

Measuring urban spatial expansion and suburbanization of Tartous city under the effect of war in Syria

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□ ABSTRACT □

Under the period of the war that started in Syria in 2011, the Syrian coastal cities like Tartous received a large part of internally displaced persons. This flow of population caused a dynamic of urban and spatial suburbanization in the localities situated in suburban area. The goal of the study is to measure this dynamic between 2011 and 2019 in Tartous city and its eastern suburban area (Dwer Shekh Saad, Shekh Saad, and Bsmaqa). The study is based on various data: satellites images and population statistics. The analysis used statistic methods as (mean annual rate of expansion AUER); (Urban Growth Coefficient UGC, and Urban Expansion Differentiated Index UEDI). The main finding is that the spatial expansion was more significant in localities of the suburban area than the city because of the low cost housing. This dynamic of suburbanization is characterized by a reduction of part of population of the city in profit of the suburban area (from 92% to 83%), referring to high rate of population in the suburban area (15.5% against 3.3%). Although the AUER were high in the suburban localities, the suburbanization is characterized by densification: (UGC) is only 0.15. The study calls for stopping war in order to return internally displaced people in their safe governorates; on one hand, that will impulse a process of reconstruction; and on the other, it will reduce densification in the coastal cities and its suburban areas. This should be accompanied with durable regional and spatial planning.

Keywords: Measuring, spatial expansion, suburbanization, Tartous.

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قياس التوسع المكاني العمراني و الحضرة لمدينة طرطوس تحت تأثير الحرب في سورية

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□ ملخص □

خلال فترة الحرب التي بدأت في سورية عام 2011، استقبلت المدن السورية الساحلية جزء كبير من النازحين القادمين من الداخل السوري. هذه التيارات من النازحين سببت دينامية عمرانية و حضرنة القرى و البلدات الواقعة في ضواحي المدن. تهدف هذه الدراسة إلى قياس هذه الدينامية بين عامي 2011 و 2019 في مدينة طرطوس و ضواحيها الشرقية (دوير الشيخ سعد، الشيخ سعد، و بسماقة). تستند الدراسة على عدد من قواعد البيانات المتنوعة: صور فضائية وإحصائيات سكانية). يستخدم التحليل أساليب إحصائية مثل : المعدل السنوي للتوسع AUER، معامل النمو العمراني UGC و مؤشر التوسع العمراني المتباين (UEDI). أهم النتائج هي أن التوسع المكاني كان أهم في ضواحي المدينة من المدينة نفسها. فقد تميزت الدينامية العمرانية بانخفاض نسبة السكان في المدينة لصالح الضواحي حيث تناقصت نسبتهم من 92% على 83% و التي تعود إلى ارتفاع معدل النمو في الضواحي الذي سببه النزوح السكاني (15.5% مقابل 3.3%). و لكن تميزت عملية الحضرة بالتكدس حيث أن UGC بلغ فقط 0.15. تقترح هذه الدراسة إيقاف الحرب كي يعود النازحون على محافظاتهم في الداخل السوري من جهة، و لأن ذلك سيحفز فيها عملية الإعمار و إعادة البناء من جهة أخرى، و ستخفض من التكدس السكاني في المدن الساحلية و ضواحيها. إن هذه العملية يجب أن تكون متصاحبة مع عملية تخطيط إقليمي و مكاني مستدام.

الكلمات المفتاحية: قياس، توسع مكاني، حضرنة، طرطوس.

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Introduction

Suburbanization is how urban area expand and change, (Harris, 2015, 661). Extrapolating, a world that is now predominantly urban will increasingly become suburban. (Harris, 2015). Currently, some studies already point the fact that it is no longer appropriate to use the territorial division of urban space in to a central and suburban area, because the current world is already in the post-urban phase (Hlaváček p. *et al*, 2019). It happens when urban population increase, incomes rise, transportation technology improves, and jobs decentralize (Harris, 2015). Less factors are cited by Gordon and Richardson viewpoints includes increasing income inequality, central city decline, sense of isolation, elevated blood pressure, intolerance, (Habibi, Assadi, 2011). Researchers use these terms to denote patterns of urban development, process of extending the reach of urbanized areas, the cause of particular practices of land use, and the consequences of those practices (Galster *et al*, 2001). In North America, Europe, Australia, and Japan, Suburban development occurs within the formal sector. In many cities elsewhere, informal development is common (Harris, 2015). A growing amount of suburban development is undertaken by "pirate" entrepreneurs. Although informal settlement are illegal, they may be tolerated or implicitly encouraged by municipalities because they relieve the shortage of housing for low- and moderated- income families (Klaufus, 2012, Harris, 2015). Around the cities in the global South, the formal and informal land markets are interdependent, and together produce suburbanization, (Benjamin, 2004, Harris, 2015).

As a developing country, Syria has experienced an urban expansion and suburbanization effecting both urban and rural area over last several decades, especially in the 1980s. This process has affected regional metropolis, like Damascus, Aleppo, Homs, in inner Syria, and Latakia in the coastal region. It was generated by population growth due to high natural increasing rate (3.4%. K. Wazzan, 2017), coupled with massive rural migration, urban development; infrastructure and network road. This dynamic has caused the emergence of new urban patterns like informal housing and settlement, around agricultural village and their development spread along the truck road and national highway in the neighborhood of the interchange and the road emanated from these core area. Most of these suburban area has been produced informally, and materially underequipped, with some control and upgrade from the state.

In the middle of the 2000s, this suburbanization process started to appear in the south of the coastal region, at the medium sized city of Tartous (115.000 p. in 2004). At this rang, the spatial cycle of cities began to shift from urbanization to the second phase suburbanization. Thus, Tartous city had a notable dynamic of expansion in its eastern agricultural suburb around the village situated in border municipalities, at the feet mountain. At first, this process occurred as result of several factors of suburbanization development: the approving of General Master Plan of the city in 2004, which is nearly a match with the administrative boundary; the establishment of Tartous university; return of labors and army from Lebanon in 2005; the enlargement of port and the executing of the program social housing program *Alshabab* at the east entry of the city, and amelioration of transportation and communication technology. Beside formal production, this urbanized area are produced, by private agents of informal promoters and developers, with the complicity of the municipality of villages. Thus, most of housing are with loose regulation of land subdivision, but accompanied by good controlled infrastructure also some shops and other services development provided from the municipalities and the State. This suburbanization are erected by a new form of housing agglomeration of a good apartments

building with 3 to 5 floors (Figure 2). This suburbanization process, is supposed to have an accelerating rate with the declaration of the violent insurrection in march 2011, which followed by never-ending war. In fact, the coastal region was seemed to be as safe region excluding from terrorism, hostilities and major military operation. This is why it received continually large numbers of displaced from governorate of inner Syria, including a significant number of repatriated and person returning, all fleeing war and persecution. Thus, the increasing of population should engender a need to land and housing. By consequence, the eastern suburb of Tartous city seems to be heading toward a steady suburbanization. Three villages with a notable housing trend, namely, Dwer Shekh Saad, Shekh Saad, and Bsmaqa, are most considering.



Figure 1.

Urban expansion and type of housing in the Suburban area of Tartous:(A, B, C,) Shekh Saad (D. the road linking Shekh S. to Tartous city. C. On the high way to Drekish. Bsmaqa appears in the background) ; (D, E) Dwer Sh. S. (D. the road linking Dwer Sh. S. to Tartous city; E. D.Sh.S. on the high way to Drekish) (source:A. web. Shekh-Saad Tartous;.D. doiralsheksaad.com, B.F., the author)

Methodology and study area

Study area

The study area is Tartous city and its east suburban area. These are located at 34°52' N and 35°52' E, bordered the eastern coastline of the Mediterranean Sea at the west part of Syria. The city is the headquarter of the governorate of Tartous with area of 1892 km² (1 % of total Syria), divided in 6 administrative districts, and inhabited by 800000 people in 2011 (3.5 % of Syrian population). As situated in the Syrian coastal region, the governorate is distinguished by the mountainous relief covering the majority of its area, comparing to the coastal plain. It is enjoyed with a typical Mediterranean climate and vegetation. People are distributed on many hundred villages, towns, and 6 mains cities, with ongoing

concentration in the coastal plain. Tartous is the largest city with a total resident population of over 130000 inhabitants in 2011, (55%) of urban population and (16.3%) of the total population of the governorate. The population growth rate is closely similar between rural and urban area (1.8%), considered one of the most lower growth population rate in Syria (2.5%). Tartous city occupies 13.5 km² inside its administrative boundary which refers to its urbanized area. It has a leaner form that extended north-south along the coastline sea with 6 km of length, and west-east of 3 km between coastline sea and the highway road to Damascus in the East. The administrative boundary of the city limits the boundaries of villages municipalities at the suburban area situated at the feet of the mountain surrounding the city by the east ranging between 100 to more than 200 of altitude. This suburban area with a population of 10458 in 2011, consists of 3 villages experiencing an urban expansion: Dwer Shekh Saad, Shekh Saad, and Bsmaqa, located along the road linking Tartous with the mountainous city of Drekish.



Figure 2. Location of Tartous city and its suburban area.

Source: the author

1. Objective of the research:

The purpose of this paper is not to analysis or understand the mechanism of this actual process of urban expansion dynamic and suburbanization under war. The goal is just to identify wither and to what extent these trends can be identified as suburbanization and what the local specific may be at the level of average city. The paper aims at exploring spatial and urban patterns and general population trends and change between Tartous city and its suburban area, to clarify the pattern and characteristic of expanding suburbanization, and its disparities between different urban units, as the faster rate between built up area and population growing.

2. Data, measures and interpretation

The methodological approach to the analysis of the suburbanization trends is based on the literature reviews. The study explore the spatial characteristics and features of urban development (built up area), and the population change in comparing 3 levels of urban units: Tartous core city, suburban area, and total built up area, by employing indicators to measure the change of indicators values between 2 times, (2011 and 2019). Population data was collected from the Statistics Office of Tartous which is projected from census of 2004 for 2011 and a result of survey for 2019 comprising the number of displaced persons.

Urban expansion data is obtained from satellite images analysis. This is quantified based on the amount of urban built up areas between 2 times under investigation. Based on different studies, the indicators are selected and projected on this case study of Tartous city depending to the similarities between the examples studied and the existing data about the case study. This study use these indicators of suburbanization referring to population and urban change:

- Change of the Share of the population living in the total urbanized area

It will be meaningful to compare as a preliminary analysis the share of population living in the different urban unites of the Total urbanized area. The growth of the total urbanized area is urban expansion; an increase of the core area indicates growing monocentricity that counteract urban sprawl, whereas an increase in the suburban area, indicates suburbanization, (Slaev, A., 2014). Then, the study identifies population change rate as decline indicators. The smaller the values of this indicator are, the greater the urban decline is. (Hwang and Woo, 2020). Decline - 1 in core city means suburbanization. The formula is as follow:

population change rate = (pop. 1/pop.0)

- Annual Urban Expansion Rate and Urban Growth Coefficient:

$$AUER_i = [(ULA_i^{t^2} / ULA_i^{t^1})^{1/t^2-t^1} - 1] \times 100$$

Where $AUER_i$ is the annual Urban Expansion Rate, $ULA_i^{t^2}$ and $ULA_i^{t^1}$ are the area of urban built-up land at time t^2 and t^1 , respectively. In this paper $t^1 = 2011$ and $t^2 = 2019$. Once the rate of urban expansion was quantified, Urban Growth Coefficient was calculated to determine whether urban growth is sprawling or densifying. The coefficient formula is:

$$UGC = \frac{\text{Rate of Urban Expansion}}{\text{Rate of Urban population Growth}}$$

UGC greater than 1 indicates a sprawling growth, i.e., built -up land is increasing faster than the population in a given area. On the other hand, a UGC of less than 1 signifies densification. (Akubia and Bruns, 2019).

- Urban Expansion Differentiation Index:

$$UEDI^i = \frac{(ULA_i^{t^2} - ULA_i^{t^1}) \times ULA^{t^1}}{(ULA^{t^2} - ULA^{t^1}) \times ULA_i^{t^1}}$$

Where $UEDI^i$ indicates the Urban Expansion Differentiation Index of unit I; $ULA_i^{t^1}$ and $ULA_i^{t^2}$ indicate the areas of urban land of unit I at times t^2 and t^1 , respectively; and ULA^{t^2} and ULA^{t^1} indicate the total areas of urban built-up land in the study area at time t^2 and t^1 , respectively. This index basically compares urban expansion of a given unit. Generally, the $UEDI^i$ of a region, has a mathematical constant of 1. This serves as the reference point for identifying the urban development hotspots in the region. Three reference categories of $UEDI^i$ can be deduced: (1) when the constitute spatial unit has a differentiation index > 1 , it is considered as a "fast" growing area in relation to the region; (2) when the differentiation index is < 1 , the area is classified as a "slow" growing area relative to the region; and (3) when the differentiation index of the district is equal to 1, it is regarded as a "moderate" growing area in relation to the region. (Akubia and Bruns, 2019).

Results and discussion:

1. Measuring the change of the population living in the Tartous city and its suburban area

Table 1. Assessment of the change in population in total urbanized area (Tartous and suburban area)

Urban unite		Pop. 2011	Pop. 2019	%share of pop. 2011	% share of pop. 2019	Change rate 2011-2019	APGR•
City	Tartous monocentric	130725	169457	92.57	83.64	1.3	3.3
Sub.	Dw.Sh.Saad	4649	15815	3.30	7.80	3.40	16.53
	Shekh-Saad	4569	15717	3.24	7.76	3.44	16.7
	Bsamaqa	1267	1608	0.89	0.79	1.27	3.02
	Total Suburban area	10485	33140	7.42	16.37	3.16	15.47
Total urbanized area		141210	202597	100	100	1.43	4.6

Sources: author' calculations, APGR is the annual population growth rate, calculated like the AUER.

During the period 2011-2019, the number of the population in the Total Urbanized Area increased from 141210 to 202597 p., an increase of 61387 p (43,5 %), recording high rate of population change and annual growth rate (1.43, and 4.6% respectively), compared to the period before (1.8% in 2010). All urban units recorded a positive high rate of population growth, uneven from unite to another. Although Tartous population core city was high (1.3 and 3.3%), and it was the lowest rate when compared to the suburban area which recorded the highest rate and notable increase, (3.16 and 15.47%), because of the high rate of both Dwer Sh. S. (3.40 and 16.53%), and Sh. S. (3.44 and 16,7%).

So consequently, the distribution of population in the total urbanized area has changed between Tartous city and suburban area. The share of the population living in Tartous's core city has decreased from 92.57 to 83.64%, while the suburban area's population has increased from 7.42 to 16.37% at the expense of the city, which confirm a trend towards suburbanization. Thus, while Tartous's core city shrank by 8.93 percent, the suburban area grew by this percent value. At the level of suburban area, Dwer and Shekh-Saad has the most share and a similar percentage of population (3.30, 3.24%, 7.80, 7.76%), whereas Bsmaqa the most small village in number and has little decreased.

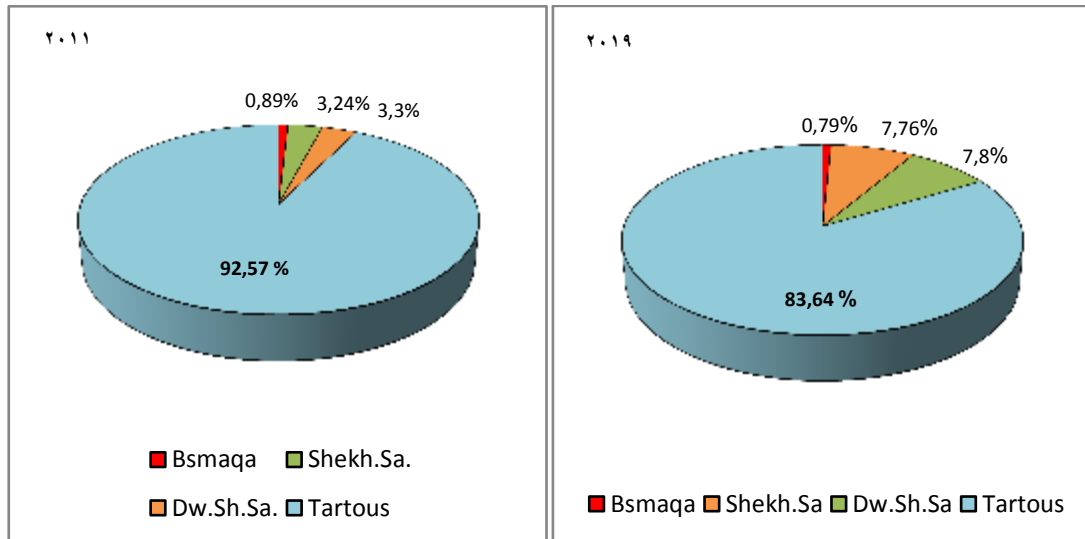


Figure 2. Change of share of population living in Tartous city and its eastern suburban area (2011 and 2019). Source: the author

2. Spatio-temporal analysis: quantifying urban expansion dynamics in Tartous, (2011-2019)

The spatial expansion of the urban extent of the Total urbanized area between 2011 and 2019 is shown in figure 3 and table 2. Table 2. shows that total urbanized area expanded 2.4 km², (20%), from 17.8 km² in 2011 to 20.2 km² in 2019; both Tartous city and Suburban area expanded for each one in 1.2 km². These spatial metrics is analyzed to detect the disparate and uneven characteristic of urban spatial expansion among different urban units of the Total built up area, using: average annual urban expansion rate, Urban growth coefficient, and spatial differentiation of urban expansion as showed in table 2.

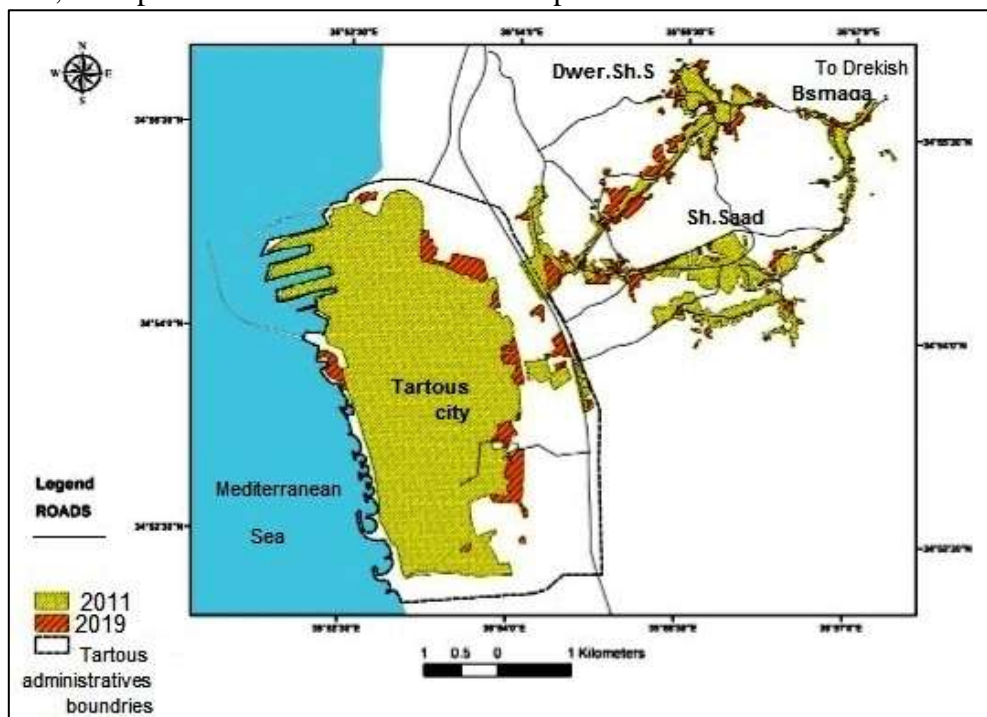


Figure 3. Expansion of built up area in Tartous city and its suburban area Source: the author

Table 2. The assessment of the urban expansion change of built up area (2011-2019) using different indicators.

Urban unit	population		Built up area (km ²)		AUER (%) 2011-2019	UGC 2011-2019	UEDI (km ²) 2011-2019
	2011	2019	2011	2019			
Tartous city	130725	169457	12	13.2	1.2	0.36	0.74
Dwer Sh. S.	4649	15815	2.2	3	3.95	0.2	2.69
Shek Saad	4569	15717	2.6	2.9	1.37	0.08	0.85
Bsmaqa	1267	1608	1	1.1	1.2	0.40	0.74
Suburban area	10458	33140	5.8	7	2.38	0.15	1.53
Total built-up area	141210	202597	17.8	20.2	1.59	0.34	1

Sources: author's calculations

At the level of Total built up area, urban expansion has varied spatially. According to the AUER scores, Total built up area recorded a high AUER of 1.6%; suburban area recorded a higher rate of urban expansion than the city (2.4% against 1.2%). Regarding the units within suburb, this rate is disparate. Dwer recorded the most high rate of (3.95%) for the suburb units and city, while Shek Saad and Bsmaqa recorded the lowest rate of (1.4% and 1.2% respectively) which is closely equal to the city. This indicates that the speed of urban area expansion was varied throughout the study area.

The analysis of UGC revealed that the Total built up area and all its urban units had a very low growth Coefficient less than 1. This signifies that the study area was experiencing an urban densification which constraint sprawl and consumption of space. The total built up area recorded (0.34), nearly equal to Tartous city (0.36), that recorded more than the Suburban area (0.15). At this level, the urban units of Suburban area of Dwer and Shekh S., recorded wide less UGC of (0.02 and 0.08), reflecting a high densification, whereas Bsmaqa recoded 40. The high densification in all the unites of study area could be explained by the housing form of apartment building of 4 to 5 floors that contained the high growth of population.

Further analyses of UEDI index showed that the urban expansion, is spatially differentiated for all units of total built up area. Table (2) reveal that the suburban area recorded UEDI scores > 1, (1.53), which means that urbanized the most and faster than Tartous city that recorded (0.74). But also, the expansion in total suburban area is not equal between its urban units; Dwer recorded UEDI scores > 1 (2.69), which is the most, not only within suburb units but on total built up area. It indicates the hotspots of urbanization and reveals that the urban expansion patterns was toward it because of shortage of land in Shekh S., that widely urbanized decade before, to have UEDI scores of only (0.85). Bsmaqa also has low UEDI scores of (0.74) due to its topography and distance from Tartous city. These scores indicate that they urbanized the least and more slowly than the suburban and the total built up area.

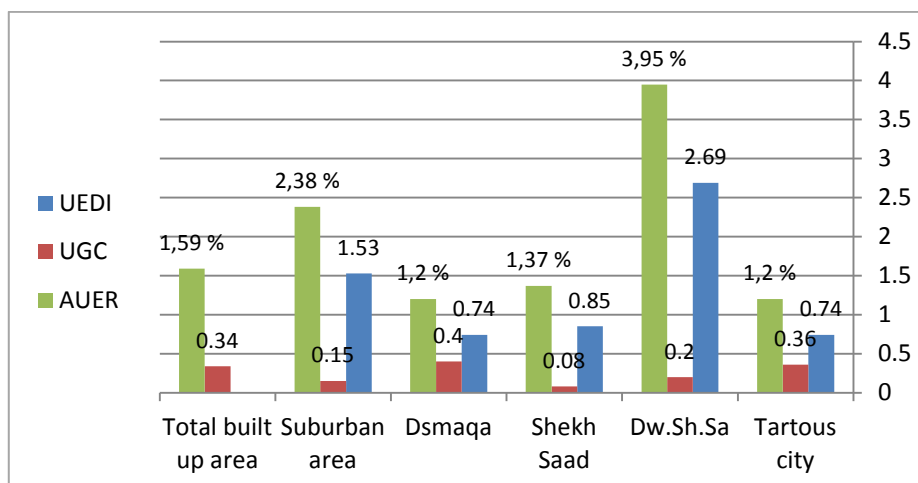


Figure 4. AUER, UGC, and UEDI of Tartous city and its Suburban area. Source: the author

Conclusion

Findings

1. The results of analysis of spatial metrics revealed that, during the war between 2011 and 2019, a significant change of spatial and urban pattern had occurred.
2. The findings of spatial and urban patterns reflect high and speed Urban growth rate and increasing in built up area. Analysis of net change of total built up area and change of various urban unites (Tartous city, Suburban area: Dwer, Shek S. and Bsmaqa), indicated that the study area connotes a significant urban expansion (from 17.8 to 20.2 km², with AUER of 1.6%), but it was uneven from unit to another.
3. The population growth rate attributed to forced migration from other governorate was high specially in the urban units of suburban area (15.5% against 3.3%), has shifted the share of population of the city in profit of suburban area (from 7.4 to 16.4%), consisting of low cost housing, thus suggesting the prevalence of suburbanization process.
4. In despite, the finding provide evidence of densification, which can be explained by a very high growth rate of population than urban extension.
5. This process is consonant with densification characterized by high density residential development.

Recommendations:

1. The study suggests to stop the war in order to encourage the internally displaced persons to return in theirs governorates.
2. This steps is very important, in one hand, to start reconstruction process in their cities, in other hand, to reduce densification in suburban area in coastal region which conserve agricultural land and vegetation, and further, conserve housing for future generations of autochthons.
3. A deliberate regional and spatial planning is necessary and beneficial for a sustainable development, conserve ecosystems, and enhance human well-being.

References

1. Akubia, J. E. K., Bruns, A. (2019). Unravelling the frontiers of Urban Growth: Spatio-temporal dynamics of Land Use Change and urban expansion in Greater Accra Metropolitan Area. *Land*, 8, 131, DOI:10.3390/Land8090131.
2. Al-sharif A., et al, (2014). Quantitative analysis of urban sprawl in Tripoli using Pearson's Chi-Square statistics and urban expansion intensity index. *In IOP Conf.Sar. Earth Environment. Sci.*2012006. DOI: 10.1080/09654313.2018.1465530.
3. Bhat P., Ahmed, P., (2017). Urban Sprawl and its Impact on landuse/land cover dynamics of Dehradun City, India. *In International Journal of Sustainable Built Environment*, 6, December, pp.513-521. <http://doi.org/10.1016/j.ijsbe.2017.10.003>
4. Basawaraja R., et al, (2011). Analysis of the impact of urban sprawl in alerting the land-use, land-cover pattern of Raichur City, India, using geospatial technologies. *In Journal of Geography and Regional Planning*, 4,8, pp. 455-462.
5. Dadras M., et al, (2014). Land Use/Cover Change Detection and Urban Sprawl Analysis in Bandar Abbas City, Iran. *In the Scientific World Journal*, ID 690872, <http://dx.doi.org/10.1155/2014/690872>.
6. Fan, Y., et al, (2017). Urban expansion assessment in Huaihe river basin, China, from 1998 to 2013 using remote sensing data. *Journal of Sensors*, <https://doi.org/10.1155/2017/9281201>.
7. Glaster, J. et al, (2001). Wrestling sprawl to the ground: Defining and measuring an elusive concept. *Housing Policy Debate*, 12,4, pp. 681-717.
8. Habibi S., Assadi. N., (2011). Causes, results and methods of controlling urban sprawl. *Procedia Engineering*, 21, 133-141. doi:10.1016/j.proeng.2011.11.1996.
9. Harris. R., (2015). Suburbanization and Suburbanism, *International Encyclopedia of the Social and Behavioral Sciences*, 2nd edition, V. 23. pp. 660-666.
10. Hirt, S., (2007). Suburbanizing Sofia: Characteristics of Post-Socialist peri-urban change. *in Urban Geography*, 28,8, pp. 755-780. DOI:10.2747/0272-3638.28.8.755.
11. Hlaváček P. et al, (2019), Impact of suburbanization on sustainable development of settlements in suburban spaces: smart and new solutions. *Sustainability*, 11,7182, DOI: 10.3390/su11247182.
12. Hwang, U., M. woo, (2020). Analysis of Inter-Relationships between Urban Decline and Urban Sprawl in City-Region of South Korea. *Sustainability*, 12, 1656; DOI:10.3390/su12041656.
13. Iga, S., et al, (2017). Urban sprawl impact on farmland Conversion in Suburban Area of Wroclaw, Poland. *IOP Conf:Mater. Sci.Eng.* 245072002. DOI: 10.188/1757-899X/245/7/072002.
14. Imam, B., et al, (2020). Urban expansion and Welfare Change in a Medium-Sized Suburban City: Surakarta, Indonesia. *In Environment and Urbanization ASIA* 11, 1, pp. 78-101, 2020. DOI:10.1177/0975425320909922.
15. Ledo E. P.,J., (2020). Peri-Urbanization in Sacaba, Bolivia: challenges to the traditional urban planning approach. *In international planning studies*. DOI: 10.1080/13563475.2020.1839389.
16. Klaufus, C., (2012). *Urban residence. Housing and social transformations in globalizing Ecuador*. Berghahn, New York.
17. Li, X., et al, (2011). Dynamic analysis of urban spatial expansion and its determinants in Xiamen Island. *In journal of Geographical Sciences*. 21,3, pp. 503-520. DOI: 10.1007/s11442-011-0860-7.

18. Mazouz M, T, Adad, M., C., (2018). Quelques indicateurs pour la mesure de la consommation des espaces et la caractérisation de l'étalement urbain de la ville d Ain Beida. *Courrier du Savoir*, no. 25, Février, pp. 143-156.
19. Youshitake, T, *et al*, (2015). Progression suburbanization and the controversial land use management in Japanese local city-a case study of Miyakonojo city, Japan. *In Journal of the Eastern Asia Society for transportation Studies*, 11, pp. 979-996.
20. Nechyaba, T-J., Walsh R.P., (2004). Urban Sprawl. *Journal of Economic Perspectives*, 18, 4, pp. 177-200.
21. Slaev A., D., *et al*, (2014). Suburbanization and Urban Sprawl in post-socialist Belgrade and Sofia. *In European Planning Studies*, April 2018, DOI:10.1080/09654313.2018.1465530.
22. Qian Y., and Wu Z., (2019). Study on urban expansion using the spatial and temporal dynamic changes in the impervious surface in Nanjing. *Sustainability*, 11, 933, DOI:10.3390/su11030933.
23. Wang L., *et al*, (2011). Analysis on urban densification dynamics and future modes in southeastern Wisconsin, USA. *PLoS ONE* 14(3):e02011964. <https://doi.org/10.1371/journal.pone.0211964>.
24. Wazzan, K., (2017). *La production de la périphérie nord de Lattaquié (Syrie)*. Editions universitaires européennes, Germany, 692 p.