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The Contribution of LANDSAT Satellite Images for Spatiotemporal Analysis of Urban Expansion: A Case Study of Setif City, North Eastern of Algeria

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Abstract		

Urban remote sensing and geographic information systems GIS represent the main innovations in the world of geographic analysis methods, mapping, planning, development and management of urban space. According to several researchers, the analysis of the expansion of urban areas constitutes a major global phenomenon that has a well-known reasons, taking advantage of these developments is necessary. For a perspective sustainable development, the space of urban expansion that the city of Setif is subject to, requires managers to have recent, reliable, and continuously updated data in order to be able to well understand this latter, identifying its challenges, tracking and mapping the changes that have occurred in their territory. Here, we aim to control the evolution directions of urban task, using the ability to characterizing and mapping the urban space quantitatively and qualitatively. To highlight the process of expansion of Setif city, between 1985 and 2019, and in an attempt to establish a mapping of changes that have occurred in its spatiotemporal evolution, we used the method of maximum probabilities; by a successive treatment based on the supervised classification of a series of LANDSAT images at medium resolution and at different dates. The results obtained by this technique, coupled with GIS software, confirm that since 1985 this large city of regional importance has been experiencing rapid urbanization and significant urban dynamics, which have led to a flagrant increase in its urban task. This situation is largely linked to its geographical position as a crossroads, and to the particular interest attributed by the central authorities to this city as part of the development program for the Eastern Highlands region as a regional hub.

Key words: Remote sensing, Urban expansion, Spatiotemporal analyze, the city of Setif.

INTRODUCTION

At the beginning of the 21stcentury, Jean-Pierre Paulet in his treatise "urban geography" had written: "a majority of people now live in urbanized areas; by 2050, three out of four inhabitants will probably be city dwellers"(*Jean-Pierre*, 2000). According to the records of recent studies:the global urban population in 2008 recorded a rate of 50% (*Bouhata* et al, 2016), whereas it was only 15% at the beginning of 1950 (*Jean-Pierre*, 2000). According to the same source, it exceeded 33% in 1960. Consequently, the cities of the whole planet are constantly growing and expanding spatially. This phenomenon, called urban sprawl, consumes a huge amount of land surfaces and requires reviewing the urban policies and problems in order to achieve a reasonable management of these problems (*Simon*, 2016).

Urban sprawl has been a major process in developing countries for the past thirty years; it has become the theme of interest for several disciplines (*Guichi* and *Alkam*, 2017). In Algeria, (*Marc Côte*, 1993) estimated that; in 1990 both rural and urban populations were balanced, with 11.5 million inhabitants each; since that date, Algeria has initiated a major reversal in the structure of its population. It reached 64% of city dwellers in 2008 (*Bouhata* et al, 2016). Even though, the city of Sétif considered being as a regional hub, located at the center of a vast agricultural region, and at the crossroads of a road network of national importance, it has not escaped this sprawl. Since 1987, Setif has occupied the 7th place in the hierarchy of the urban network with a population of 170,182 inhabitants (ONS, 2000). In 1998, it has been classified in the upper urban category, with a population of 214,842 inhabitants (ONS, 2000). In 2018, it freed the official demographic threshold of 300,000 inhabitants used for the ranking of metropolitan areas(law 01/20, 2001). Consequently, the city is currently experiencing a significant development and a fragmented spatial evolution that is

occurring at an accelerated pace. This situation requires city managers to control regularly its urbanization phenomenon, to mapping and identifying its management and development issues. In this context, urban areas have continued to grow, affecting more and more agricultural lands and forests, which will continue suffering gradual decline.

Thus, to participate in the resolution of the urban problems known in this city; satellite images from the Landsat sensor and GIS are important tools for observing and monitoring the evolution of its urban space. Therefore, we used a spatio-temporal analysis of the evolution of land cover, based on four images of the years: 1985, 1999, 2013 and 2019.

PRESENTATION OF THE CITY

The city of Sétif is administratively the capital: of the Wilaya, the daira and the municipality of Sétif. It is located in the region of the eastern highlands where it occupies almost a position in the geographical center of the wilaya. It is a real crossroads of exchange and obligatory transit center for traffic between the Eastern and Central Highlands regions and that of the Northeast and North-West regions. This position is mainly reinforced by the completion of Ain Arnet Airport, which is located 9km from the city and from the East-West motorway. Therefore, it is located at the crossroads of a national importance roads network; the road N°5 which crosses and structures the city as an axis of national economic importance; the RN°75provides a link between the city and the southeast of the country, passing through the city of Batna; the road N°9 which connects the city to the coast and especially to the harbor of Bejaia; the last road that connects Sétif to M'sila, Djelfa and Biskra is RN°28. This is how this city ensures a spatial role of training and animation throughout its region.



Fig. 1. location of the study area.

The city of Sétif has known several civilizations and their imprints remain on its territory, but, despite this, it was only after the advent of the rail in 1925 that its urban fabric underwent significant development, which leads to exceeding the intramural city limits (ANAT, 2010). The spatial evolution of the city took place on the periphery of the historic core in all directions in a radio-concentric pattern (*Anoune* 2010). During the period of the liberation war, the districts of Yahiaou, Bounachade and L'Avenir came to graft themselves onto the colonial fabric, thus forming the second crown (CERU 2011),During the period of the liberation war, unplanned neighborhoods were added to the fabric on top the colonial fabric, thus forming the second crown (*Harkat*, 2012).

After independence, and since the 1970s, the construction of housing complexes, industrial and activity zones, housing estates and structuring facilities gave rise to a third crown (CERU 2011).

In 2008, Sétif counted more than 252,000 inhabitants with a growth rate of 1.64%. The city was classified at that time in the 7th place in the hierarchy of the national urban network and is classified in the upper urban stratum (ONS, 2011). In 2018, according to the latest records, the city has counted more than 370,000 inhabitants (DPSB, 2019). Thus, exceeding the official demographic threshold for classifying metropolitan areas in Algeria.

METHODS

For this study, we have chosen 04Landsat images with are solution of 30x30; taken in different dates of time (1985; 1999; 2013 and 2019) respectively. These scenes are selected in favor of their temporal similarity (scenes taken during the same seasons of the year and at very similar times) in order to ensure a better similarity in terms of atmospheric

and phenological conditions (*Assoule* and *Alkama*, 2020). We opted for a colored composition with the combination of the bands (4, 3, 2) for the Thematic Mapper (TM) images of 1985, 1999, 2013 and the bands (5, 4, 3) for the Landsat Data Continuity Mission (LDCM) image of 2019, in order to better visually identify land uses in comparison with other colored compositions. Based on visual interpretation and knowledge of the reality on the ground, we have defined five land use classes: buildings, forests, bare soils, agricultural soils and water. This choice is made for a better identification of the details of the space.

In our case, we used the Pan-sharping technique to improve the quality of the 30m medium resolution multispectral images by the panchromatic image (band 8) which has a high spatial resolution of 15m obtained by the LDCM sensor. The result is a multispectral image with a resolution similar to the panchromatic image (15m).

THE CLASSIFICATION

The spectral responses of objects present on scenes from satellite sensors allowed to characterize them, and therefore grouped according to their belonging to a determined class of objects (Simon2016). Once the classification is done, the evaluation is preceded. The classification assessment is crucial in order to proceed the thematic analysis. It provides information on the precision level of the maps produced by the classification (Assoule and Alkama, 2020). In this case, we have chosen a statistical classification according to the "maximum likelihood" algorithm (Deng sheng and Weng, 2007), using the software (ENVI4.5) in the two colored compositions. The choice of this method is dictated by the minimum error rate that it achieves. There are several methods of assessing classification: the most common is the confusion matrix (Congalton, 1991). The performance average for our case is 94.62% for the 1985 image, 96.89% for the 1999 image, 95.94% for the 2013 image, and 97.52% for the 2019 image.

For the accuracy assessment, we used a synthetic index from the confusion matrix called the Kappa index. It is a quality indicator used to measure the performance of a classification by examining all of the elements constituting the matrix (Stehman, 1996). The Kappa coefficient is a statistical index varying between 0 and 1, used in particular to evaluate the degree of efficiency of a model (in this case a classification), in a way of classifying a set of objects in a certain number of classes (Kieffer and Serradj, 2013). With an average value of 0.9350 for our four images, we can consider that the correspondence between the sampling pixels and the reference pixels is almost total in our case.

After Classification

Once the images are prepared for diachronic representation, they are transformed into separate vector layers, one for each of the previously chosen classes for each year of the series.

In order to study the evolution of our city and to understand its evolutionary mechanisms, it was necessary to add to the successive layers of buildings, a base-map relevant for the analysis. So it was chosen and inserted, to identify the phenomenon of urban sprawl within administrative boundaries and main roads, it also contains the toponymy of districts.



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Figure 6. Evolution of built space between 1985 and 2019

For the cartographic representation of (**Figs. 2, 3, 4** and **5**), the black color was chosen to represent the expansion of the buildings, dark green for the forest, light green for agricultural soils, beige for bare soils and blue for water. In order to understand the spatial influence of each period in global evolution, we developed a synthesis map by the superposition of these layers.

In Figure 6, the black color selected to present the surface area of the building in 1985, yellow color is for the period between 1985 and 1999, red figures the period between 1999 and 2013, while the blue presents the period between 2013 and 2019. As for the records corresponding to these growth periods, they appear in the following table (Tab. 1).

Year	Cumulative surface of building (ha)	Absolute difference	Rate of built area to the total area %	Annual average extension (ha/an)
1985	618		4,72 %	
1999	1193	575	9,11 %	41,07
2013	2408	1215	18,39 %	86,79
2019	2934	526	22,41 %	87,67
Total		2316		68.12

The spatial evolution of the built-up area of the city of Sétif between 1985 and 2019 is highlighted by the use of four LandSat images and GIS-type software. According to our knowledge of the field, each interval between the acquisition dates of the images is characterized in the field by the urban sprawl phenomena, and more or less marked urban densification operations.

From the summary map (Fig. 6) and curve N°01 (Fig. 7) we can generally see a positive and rapid trend in the development of the built-up area of the city. In 1985, in black color, the latter is equal to 618ha, which represents 4.72% of the total area of the municipality. It consists of the colonial core and the first extension crown, following the realization and subsequent finalization of the Constantine plan. It is mainly located in the east and south-west part, under the effect of the main roads RN75 and RN05.



Figure 7. Evolution of the indicative parameters of the urban extension of Setif city

Between 1985 and 1999, in yellow color, we see a clear progression of this surface, which has increased by 575ha in 14 years. This represents 9.11% of the overall area of the municipality, with an expansion speed of 41.7ha / year, and a geographical location especially in the eastern and northeastern part, influenced by the existence of land reserves and by the 'attractiveness of national roads N09 and N05. These extensions took place within the framework of the policy of large housing projects, as well as for the industrial and economic projects: such as the ZHUN project, and the creation of new districts such as the districts of: November 1st, El Maabouda, Hachmi ... Etc. In addition to real estate development projects and housing estates for example; the extension of El hidabe, ElaidDaho and the May 08 district. At the same time, some district of the five executed. As for industrial and economic projects, we highlight the creation of the "Sonacom" factory, and the extension of the activity zone in the eastern part, and the industrial zone in the southern part.

From 1999 to2013, the built surface of the city, in red color is doubled yet another time, with a growth rate of 86.79ha / year and a net increase of 1215ha (Fig. 7). It reached at the end of this period 2408h that represents 18.4% of the overall area of the municipality. It is mainly Concentrated in the northern part, along the way which connects the roads 05 and 09, and the RN09 that link Sétif region to Bejaia region, and to the North-East (the extension of El Hidab university pole). In addition to the secondary center, that surrounds the city (Chouk el kdad in the Northeast, Fermatou in the

North, Ain Sfiha in the South-West and Ain trick in the South). This secondary center began to receive the surplus from Sétif. This situation is due to the multiple housing projects that the city has experienced as part of the President of the Republic's program to build 1 million housing units(*Anoune* 2018). During this period, some districts have benefited from renovation and restructuring operations, such as Lenderyouli and someparts of Kaaboub. At the same time, we noticed the construction of certain public facilities at district level, such as the technical school in the 1006housing district. In addition, the city benefited from some economic projects like the sanitary pole in Chouf Lakdad region, and sports pole in Bir Elnsa region.

Between 2013 and 2019, in blue color, the built surface continued to grow rapidly. With a net increase of 526ha in 06 years, and a speed of 87ha/year(Fig. 7). At the end of this period, it reached 2934ha. Hence, it represents more than 22% of the total area of the municipality. At the same time, we recorded a decline in the area of agricultural land and bare soil from the beginning of 1985 until 2019, with an overall deficit of 1498 ha for agricultural land and 885 ha for bare soil; which represents an average rate of regression of 44ha / year for the first and 26.02ha / year for the second.

These results prove that the expansion of built-up space comes at the expense of bare soil and agricultural land. These areas (bare soil and agricultural land) which undergo operations of agricultural lightning especially in the secondary agglomerations, where we noticed a new extensions that touched the districts of Boussekin, Ain Sfiha and Chouflakdad. In addition, the realization of the economic projects such as the construction of the wholesale fruit and vegetables market, which contributed to further increase the attractiveness of the study area.

CONCLUSION

Setif like other large Algerian cities is characterized by strong demographic and spatial growth; this accelerated development has caused significant urban dynamics. Some neighborhoods have taken a chaotic form during its development. Despite this, the city continues to grow in a massy way, each time hosting ad hoc actions according to the emergencies of each moment.

In this context, and to understand this situation, we used urban remote sensing coupled with GIS tools as an innovation in the methods of mapping, analysis, planning and management of urban space. The Setif city proved that, it has a very extensive spatial coverage, a spatial and temporal resolution, and an ease of acquisition and analysis, which constitutes an asset, for attracting the attention of planners and managers of urban space, as well as the various users who seek spatial information and who integrate it into their working methods.

Finally, it should be noted that, given the excessively high cost of high-resolution images, the difficulty in using this technique lies in the fact that the resolution of the images provided free of charge does not allow the analysis to be pushed further towards more précised objectives.

REFERENCES

- 1. Anoune, N.(2010). The transformations of the inner urban dynamics of the city of Batna. *Journal of Architecture and Planning*22(2), 167-187.https://cap.ksu.edu.sa/sites/cap.ksu.edu.sa/files/imce_images/jap_ksu_jul2010_ar2.pdf
- 2. Anoune, N. (2018). The role of development policy and regional planning in strengthening Algerian national security. *Algerian Journal of Security and Development* 07(10), 187-198. https://www.asjp.cerist.dz/en/article/35735
- 3. ANAT.(2010).The land use plan of Sétifwilaya. Department of land use planning of the wilaya of Sétif
- 4. Assoule, D., D. Alkama(2020). The detection of the change in urban sprawl in the Algerian Lower Sahara: contribution of space remote sensing and GIS. Case of the city of Biskra(Algérie). *French journal of photogrammetry and remote sensing* 222,41-51. https://www.sfpt.fr/rfpt/index.php/RFPT/article/view/486/267
- 5. Bouhata, R., M. Kalla, B. Aida, and Y. Habibi(2016) The spatio-temporal analysis of urban expansion of Biskra city (south eastern Algeria) by the use of LandSat satellite images. *Anale de l'université Dim Oradea*, 2, 151-166. https://www.researchgate.net/publication/342380930_the_spatiotemporal_analysis_of_urban_expansion_of_biskra_city_south_eastern_algeria_by_the_use_of_landsat_satellite_images
- 6. CERU.(2011). master plan for inter-municipal development and town planning, Department of land use planning for the wilaya of Sétif

- 7. Congalton, R.(1991).a review of assessing the accuracy of classification of remotely sensed data. *Remote sensing of environment*.37(1), 35-46https://www.sciencedirect.com/science/article/abs/pii/003442579190048B
- 8. Dengsheng, L., Q. Weng(2007). a survey of image classification methods and techniques for improving classification performance. *International jornal of remote sinsing* 28 (5) 823-870, doi: 10.1080/01431160600746456
- 9. DPSB.(2019). Statistical yearbook. Algeria, Department of land use planning of the wilaya of Sétif
- 10. Guichi, I.,Alkama, D.,(2017). Contribution of remote sensing for the diachronic mapping of urban sprawl and the morphological analysis of the Guelma agglomeration. *knowledge mail journal* 24, 73-80. http://revues.univ-biskra. dz/index.php/cds/article/view/2242
- 11. Harkat, N. (2012). vulnerability of the city of Sétif to environmental risk Case of the industrial zone, Thesis with a view to obtaining the master's degree in architecture and town planning, Option: City and urban risks, Department of architecture and town planning
- 12. Jean-Pierre, P. (2000). Urban geography. Collection U geography, Paris, Armand Colin
- 13. Kieffer, E., and A. Serradj 2013 : Remote sensing in the service of urban studies Expansion of the city of Pondicherry between 1973 and 2009.*Géomatique Expert*,95,68-79. https://www.researchgate.net/publication/259645515_La_Teledetection_au_service_des_etudes_urbaines_Expansion_de_la_ville_de_Pondichery_entre_1973_et_2009.html
- 14. Law 01/20.,(2001) : Official Journal of the People's Democratic Republic of Algeria
- 15. Marc, C. (1993).Urbanization in Algeria: received ideas and realities. *Work of the Geographical Institute of Reims*, 85, 59-72.https://www.persee.fr/doc/tigr_0048-7163_1994_num_85_1_1304
- 16. ONS (2000) National office of statistics, Urban frame. Statistical collection 97, series S
- 17. ONS (2011) National office of statistics, Urban frame. Statistical collection 163, series S
- 18. Simon, S. (2016) Contribution of very high spatial resolution satellite images coupled with multi-source geographic data for the analysis of urban spaces. Doctoral thesis, University of Strasbourg
- 19. Stehman, S. (1996) Estimating the kappa coefficient and its variance under stratified random sampling. *Photogrammetric engineering and remote sensing*, 62, 401-407. https://citeseerx.ist.psu.edu/viewdoc/download? doi=10.1.1.461.9979&rep=rep1&type=pdf

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