسيله لتعزيزالتنميه الحضريه المستدامه بها. وذلك من خلال دراسه وتحليل الوضع الحضري الراهن لاحد نماذج المدن الجديده فى مصر(مدينة العاشرمن رمضان)، ثم تطبيق تلك المنهجيه لتقييم حاله البنيه التحتيه بالمدينه وتحديد اوجه واسباب القصور فيها. حيث يظهر من التقييم أن مدينة العاشر من رمضان تفتقر إلى بعض امدادات المرافق والخدمات الأساسية ، حيث انها لا تستوعب السكان المحليين ، مما تسبب في ظهور بعض المشكلات الحضريه بالمدينه وضعف قدرتها على استيعاب السكان المستهدفين.**

***Abstract*— Urban growth is steadily increasing in the developing world, as indicated by the United Nations World Population Report 2007. This expansion leads to the deterioration of the urban environment due to its powerlessness to accommodate population prerequisites. This weakening is increasingly obvious in the infrastructure elements, which need protection and good use to accommodate the necessities of the present and future. The concept of carrying capacity of the elements of the urban environment has the attention of many authorities worried about support urban sustainability globally, and a methodology for the assessment of urban carrying capacity (UCC) has been developed in cities, one part of which is assessing the condition of infrastructure in the urban environment. Therefore, the paper aims to study and feature this methodology, and spotlight on one of its main aspects, namely: (infrastructure and urban services). And study the plausibility of applying it to the new Egyptian cities as a way to promote sustainable urban development. This continue by studying and analyzing the current urban circumstance of one of the new urban communities' models in Egypt "tenth of Ramadan City", and**

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afterward applying the (UCC) methodology to assess the condition of the city's infrastructure, and to identify causes of its shortcomings. Where the assessment shows that the city of "10th of Ramadan" lacks some supplies of basic facilities and services, as it does not accommodate the local population, causing the emergence of some urban problems in the city, and the weak ability to accommodate the target population.

I.INTRODUCTION

THROUGHOUT the world, and in the developing world in particular, many problems have emerged in the urban environment of cities. Specially, in the infrastructure elements. This has impeded the achievement of sustainable development. In this way, urban expansion had viewed as perhaps the best answer to deal with rapid urbanization around the globe. Also, the undertaking for building new urban areas in Egyptian desert was a piece of this undertaking. However, the old forty years' involvement of setting up new urban communities within the Egyptian desert is progressing with a constrained success in achieving the goals of sustainable urban development.

Because of the frail ability of infrastructure to accommodate the requirements of the population in cities, it is in need to be developed with good use to accommodate the needs of the present and the future. Consequently, there was a need for continuous systematic evaluation to assess of the carrying capacity of the infrastructure elements with steps of sustainable development. The concept of carrying capacity of the urban elements has the attention of many authorities concerned with support urban sustainability globally, and a methodology for the assessment of urban carrying capacity (UCC) has been developed in cities, one aspect of which is assessing the state of infrastructure in the urban environment.

The research paper aims to study the methodology of urban carrying capacity, and focus on one of its aspects, namely: (*infrastructure and urban services*), and study the possibility of applying it to one of the new cities in Egypt "*10th of Ramadan City*". The study begins by analyzing the current urban situation in the city, and then conducting the assessment using the (UCC) methodology, through which it can identify the reasons for the weakness in the carrying capacity of the infrastructure in the city, making it easy to deal with them. So, this methodology is a very good mean for planners and city managers to make decisions for infrastructure, services, and management urban.

II.CONCEPT OF CARRYING CAPACITY

This concept is very wide and has different perspectives, like social, cultural, political, ecological, etc. And it presented firstly by Thomas Malthus in 1798. He anticipated that the earth can only sustain a definite amount of human growth for a definite time. This determine the state of an ecosystem with regard to the compressions forced by population's demands. Where the whole carrying capacity of an area can defined as the maximum limit of population that can be supported by the urban environment of that area through best use of accessible resources, as shown in (Figure 1). It is also not a stable, it can increase or decrease immensely affected by several factors. One of the main factors that much affects the carrying capacity is the extent of using resource and urban facilities, which highly depends on social, cultural and economic status of the people, (ENT, 2012).

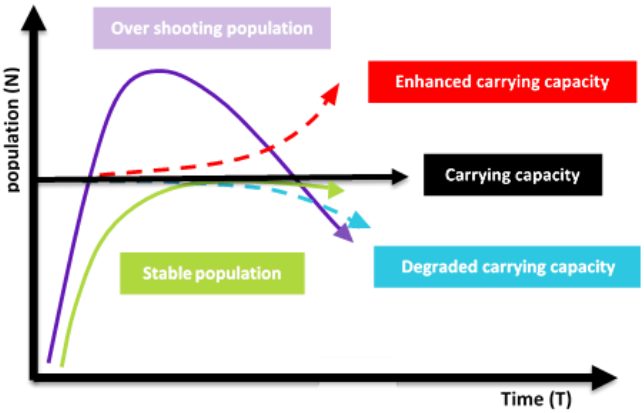

Figure 1. The relation between population rise and carrying capacity, Source: (ENT, 2012)

III.COMPONENTS AND LEVELS OF URBAN CARRYING CAPACITY

UCC is not related to ecology or physical infrastructure only, but economic, social, environmental, and institutional aspects as well. One of the highlights of UCC is that it is dynamic and improvable not a static. It can be altered by the interactions between using technology, individual favorites, investing, and production. The main indicators that define the urban carrying capacity for an area are grouped into five major sectors as shown in (Figure 2), (Sarma, 2012).

Figure 2:Main sectors of UCC and their relationships

The suitable indicators were chosen to assess urban carrying capacity according to a number of key principles through a comprehensive review of the literature. The key factors for UCC assessment abridged in 5 levels, each level incorporates some indicators; environmental impacts and

natural resources; infrastructure and urban services, public perception; institution setting; and society supporting capacity. (Graymore, 2010).

IV.THE URBAN CARRYING CAPACITY CALCULATION FRAMEWORK

Based on this, (Wei, 2016), addressed key indicators that have been developed into an assessment system. The system involves five groups of variables; (economy, resources, environment, infrastructure, and transport). The current study, for evaluating the selected case study, focuses on the level of Infrastructure and urban services capacity as explained in (Table 1) and (Table 2). Because of the vital transport role in large cities, this study separates transport from infrastructure as an individually dimension when calculating weights based on the analytical hierarchy process as in the following section.

Table 1
The definition of (Infrastructure and urban services) component concerned with the study

Component	***Definition***
Infrastructure and urban services	It means the volume of human activity that can be supported by urban infrastructure and services in a given area without causing a deterioration in the quality of life. On the basis that demand for supply in urban infrastructure and services should be balanced, as well as the intensity, efficiency and pattern of resource use in infrastructure development.

Table 2
Benchmarks for UCC indicators, (Wei, 2015).

Dimensions	***Indicators***	***Benchmarks***	***Ref***
Infrastructure and urban services	***Basic municipal facilities such as water, electricity, and gas supply and communication links:***		
	Urban gas connection rate (%)	=100%	*a*
	Access rate of Cable TV (%)	=100%	*a*
	The normal supply of tap water (days/year)	=365 days/year	*a*
	Cultural and recreational facilities:		
	The number of libraries per 10 thousand people	≥ 0.3	*a*
	The number of museums per 10 thousand people	≥ 0.3	*a*
	The coverage rate of free open sports facilities within 1000 meters of residential areas (%)	= 100 %	*a*
	Per Capita floor space of houses in urban areas (m2)	≥ 26 m2	*a*
	Sports facilities:		
	Public satisfaction rates for sports, education and culture facilities (%)	*= 100 %*	*a*
	Healthcare facilities:		
	Number of hospital bed per thousand persons (%)	≥ 90	*a*
	Population life expectancy (years)	≥ 75 years old	*a*
	Public traffic:		
	Per capita road areas (m2)	≥15 m2	*a*
	Public transportation ridership rate (%)	≥ 35% for large and medium cities	*a*
	Social parking rate (%)	≤ 150% for large cities ≤ 100% for small-medium cities	*a*
	Resident's average commuting time (One-way) (%)	≤ 30 minutes	*a*

a Refers to information from the Chinese Society for Urban Studies (CSUS) (2007).

V.DETERMINING THE WEIGHT OF INDIVIDUAL INDICATORS

To calculate the weights of the elements of the evaluation criteria in this research, the method of "Analytic Hierarchy Process (AHP)" for criteria elements were used and the estimation based on evaluator's knowledge of sub-criteria. In this method, weights are set for criteria elements according to their relative importance to each other. The weighting and measurement process and its values are summarized in the following steps:

Step (1): Comparing the four main elements of urban carrying capacity assessment according to the importance indications shown in (Table3), leading to the values listed in (Table 4). (Chao-Shi,, 2007).

Step (2): Normalize the cell values resulted in step 1 by dividing the rate of each cell by its column summation and determine the weights by calculating the mean value of each row. See (Table 5).

Step (3): Calculating Consistency Ratio (CR)

- λ_{max} is the principal Eigen Value.

n	1	2	3	4	**5**	6	7	8	9	10
RI	0	0	0.58	0.90	**1.12**	1.24	1.32	1.41	1.45	1.49

- λ_{max} = Σ the products between each element of the priority vector and column totals.
- λ_{max} = (0.17*6.8) + (0.18* 7.8) + (0.26* 4.3) + (0.26* 4.1) + (0.1 * 11) ≈ 5.38
- **CR** = (λ_{max} - n) / n -1 where (n) is the number of factors.
- **CR** = (5.38 – 5) / (5 – 1) ≈ 0.095

Step (4): Calculating Index (CI)

- **CI** = Consistency Ratio (CR) / Random Consistency Index (RI).
- Where (**RI**) can be calculated from the following Saaty's rule as 0.90

Then, CI = CR/RI = 0.095/1.12 = 0.08, (CR< 0.1; Acceptable)

Table 3
Indications of scaling for the Analytic Hierarchy Process (AHP), shown in (Table3)

Importance	Meaning
1	equally important
2	weak
3	the former element is moderate important
4	moderate plus
5	the former element is strong important
6	strong plus
7	the former element is very strong important
8	very, very strong
9	the former element is Extreme important

Table 4
Comparing criteria elements using importance indications, adapted from (Saaty, 1980).

	Economy	Resources	Environment	Infrastructure	Transport
Economy	1	3	1/2	1/3	2
Resources	1/3	1	2	1/3	3
Environment	2	1/2	1	2	3
Infrastructure	3	3	1/2	1	2
Transport	1/2	1/3	1/3	1/2	1
Sum (Σ)	6.83	7.83	4.33	4.16	11

Table 5
Normalization values and calculate weights, adapted from (Saaty, 1980).

	Economy	Resources	Environment	Infrastructure	Transport	Sum (Σ)	priority vector "Weight" Sum (Σ)/5
Economy	0.14	0.38	0.11	0.07	0.18	0.88	0.177
Resources	0.04	0.12	0.46	0.07	0.25	0.94	0.180
Environment	0.30	0.06	0.23	0.48	0.25	1.32	0.259
Infrastructure	0.44	0.38	0.12	0.24	0.16	1.35	0.260
Transport	0.073	0.042	0.07	0.12	0.09	0.41	0.12

As shown in the four steps above, the authors have developed a judgment matrix for the elements of urban carrying capacity derived from the experiences of previous judgments. And after the calculation of the "consistency ratio", the Consistency Index (CI) is equal to 0.08 and then the degree of consistency proved as satisfactory. When CI ≤ 0.1, the rate between the elements are realistic. Therefore, the weights are acceptable. Then , in the same way, the weight of individual indicators was calculated only for 30 of them, as shown in (Table 6).

Table 6
The weight of individual indicators of UCC, Updated from (Wei, 2016)

Sectors	Indicators	weight
Economy (0.177)	X_1: Urban registered unemployment rate (%)	0.034
	X_2: Per capita disposable income of urban households	0.037
	X_3: Per capita Fiscal income (Yuan)	0.033
	X_4: Per capita GDP (Yuan)	0.038
	X_5: Annual GDP growth rate	0.034
Resources (0.180)	X_1: Per capita water supply (ton)	0.030
	X_2: Per capita daily domestic water consumption (liter)	0.044
	X_3: Per capita constructive land (m2)	0.037
	X_4: Per capita gas supply (m3)	0.031
	X_5: Per capita domestic electricity consumption (kwh)	0.037
Environment (0.259)	X_1: Industrial wastewater discharged per 10,000 Yuan GRP (ton)	0.039
	X_2: Industrial CO2 emissions per 10,000 Yuan GDP (kg)	0.029
	X_3: The ratio of industrial solid waste that is used extensively	0.040
	X_4: The ratio of sewage treated (%)	0.034
	X_5: Living garbage treatment rate	0.029
	X_6: The number of days with air quality above Grade-2 standard per years	0.030
	X_7: Per capita green area (m2)	0.025
	X_8: Green coverage rate of urban built-up areas (%)	0.032
Infrastructure (0.260)	X_1: Number of hospital beds per 10,000 persons	0.029
	X_2: Per capita floor space of urban residents (m2)	0.034
	X_3: The density of drainage pipe in urban built-up areas (km/km2)	0.029
	X_4: water access rate (%)	0.037
	X_5: gas access rate (%)	0.038
	X_6: Number of Internet per 10,000 persons (user)	0.030
	X_7: Number of mobile phone users per 10,000 persons (user)	0.027
	X_8: Number of fixed telephone users per 10,000 persons (user)	0.035
Transport (0.12)	X_1: Number of bus per 10,000 persons (unit)	0.031
	X_2: Number of private cars per 10,000 persons (unit)	0.031
	X_3: Per-capita urban road areas (m2)	0.036
	X_4: Highway density (km/km2)	0.029

VI. Methodological Steps to Assess Urban Carrying Capacity

The case study methodology passes by three stages as shown in (Figure 3). First of all, the case study will be selected by several target characteristics. Secondly, determine the benchmarks for urban capacity indicators of the city, and compare them with the current situation in the city. Then evaluating the city accordingly and calculate the numerical value of the sector related to infrastructure. The case study procedure depends on six steps to reach the final step embodied in the discussion and conclusion.

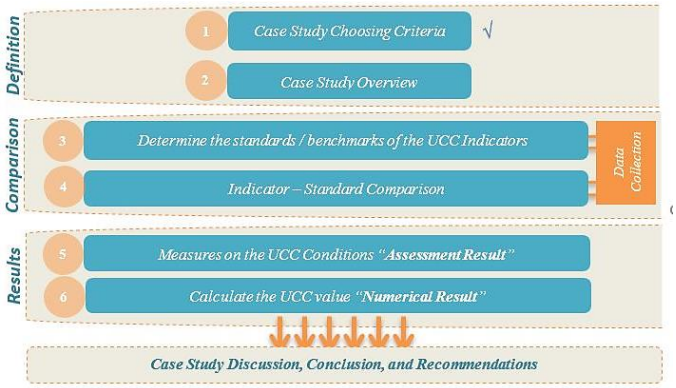

Figure 3:The methodology of the case study

A. *Case Study Overview:*

This step is a summary that shows the basic information of the selected city "10th of Ramadan" (1st Generation), and also discuss the current urban situation, as follow:

B. *Basic Information about The City:*

10th of Ramadan City, the first new urban industrial cities in Egypt, established by 1980, and it belongs to the (1st Generation) of new cities. Situated on 55 km from Cairo, passing through the city of Al Obour, linked to the Delta region through province of Sharqia, as shown in (Figure 4). The city has a total area of 95 thousand acres, which planned to accommodate (480 thousand) people by 2017, and to accommodate (2.1 million) by 2032. Where the current population actually reached (500,000 people) in 2017. The city is divided into 3 Subdivisions; Knowledge Village, Business and Finance region, Regional Services center, with 8 sub-districts, with a density of 37 person / acre.

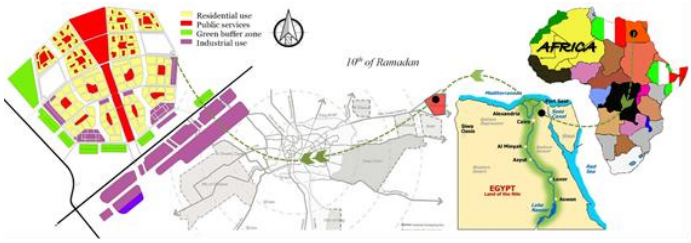

Figure 4: The location of "Tenth of Ramadan" City

C. *Housing and Buildings Type in The City:*

The city had been initially planned for housing all economic sectors of the society, but it has instead been developed as an industrial city over time and the housing intensified on small segment. The total area distributed for housing in the city is 12768 acres. And the housing sector is divided into three axes as follow: *The Residential Units Implemented*, *Project of Million Housing Units (The Social Housing)*, and *Investors plots*, as shown in (Figure 5).

Figure 5: Housing and Buildings Type in tenth of Ramadan City

Finally, the city did not realize its population objectives, where the rate of urbanization did not override 50% from what was planned to be achieved. While industrial development has overrode the main plan expectations, where the number of workers had reached to 225 thousand in 2010, this rise in labor estimated to be more than 300% of what was wanted to be achieved at the end of planning period in 2002.

D. *Land Use in the city:*

The total area of the city is 95000 acres, while the total urban area is 80368.9 acres. Built up area of the city is designed in a symmetrical shape around a linear axis representing the city center, this symmetry is shown in number of districts and neighborhood, and (Figure 6) shows the current utilization of land for 10thof Ramadan.

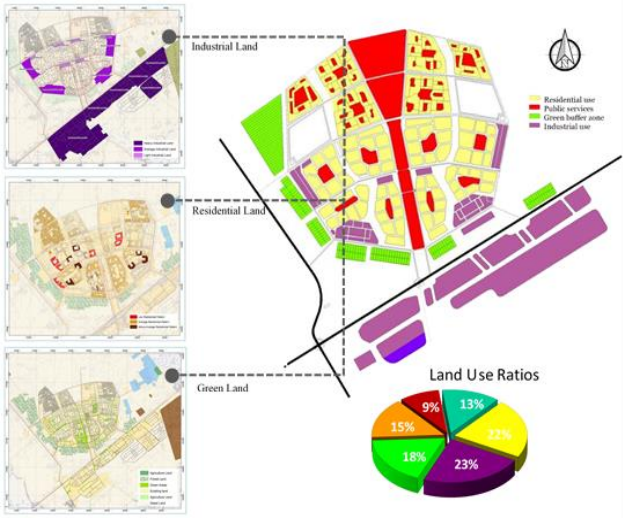

Figure 6: Current land use for10th of Ramadan city

E. *Transportation in The City:*

A system of inner and regional roads along the length of 1140 km was built, follow a clear hierarchy, from the highway "Ismailia and Belbais roads" to the main collectors, working as a ring road for each neighborhood, ending with local streets where walking distances range from 300 to 400 m and do not surpass10 minutes by walking. However, from the field survey, residents claimed that some neighborhood centers are still not present or inadequate, so they must walk to the main city center, as shown in (Figure 7).

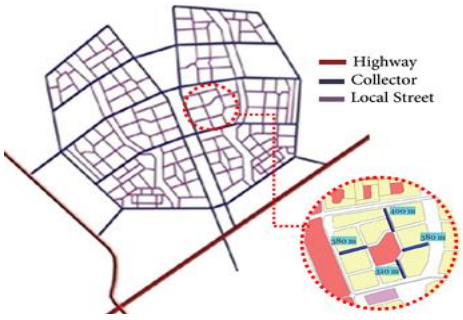

Figure 7: Transportation in 10th of Ramadan city

F. *Infrastructure in The City:*

What has been achieved of facilities in the 36 years since the establishment of the city about 16,900 acres, with rate of 470 acres / year, where the area of facilities being implemented during the last four years 2014/2018 (4444.5 acres). There is still a shortage of infrastructure supplies to cover the entire city, as shown in (Figure 8).

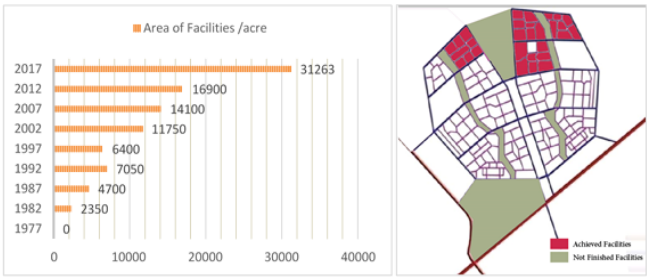

Figure 8: Supply of facilities in Tenth of Ramadan

VII. Assessment & Calculating the Urban Carrying Capacity For the Selected City

First way of assessment, the criteria and data are presented for each indicator of city urban capacity, and the results of the estimate are presented, where "NO" shows that the indicators exceed the UCC limit and need improvements. Some indicators and thresholds were distinguished by (I) due to lack appropriate statistics.

Second way of assessment, estimating the numerical value of the urban carrying capacity for the city by calculating the weights for each indicator within each sector. and weights of the indicators achieved are calculated only in each sector. The total of these weights represents the value of the urban carrying capacity of the sector. Where the total value of urban capacity of the city is the total value of those sectors. The data used has been compiled from several sources, including:

- Ministry of Housing, Utilities and Urban Communities. (MHUUC, 2018)
- New Urban Communities Authority. (NUCA, 2018).
- Central Agency for Public Mobilization and Statistics. (CAPMAS, 2019).
- General Organization for Physical Planning. (GOPP, 2019)

A. Assessment the Urban Carrying Capacity for 10th of Ramadan city:

Table 7
Assessment the urban carrying capacity (UCC) for Tenth of Ramadan City

Dimensions	Indicators	Benchmarks	Results		®
Infrastructure and urban services	**Basic municipal facilities such as water, electricity, and gas supply and communication links:**				
	Urban gas connection rate (%)	• =100%	50%	No	b
	Access rate of Cable TV (%)	• =100%	100%	Yes	b
	The normal supply of tap water (days/year).	• =365 days/year	365 day	Yes	b
	Cultural and recreational facilities:				
	The number of libraries per 10 thousand people.	• ≥ 0.3	0.001	No	i
	The number of museum per 10 thousand people.	• ≥ 0.3	Not available	No	i
	The coverage rate of free open facilities/1000 m of residential areas (%)	• = 100 %	Not available	No	i
	Per Capita floor space of houses in urban areas (m^2).	• ≥ 26 m^2	(18:30)m^2	Yes	b
	Sports facilities:				
	Public satisfaction rates for sports, education and culture facilities (%)	• = 100 %	90%	No	i
	Healthcare facilities:				
	Number of hospital bed per thousand persons	• ≥ 90	4	No	b
	Population life expectancy (years).	• ≥ 75 years old	73	No	c
	Public traffic:				
	Per capita road areas (m^2).	• ≥15 m^2	2.5m^2	No	b
	Public transportation ridership rate (%)	• ≥ 35%	25%	No	i
	Social parking rate (%)	• ≤ 100% for small cities	Not available	No	i
	Resident's average commuting time (One-way) (%)	• ≤ 30 minutes	(15:20)	Yes	c

b	*10th of Ramadan City Development Agency.* (10RCDA, 2018).
c	*Report of the Central Agency for Public Mobilization and Statistics.* (CAPMAS, 2015).
i	*indicates that information is not specifically provided in the statistical report of the city, but results provided fromprevious studies and questionnaires, site inspections and field visits.*

B. Calculating the UCC Value for 10th of Ramadan city:

Table 8
Calculating the urban carrying capacity's value For the Tenth of Ramadan City

Sector	Indicators		Benchmark ®	Result		Weight
Infrastructure (0.260)	X_1: Number of hospital beds per 10,000 persons	(0.029)	≥ 90	4	No	-
	X_2: Per capita floor space of urban residents (m^2)	(0.034)	≥ 26 m^2	(18:30) m^2	Yes	0.034
	X_3: The density of drainage pipe in urban built-up areas (km/km^2)	(0.029)	≥ 15km/km^2	Not available	No	-
	X_4: water access rate (%)	(0.037)	= 100%	100%	Yes	0.037
	X_5: gas access rate (%)	(0.038)	= 100%	50%	No	-
	X_6: Number of Internet per 10,000 persons (user)	(0.030)	=100%	< 100%	No	-
	X_7: Number of mobile phone users per 10,000 persons (user)	(0.027)	=100%	100%	Yes	0.027
	X_8: Number of fixed telephone users per 10,000 persons (user)	(0.035)	=100%	< 100%	No	-
Infrastructure (UCC) = Σ weights = 0.098						
Transport (0.12)	X_1: Number of bus per 10,000 persons (unit)	(0.031)	≥ 10000	< 10000	No	-
	X_2: Number of private cars per 10,000 persons (unit)	(0.031)	≥ 5000	7500	Yes	0.031
	X_3: Per-capita urban road areas (m^2)	(0.036)	≥ 15 m^2	2.5m^2	No	-
	X_4: Highway density (km/km^2)	(0.029)	= 50 ($km/100km^2$)	28 $km/100km^2$	No	-
Transport (UCC) = Σ weights = 0.031						

VIII. Conclusion

Following the application of the UCC assessment by the two methods on the city of case study, according to the city's strategic plan and the reports of New Urban Communities Authority, and General Organization for Physical Planning, it was discovered that there are some strengths and weaknesses in sector of " Infrastructure and urban services" in terms of their urban capacity, Optimal values for each area of urban capacity, shown in (Figure 9). 10th of Ramadan city with its resources and elements in urban environment is getting near to the standard limit, but because of misuse, these resources become inadequate. As for infrastructure and services, the city lacks a supply of services, doesn't suit the local population (the weight of carrying capacity for infrastructure 0.098), causing the emergence of some ecological issues which were a natural response to the contradiction of their urban capacity with the needs of the population, and with considering urban carrying capacity in the pre-planning phase of new communities in accordance with the targeted population density, sustainable urban development can promoted.

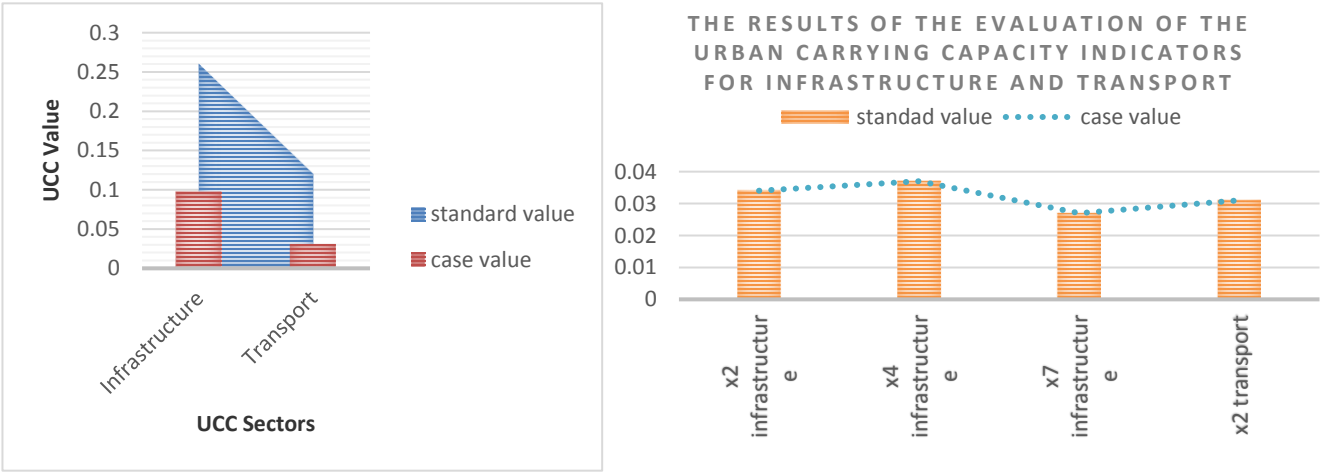

Figure 9: Evaluation Results of Aspects of UCC Framework for 10th of Ramadan city

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