INTRODUCTION

At the beginning of the 21st century, 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). 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°75 provides 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.

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

Figure 4. Land Use 2013  
Figure 5. Land Use 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).
The Contribution of LANDSAT Satellite Images for Spatiotemporal Analysis of Urban Expansion: A Case Study of Setif City, North Eastern of Algeria

Table 1. Setifcity: Transformation of the built surface between 1985 and 2019

<table>
<thead>
<tr>
<th>Year</th>
<th>Cumulative surface of building (ha)</th>
<th>Absolute difference</th>
<th>Rate of built area to the total area %</th>
<th>Annual average extension (ha/an)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>618</td>
<td>--</td>
<td>4.72 %</td>
<td>--</td>
</tr>
<tr>
<td>1999</td>
<td>1193</td>
<td>575</td>
<td>9.11 %</td>
<td>41.07</td>
</tr>
<tr>
<td>2013</td>
<td>2408</td>
<td>1215</td>
<td>18.39 %</td>
<td>86.79</td>
</tr>
<tr>
<td>2019</td>
<td>2934</td>
<td>526</td>
<td>22.41 %</td>
<td>87.67</td>
</tr>
<tr>
<td>Total</td>
<td>--</td>
<td>2316</td>
<td>--</td>
<td>68.12</td>
</tr>
</tbody>
</table>

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 districts have benefited from restructuring operations such as the Thlidjan district, El mostakbel, Bounechada and the 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 to 2013, 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 2408ha 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 klad 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 some parts of Kaoubou. At the same time, we noticed the construction of certain public facilities at district level, such as the technical school in the 1006 housing 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 Choufflakdad. 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

3. ANAT. (2010). The land use plan of Sétifwilaya. Department of land use planning of the wilaya of Sétif
6. CERIU (2011), master plan for inter-municipal development and town planning, Department of land use planning for the wilaya of Sétif
The Contribution of LANDSAT Satellite Images for Spatiotemporal Analysis of Urban Expansion: A Case Study of Setif City, North Eastern of Algeria


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.


Copyright: © 2022 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.