Scientific Journal for Damietta Faculty of Science **12**(1) 2022, 50-55
doi: 10.21608/sjdfs.2018.194790
ISSN Print 2314-8594
ISSN Online 2314-8616

https://sjdfs.journals.ekb.eg/

Urban Sprawl Assessment and Modelling of the Shahat City, Libya, using Space Data and GIS

Rasha M. Abou Samra[1], Talaat Abdel-Monem Hegazy[1], Mohamed Abd El Galil[1], Mac Tar Mohamed[2] and Saleh S M Al Saleh[2*]

[1] Environmental Sciences Department, Faculty of Science, Damietta University, Egypt.
[2] Geography Department Faculty of Education, Omar Al-Mukhtar University.

Received: 20 February 2022 /Accepted: 3 April 2022

* Corresponding author's E-mail: saleh_197576@yahoo.com

Abstract

Determining the spatio-temporal manners of urban sprawl is considered one of the most influential challenges in evaluating the present and future directions of the urban expansion issue. Random growth is considered as a kind of meeting the needs of the human being and expressing the achievement of its basic requirements when the state is unable to solve. This paper aimed to assess the sprawl and growth dynamics between 2010 and 2020 in Shahat City, Libya using remote sensing and GIS techniques. Three Landsat TM, ETM+, OLI images dated 2010, 2015, and 2020 were used to generate urban maps of the research area. Chi-square test and Urban expansion intensity index (UEI) were used to assess urban growth patterns in study zone. The results of the study confirmed that urban growth in the city has increase from 4.2 km2 in 2010 to 22.4 km2 in 2020. The results displayed that Shahat city has unbalance urban growth and its urban development had high freedom degree during period from 2010 to 2020.

Keywords: Urban expansion ,GIS, UEII, remote sensing, Libya.

Introduction

The phenomenon of informal settlements is a global issue around all the world. However, the causes and patterns may vary from country to country where random growth is considered as a kind of meeting the needs of the human being and expressing the achievement of its basic requirements when the state is unable to solve (Hansen, 2010). Random growth is only a kind of self-solutions that are taken by a citizen in order to find a solution to the housing and economic problems he faces. (UN-HABITAT, 2010). Informal settlements take many forms, varying according to the environments in which they were raised. Despite the negatives they suffer from, they have the positives that provide a great opportunity to deal with these areas, especially if we consider the human dimension as the basis (Pennock, 2004) .

Informal settlements are ever changing, movable and a regular challenge. The residents

in that settlements doing in ways that are deleterious to the environment, and a passive impact on it (UNECE, 2008). The challenge of informal settlements must be addressed, resulting in the environment regaining stability again and reducing the impacts through human settlements (Msimang, 2017). There are several definitions of informal settlements. The most well-known definition is that they are areas where inhabitants face a lack of one or more of the following: durable housing, sufficient living spaces, easy access to clean water, adequate sanitation, and security of ownership. They also differ in their size, shape, pattern, and population (UN-HABITAT, 2003).

The environment impacts of informal settlements include soil erosion, as well as water, land, and air pollution (Monteduro, 2015). A studies have shown that informal settlements are a challenge to the environment, such as deforestation in order to have space for settlement development, lack of both sewage and water supply systems, in addition to waste disposal within slums, which led to air, water, and soil pollution (Pearsall and Christman, 2012). Environmental risks often occur in informal settlements. We constantly find that living in these areas threatens the quality of life as there are no available alternative options (Chadha Behera et al. 2007).

Geographic Information System (GIS) is now widely used to study, monitor, and model urban growth and land use. GIS tools can be used to find, map, and evaluate physical changes and patterns of urban growth across landscapes. GIS can also be used to give a future picture of the spatial pattern of unplanned development within an area, in addition to link interrelationships between the social and geophysical characteristics of informal settlements, and to help in project modeling (Kombe, 2005). GIS helps authorities, urban planners, and other stakeholders in their proactive management by monitoring the spatial dynamics of informal settlements of the current and future expansion of informal settlements (Musa, 2020).

In Libya, the phenomenon of informal settlements growth outside the urban plans of cities is one of the challenges facing the urban plans. It takes in its concept and form a different form from the general concept of these areas, as it has not appeared clearly only in the past years when its spread increased significantly and very fast in comparison to some other developing countries. it is known as the growth that occurs outside the approved urban plans, while the growth within the plans was defined as opposite growth (Ministry of Housing, 2016). Libya is not an exception to this phenomenon due to the rapid population and economic growth, resulting in increased demand for land for both population and economy. Rapid urban growth has become a complex environmental issue due to the multiplicity of its patterns. The different causes and the impact on the ecosystem understanding spatial patterns of growth urban is one of the most important challenges for researchers, planners, and decision makers in order to realize and the principle of urban development sustainable.

The main aim of this paper is to assess the sprawl and growth dynamics during the period from 2010 to 2020 in Shahat City, Libya using remote sensing and GIS techniques.

Materials and methods

Study area

Shahat city is located northeast of Jabal Al-Akhdar between longitudes 21°51'44"E and latitudes 32°49'40"N (Figure 1). It is situated 10 km east of Al-Baydah city. Its height is about 600-650 meters above sea level, surrounded by pine forests, cypresses, and agricultural lands. It is characterized by archaeological monuments founded by the Greeks in 631 BC. It is now ranked second in the urban and demographic hierarchy, with 75,000 people in 2012. The climate of the study area, in general, is the Mediterranean climate, which is warm, rainy in winter, hot, dry in summer, and the prevailing winds are from north to northwest in winter, northeast, and sometimes southern in summer. In this mountain station, the mean annual temperature is about 16.5°C. The mean monthly temperature ranges between 15°C in April to 23.6°C in July (the warmest month in the year) and decreases to 9°C and 10°C in January and February respectively throughout 1985- 2019. Shahat station received the highest rainfall in northeast Libya during the period at 563 mm yr^{-1}, whereas rainfall ranged between 53 mm in October to 123 mm in January. Overall, the

diversity of natural factors in the Al Jabal Al-Akhdar, such as elevation, landforms, and location next to the sea and natural vegetation, have led to differences in temperature and rainfall across the region (Ageena, 2010; Bukhechiem, 2006). However, the differences are minor between the coastal stations and the mountain stations.

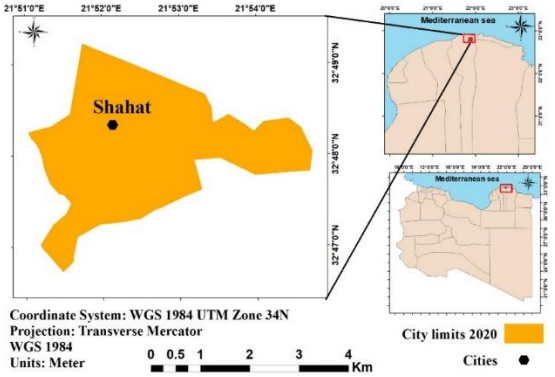

Figure (1) Location map of study area

Methodology

To achieve the aim of this study, three Landsat TM image acquired on 2010, ETM+ image obtained on 2015, OLI image acquired in 2020 were used with spatial resolution of 30 m. The images were obtained with less than 10% cloud cover and downloaded from http://reverb.echo.nasa.gov/reverb. All the images were reprojected to UTM zone 32N. Landsat images were atmospherically corrected using FLAASH model based on the MODTRAN radioactive transfer code. The images were processed using ArcMap 10.2. The research area was divided into eight geographic directions to estimate urban sprawl direction. Maximum likelihood supervised classification technique was utilized to classify the images and to extract land-use/ land-cover classes and the built-up regions. The high-resolution images supplied by Google Earth™ were used to enhance the accuracy of the classified images. Pearson's chi-square technique and urban expansion intensity index were utilized to compute the urban expansions.

Results and Discussion

Table (1) & Figure (2) represent land-use/ land-cover classes of the study area for 2010 and 2020. Residential class was the predominant classes in 2010, covering an area of about 60.1% of the total area. This area increased to about 75.7% by 2020. While agriculture lands decreased from 8.4% to 0.9% between 2010 and 2020. Additionally, green areas, agriculture lands, archeology, and barren lands were diminished during the study period. These classes were converted to residential and services classes along the study area. In general, the built-up zone has crucially increased that led to deteriorating agricultural resources.

Table (1) The area of the different land covers for 2010 (a) and 2020 (b)

Class name	2010 (a) (Area in km^2)	Percentage %	2020 (b) (Area in km^2)	Percentage %
Green Areas	0.45	10.8	0.23	1.0
Agriculture	0.35	8.4	0.20	0.9
Archeology	0.06	1.4	0.06	0.3
Residential	2.5	60.1	16.93	75.7
Services	0.35	8.4	2.95	13.2
Barren land	0.45	10.8	1.99	8.9

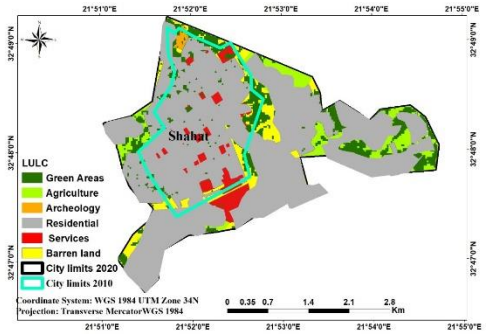

Figure (2) Land cover map of the study area between 2010 and 2020

According to the findings of this research, urban growth in Shahat city expanded from 4.161 km^2 in 2010 to 22. 36 km^2 in 2020, as shown in table (2) figures (3), (4). It was observed that the urban growth has increased rapidly during the period from 2010 to 2020. This is due to the fact that Shahat city is considered the headquarter of the largest municipalities of Al-Jabal Al-Akhdar, and is close to services and commercial activities and others. This rapid increase in the built-up area, including residential, commercial, industrial, and network

infrastructure, results from population and commercial growth in the city. The long periods of unstable conditions pushed the population to search for cheap and suitable land for construction outside the approved city plans, which greatly contributed to the worsening of the problem of uncontrolled urban growth or what is known as urban sprawl. As it becomes clear to us by dividing the area into multiple geographical directions, the eastern and northeastern regions were the highest in terms of urban growth, followed by the southeastern and southern regions.

Table (2) Built-up area in Shahat city in different directions and times, Km^2

Years	N	NE	E	SE	S	SW	W	NW	Total
2010	0.221	0.226	0.147	0.214	0.120	1.019	1.142	1.072	4.161
2015	0.324	0.365	2.412	1.321	2.958	2.002	2.014	1.874	13.27
2020	0.450	1.254	6.102	4.471	3.483	2.662	1.958	1.987	22. 367

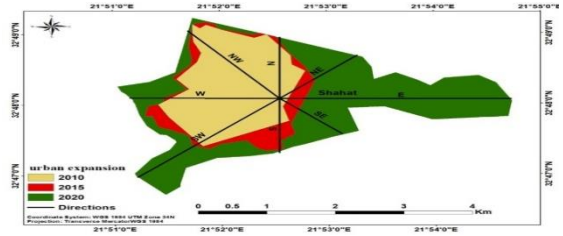

Figure (3) Division of the urban area based on the approach of spatial direction Shahat city

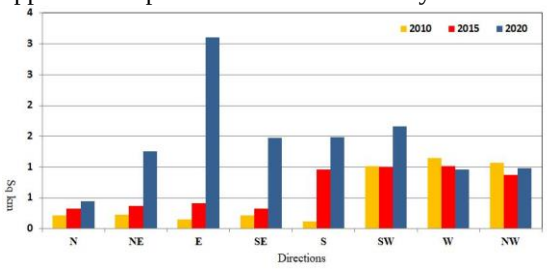

Figure (4) Comparison built up based on the approach of spatial direction (shahat city)

Observed and expected growth

As shown in table (3), the largest increase in urban expansion was in the direction of the east, south, southeast and northeast, and the expansion almost stopped in the direction of the west, north and northwest due to the presence of the archaeological area. In general, the increase in urban expansion for the period 2015 - 2020 was more significant than in the period 2010 – 2015; this confirms the steady growth of the phenomenon, its negative impact on agricultural lands, surrounding forests and negative environmental influences.

Table (3) the observed growth of the built-up areas in Shahat city in different directions and periods (km^2)

Years	N	NE	E	SE	S	SW	W	NW	Total
2010 -2015	0.103	0.139	2.265	1.107	2.838	0.983	0.872	0.802	9.109
2015- 2020	0.126	0.889	3.690	3.150	0.525	0.660	- 0.056	0.113	9.097
	0.229	1.028	5.955	4.257	3.353	1.643	0.816	0.915	18. 196

Table (4) the theoretically expected growth of urban expansion in Shahat city in different directions and periods (km^2)

	N	NE	E	SE	S	SW	W	NW	Total
2010 -2015	0.115	0.515	2.981	2.131	1.678	0.822	٠.٤٠٨	0.458	9.108
2015 -2020	0.114	0.514	2.977	2.128	1.676	0.821	0.407	0.457	9.094

To comprehend the urban growth deviation, the empirical growth should be compared to the theoretically expected urban growth. The results indicated the statistically estimated theoretical anticipated urban area increase for all zones in each time duration (Table 4). The deviation of urban growth for each part and each period could be calculated by deducting theoretically anticipated growth from observed growth, as displayed in Figure (4). Positive values approved more growth than expectations, while negative values displayed less growth. The conclusions in table (5) revealed that the empirical urban expansion in several zones (especially at built-up area fringes) varied from the expectations. Also, the variation is persisting, showing urbanization, and growing with time. Those higher deviations demonstrate independence of the urban expansion. Based on these data, it can be deduced that in the period 2010 to 2020, there is a definite urban sprawl occurring in most zones of the study area.

Table (5) Subtraction of the observed and expected growth in shahat city in different directions and periods (km2)

	N	NE	E	SE	S	SW	W	NW
2010 -2015	-0.012	-0.376	-0.716	-1.024	1.160	0.161	0.464	0.344
2015 -2020	0.012	0.376	0.716	1.024	1.160	-0.161	-0.464	-0.344

Freedom degree of urban expansion

The chi-square is used to compute the freedom degree for urban expansion, which reflects the sustainability or the unsustainability of growth. The high freedom degree is a sign of the urban growth processes.

In Shahat city, table (6) revealed that the urban growth in the study was unsustainable during the period from 2010 to 2020. The degree of freedom of the regions is an alert of unbalanced growth within the region in the future. Higher degrees of freedom for a period can be thought of as higher asymmetry between regions in urban growth. However, we cannot conceive a higher freedom degree as sprawl, but we should regard it as a variance in urban growth.

Table (6) degree of freedom of time periods (shahat city)

Period	Degree of freedom
2010 - 2015	1
2015 - 2020	9

Urban expansion intensity index (UEII)

The UEII represents the potential future direction of urban growth. It examines the rate of urban land-use change, as well as the environmental impacts in different periods. The following are the sections of the UEII standard: Slow development is 0 to 0.28; low-speed development is 0.28 to 0.59; medium-speed development is 0.59-1.05; high-speed development is 1.05-1.92; and extremely high-speed development is >1.92.

Table (7) showed that UEII has reached a score of ten. This implies rapid urban expansion in the research area, confirming the degree of urban growth freedom and indicating that Shahat city's urban growth is uneven and unsustainable. The significant increase in UEII gives a warning of the increasing phenomenon of urban sprawl.

Table (7) urban expansion intensity index shahat city

Period	UEII
2010 - 2015	3
2015 - 2020	7

This study demonstrated that there is a notable urban sprawl in Shahat City, Libya, over the past ten years. The built-up area was the predominant class while the agricultural zone decreased. These changes could be enhanced by a variety of socio-economic, political, and environmental factors. The agricultural and green lands represented a net loss of about 17.3% between 2010 and 2010. While the residential and services zones increased by about 20.2 % during the research period. Several factors including socio-economic, demographic, development policies promoted tremendous conversion of productive lands to urban areas in the research area. This may include a long-term impact on environmental deterioration, soil degradation, climate change, and economic trouble.

Conclusion

Urban expansion change in Shahat City, Libya was estimated and monitored between 2010 and 2020 by using remote sensing and GIS tools. Rapid urban sprawl has resulted in major changes. The study area witnessed a large urban sprawl that led to the disappearance of large areas of agricultural land in the region, as the urban area developed from 4.2 km^2 in 2010 to 22.4 km^2 in 2020. The degree of freedom indicator indicated that the urban growth in the study is unbalanced or unsustainable between 2010 and 2020. The high increase of UEII gives an alarm to the increasing urban sprawl phenomenon. This study confirmed the urgent need to create sustainable and effective policies to reduce the phenomenon of urban sprawl on agricultural lands, especially that Libya is characterized by limited agricultural land. Additional research is needed to employ appropriate measures in compliance with research-based planning for future urban growth.

Reference

Ageena, I. (2010): Trends and patterns in the climate of Libya (1945-2010) (Doctoral dissertation, University of Liverpool).

Bukhechiem, A. (2006). The climate of north east of Libya. Annual report of the north east Libya, Benghazi, Libya, 2, (1), 54-203.

Chadha Behera N, Chourou B, Oswald Spring U, Liotta P, Kameri-Mbote P (2007) Globalisation and Environmental Challenges: Reconceptualising Security in the 21 st Century Hexagon Series on Human and Environmental Security and Peace 3

Hansen, G., (2010). Basic principles of landscape design. Environmental horticulture department, UF/IFAS Extension، CIR536, Available at: http://edis.ifas.ufl.edu/mg086. (Accessed 10 April 2014).

Kombe, W. J. (2005). Land use dynamics in peri-urban areas and their implications on the urban growth and form: the case of Dar es Salaam, Tanzania. Habitat International, 29(1), 113–135. doi:10.1016/S0197-3975(03)00076-6.

Ministry of Housing (2016): Libya State Habitat III Report.

Monteduro, M.; Buongiorno, P.; Di Benedetto; S.; Isoni, A. (2015). Law and Agroecology: A Transdisciplinary Dialogue; Springer: Berlin, Germany.

Msimang, Z. (2017). A study of the negative impacts of informal settlement on the environment: a case study of Jika Joe, Pietermaritzburg.

Musa, A. (2020). The study of the random growth area, case study, the city of Janzour, using GIS. Fourth International Conference on Geospatial Technologies, Libya Geotech 4, Tripoli – Libya.

Pearsall, H.& Christman, Z. (2012). Tree-lined lanes or vacant lots? Evaluating non-stationarity between urban greenness and socio-economic conditions in Philadelphia, Pennsylvania, USA at multiple scales Applied Geography 35:257-264

Pennock, R. (2004). Urban Sprawl & Local State. The Florida University.

UNECE. (2008). Report on Informal Settlements in the ECE Region. Web Page. Retrieved July 02, 2014, from

UN-HABITAT (2003). The Challenge of Slums. Unpublished Global Report on Human Settlements. Retrieved July 22, 2014, from

UN-HABITAT. (2010). State of the World's Cities 2010-2011. International Report on World Cities. Retrieved July 19, 2014, from http://sustainabledevelopment.un.org/content/documents/11143016_alt.pdf..

الملخص العربي

عنوان البحث: الملخص العربي

تطبيق التقنيات الجغرافية المكانية لتقدير الامتداد العمراني: دراسة حالة لمدينة شحات، ليبيا

رشا أبوسمرة[١]، طلعت عبد المنعم[١]، محمد عبد الجليل[١]، مختار العشري[٢]، صالح سعيد[١]*
[١] قسم علوم البيئة، كلية العلوم، جامعة دمياط، مصر
[٢] قسم الجغرافية، كلية التربية، جامعة عمر المختار، ليبيا

اهتمت هذه الدراسة بتقييم أنماط النمو العمراني وقياسها في مدينة شحات (ليبيا)، في الفترة ما بين ٢٠١٠-٢٠٢٠ ، ولمعرفة حدود هذه الظاهرة. وفهمها، تم الاستعانة بثلاث صور من الأقمار الصناعية والتي تقدر بدقة ٣٠ متراً لمنطقة الدراسة بتواريخ (٢٠١٠، ٢٠١٥ و٢٠٢٠)، وتقنية نظم المعلومات الجغرافية والاستشعار عن بعد لتوليد خرائط التطور العمراني للمدينة. وقد أكدت النتائج أن النمو الحضري في المدينة قد ارتفع من ٤,١٦١ كلم مربع في عام ٢٠١٠ إلى ٢٢,٣٦٧ كلم مربع في عام ٢٠٢٠، وأن التوسع العمراني للفترة من ٢٠١٥- ٢٠٢٠ كان أكبر من الفترة ٢٠١٠- ٢٠١٥. فقد تم استخدام اختبار درجة الحرية ومؤشر كثافة التوسع العمراني لتحليل أنماط التوسعات الحضرية وتقييمها، حيث أظهرت النتائج ارتفاع درجة الحرية للنمو العمراني في المدينة، وارتفاع مؤشر كثافة التوسع الحضري، وأن تطورها العمراني غير مستدام وغير متوازن خلال الفترة الزمنية من (٢٠١٠- ٢٠٢٠).