International Journal of Innovative Studies in Sociology and Humanities
ISSN 2456-4931 | Open Access | Volume 8, Issue 1, 2023
DOI: https://doi.org/10.20431/2456-4931.080111

Contribution of Remote Sensing in the Diachronic Monitoring and Analysis of the Urban Sprawl Phenomenon of Setif City (North-East Algeria)

Akila Melal[1], Rabah Bouhata[2], Yahyaoui Habibi[3]

[1, 2, 3] *Laboratory of Natural Hazards and Regional Planning, Institute of Earth Sciences and Universe, Batna2 University, Route of Constantine - Fésdis, Batna 05078, Algeria.*

Received: December 31, 2022 **Accepted**: January 19, 2023 **Published**: January 21, 2023

Abstract

Urban sprawl is one of the major phenomena associated with urbanization on a global scale and which has been the subject of study by several researchers from different disciplines.In this context, the city of Setif located in the North-East of Algeria has experienced a rapid and uncontrolled urban expansion.This study aims to analyze the evolution of land use for the period 1986 to 2021, using the use of processing and analysis of Landsat satellite images several dates of the city of Setif. The result of the work can be contributed and help the local authorities to act effectively in terms of spatial planning of the city of Setif.

Key words: Diachronic study, Landsat, Remote sensing, Setif City, Urban sprawl.

INTRODUCTION

After independence, Algeria experienced a strong demographic growth especially during the first two decades (Boulahbal, 2008; Kateb, 2003). The northern cities of the country have experienced densification of the urban system linked to population growth, rural exodus and migratory flows (Kateb, 2003).The state of affairs of these cities presents an accelerated urbanization due to demographic growth and an uncontrolled spatial extension which has generated rapid urban mutations under the effect of the phenomenon and contrary to the principle of sustainable urban development. The urban sprawl of these cities has occurred under the effect of socio-economic interactions with local spatial and environmental constraints.It is accelerating with the improvement of transport networks and mobility. Micro- and macro-socio-economic factors interact; means of transport, the land market, individual residential location preferences, demographic developments, the attractiveness of urban regions, and the application of land use planning policies at local and regional scales (ONS 2010). Several definitions of urban sprawl have been carried out by researchers in the field, The European Environment Agency (2006) describes sprawl as the progression of urbanized areas faster than population growth.

For Sainteny, 2008, urban sprawl is an urban expansion happening faster than population growth: the area consumed per capita is increasing, decoupling population growth and soil artificialization .The city of Setif Located in the North-East of the country is a relevant example of study because of the phenomenon of the sprawl of urban space. However, thanks to an absence of regulation, laxity of the public authorities, and the face of ever more substantial demographic pressure, the city has developed and the urbanized spaces have exceeded the municipality's limits.Today, the actors of spatial planning faced with the problems of urban sprawl.The objective of the present study is to analyze the evolution of land use, for the period 1986 to 2021, using multi-date Landsat satellite images (Boubacar and al, 2020) which allows us to monitor changes in land use and analyze the consequences of this sprawl on the sustainable urban development of the city.This approach can help local authorities to act effectively in terms of spatial planning, with a view to the sustainable development of territories with less impact on the environment (Thériault and al, 2011).

MATERIALS AND METHODS

Description of the Study Site

The city of Setif with an area of 13094 ha is located in the North-East of Algeria between 5° 21'0" and 5 °30'0" East longitude, and 36° 15'0" and 36°9'0" North latitude. Bordered to the north by the municipality of Ouricia ; to the east

by the municipality of Ouled saber; to the west by the municipality of Mezloug and Ain arnet, and to the south by the municipality of Guedjel (Figure 1).The city of Setif is characterized by a radioconcentric structure the urbanization process has been carried out in all directions (poly direction) presenting a concentric radio scheme (Seddiki, 2009). The city is ranked second after the capital in terms of population. Based on the last RGPH of 2008, the population increase since 1966 to the present day, taken in its entirety and which amounts to 288,461 inhabitants reflecting a single rate of increase of 1.96% between 1998 and 2008.However, this rate has dropped compared to the rate recorded between 1987/1998 which showed a rate of 3.10%.

The city enjoys a remarkable strategic position which allows it to constitute a crossroads of intense exchange and an obligatory passage of traffic of all kinds.It is located in the center of a vast agricultural region par excellence and placed on the Algiers-Annaba railway axis, as well as it is at the crossroads of many national roads (RN5-RN9-RN28-and RN 75), the East-West highway without forgetting the last important infrastructures injected which are the airport and the city of Setif, therefore, constitutes a real hub ensuring the necessary complementarities between the subsets of the region: the coastline, the Eastern highlands, and the South of the country, thus promoting all types of exchanges, settlement, and population movements.

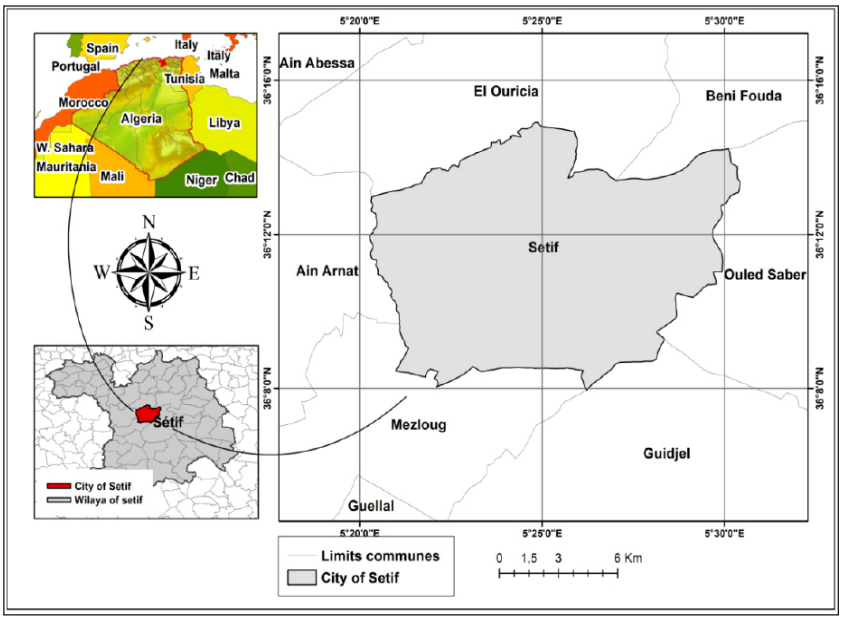

Figure 1. Location of study area

Data and Material Used

The use of the remote sensing technique makes it possible to analyze the data and identify the different chronological trends of urbanization (Boubacar and al 2020; Bouhata and al 2014; Theodore, 2012).The methodology followed is based on the exploitation of satellite images provided by the American satellite Landsat acquired at different dates1986, 2000, 2015 and 2021. (Table 1).These images selected for this study are geometrically self-rectified and geocoded prior to their dissemination by the USGS, according to the geographical referencing system WGS 84 Zone 31 North.

In order to have a real color image, you must go through the colored composition stage, the principle of the colored compositions consists in assigning to the spectral bands acquired in the wavelengths, blue, green and red (B1, B2, B3) for landsat 5 and 7, and (B2 B3 B4) for landsat 8. The resulting image therefore corresponds exactly to what an observer could observe if he were on board the satellite.The study area is extracted through the superposition of a shape file (Shp) represents the administrative division of Algeria with the satellite image using the tool (Extract by mask) of ArcGIS.

Among the objectives of the project, the production of a thematic map for the characterization of the spread of the examined territory, an important spatial resolution is necessary, that is to say a maximum pixel dimension equal to 15, 30 and 60 meters. These resolution values adapt perfectly to our problem. The table below contains all the images used provided by the Landsat satellite. The use of these images makes it possible to identify the occupation of the land, the urban area as well as agriculture, image processing performed using ArcGIS 10.1 software.

Table 1. Characteristics of landsat satellite images

Image	Acquisition date	Satellite/ sensor	Resolution	Projection	Format
1	19 May 1986	Landsat 5 TM	30m (MS) 120m (IRT)	UTM WGS 84 zone 31	Geotiff
2	04 July 2000	Landsat 7 ETM+	30m (MS) 60m (IRT) 15m (Pan)	UTM WGS 84 zone 31	Geotiff
3	23 August 2015	Landsat 8 LDCM	30m (MS) 60m (IRT) 15m (Pan)	UTM WGS 84 zone 31	Geotiff
4	06 July 2021	Landsat 8 LDCM	30m (MS) 60m (IRT) 15m (Pan)	UTM WGS 84 zone 31	Geotiff

Amelioration Treatment (Pan-Sharpening)

Image fusion is generally defined as the combination of two or more different images to form a new image using an algorithm (phol, V et al, 1998). In our work, pan-sharpening consists of merging a panchromatic image (band 8) for Landsat 7 and 8 in high spatial resolution (15 m) with a multispectral image of low spatial resolution (30 m),the result produces a multispectral image with the same resolution as the panchromatic image.

Supervised Classification: Victor Machine Support (SVM)

The technique used in this work is based on The classification support vector machines or wide margin separators in English (Support Vector Machine SVM), (Fizazi, and al 2012; Sunitha and al 2015; Ban and al, 2016; Nath and al, 2014; Assoule and al 2020). Support vector machines are supervised classification techniques designed by Vapnik in 1995. The SVMs find their root in the theories of statistical learning with a discrimination based on the existence of a linear separator maximizing the margin, that is to say, the distance to the nearest vectors called support vectors.(Cooren and al, 2009; Zidelmal and al, 2007),an analyst who tries to classify the characteristics of an image uses the elements of visual interpretation to identify homogeneous groups of pixels that represent interesting classes of surfaces.The digital classification of images uses the spectral information contained in the values of one or more spectral bands to classify each pixel individually, with the aim of assigning a particular class (Urban space, agricultural land, bare ground, forest). For each classification we have tried to identify four classes of land use;. A class of the urban grid (1), a class of the forest (2), a class of agricultural land (3), and a class that represents the bare ground (4). (See Table 2.3.4.5).This classification is a set of supervised learning techniques, intended to solve discrimination and regression problems.SVMs were quickly adopted in urban studies for their abilities to work with large-scale data, their theoretical guarantees, and their good results in practice.

In this study, two types of precision were preferred: general precision and the Kappa coefficient.The general accuracy is determined by dividing the sum of all correctly classified pixels along the central diagonal by the total number of reference pixels. Kappa makes it possible to measure the extension of the accuracy of the classification, since it counts not only for the elements of the diagonal but for all the elements that are in the confusion matrix.The Kappa coefficient is a measure of agreement between the rankings predefined by the producer and those assigned by the user (Boubacar and al 2020).

Validation of the classification

The evaluation of the classification is crucial to be able to carry out the thematic analysis; it provides information on the level of accuracy of the maps produced by the classification. There are several methods for evaluating classification; the most common is the confusion matrix (Congalton, 1991), A synthetic index from the confusion matrix is also used in the

evaluation of accuracy (Assoule and al 2020) This is the Kappa Index (Khat), It is a quality indicator used to measure the performance of a classification through the examination of all the elements constituting the matrix (Stehman, 1996) .This method of calculation makes it possible to obtain a reliable assessment of the level of accuracy of the classification, unlike the first index which is more global and whose calculation is focused only on the elements of the diagonal (Collet and al 2001). For a Khat value greater than or equal to 0.8, the classification is statistically considered acceptable; where as if the Khat varies between 0.4 and 0.8, the classification is considered of average quality (Congalton and al 2008).

In this study, the evaluation of the accuracy is carried out by proceeding first of all to the creation of an entity class with two columns, the first represents classified points (land use map) and the second presents the real points (Google Earth), the digitalization of more than 300 control points for each class (see Table 2.3.4.5).The confusion matrix is then generated from the comparison and the observation.

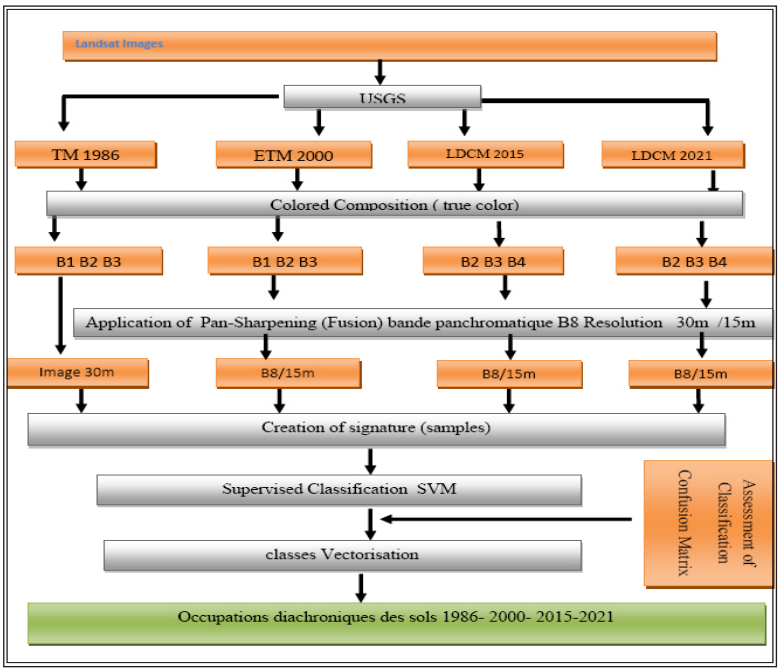

Figure 2 . Methodological flow diagram of directed classification

RESULTS AND DISCUSSION

The thematic maps obtained (land use map for the years 1986, 2000, 2015, 2021) it corresponds to figures 3, 4, 5 and 6 .The confusion matrices generated for these three maps showed a very satisfactory level of accuracy, in particular.The Kappa index (Khat) thus showed a high level of accuracy with the values 0.8943 for the year 1986; 0.8934 for the year 2000; 0.8845 for the year 2015 and 0.8845 for the year 2021.The summary of this evaluation is illustrated in Tables 2, 3, 4 and 5.

Table 2. Confusion matrix of the 1986 SVM classification

Classes /1986		Urban Space	Forest	AgriculturaLand	Bare Ground	Total	Percentage Precision %
		1	2	3	4		
1	Urban space	559	0	4	89	652	85.73
2	forest	0	587	0	0	587	100
3	Agricultural land	0	0	351	0	351	100
4	Bare ground	8	39	38	602	687	87.62
Total		559	626	393	691	2277	92.18 %
Kappa index		0.8943					

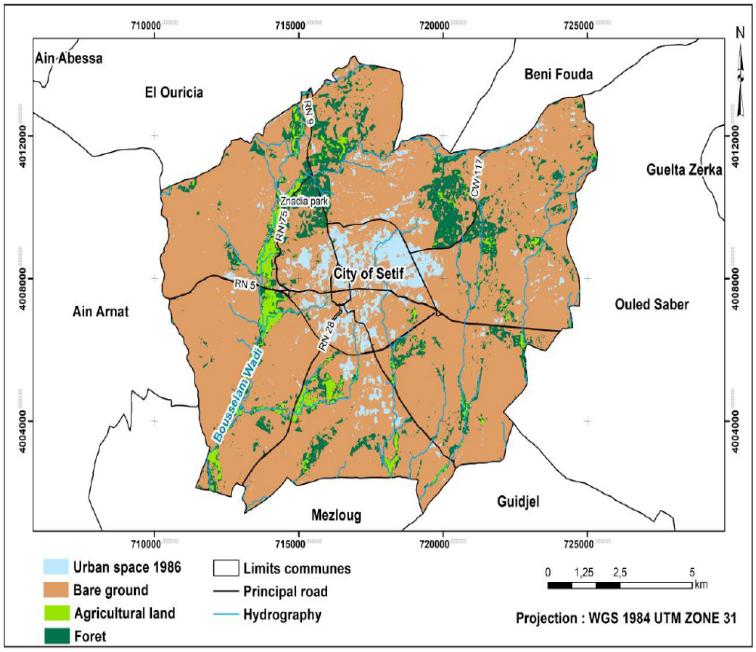

Figure 3. Land use map of Setif city in 1986

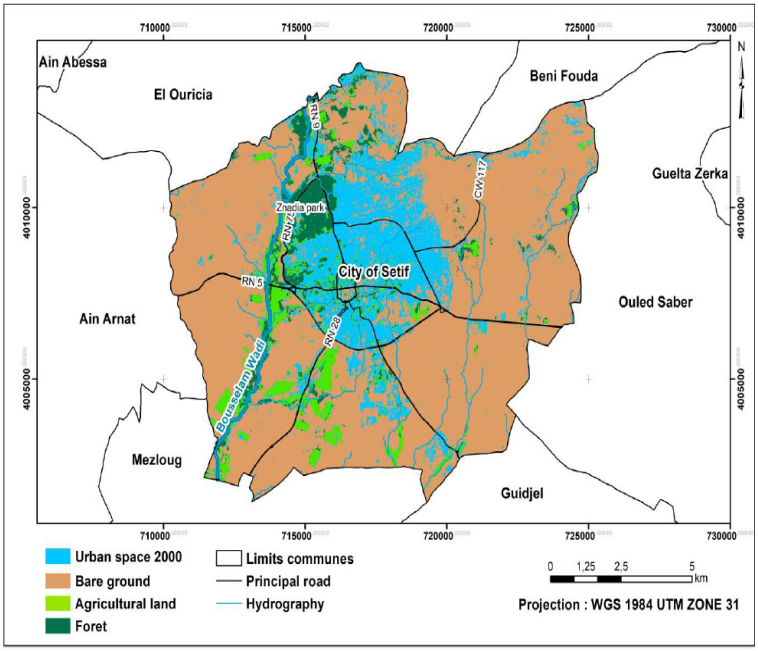

Figure 4. Land use map of Setif city in 2000

Table 3. Confusion matrix of the 2000 SVM classification

Classes / 2000		Urban Space	Forest	Agricultural Land	Bare Ground	Total	Percentage Precision %
		1	2	3	4		
1	Urban space	580	2	12	57	694	83.57
2	Forest	0	369	41	40	450	82
3	Agricultural land	4	0	515	17	536	96.08
4	Bare ground	8	0	0	642	650	98.76
Total		592	371	568	756	2330	90.38%
Kappa index		0.8934					

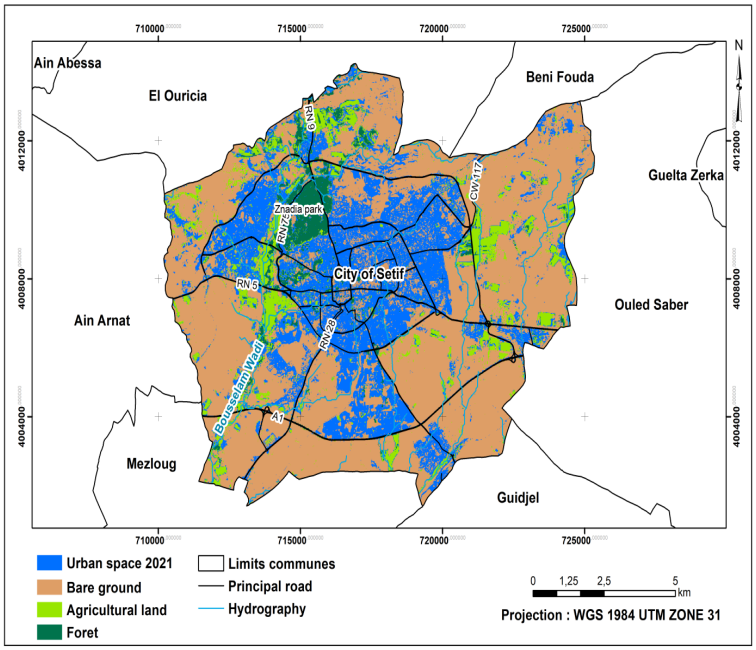

Figure 5. Land use map of Setif city in 2015

Table 4. Confusion matrix of the 2015 SVM classification

Classes / 2015		Urban space	forest	Agricultural land	Bare ground	Total	percentage precision
		1	2	3	4		%
1	Urban space	828	0	6	49	883	93.77
2	Forest	0	606	44	71	721	84.04
3	Agricultural land	12	6	1084	95	1257	86.23
4	Bare ground	5	0	0	576	581	99.13
Total		845	612	1134	791	3442	89.88%
Kappa index		0.8845					

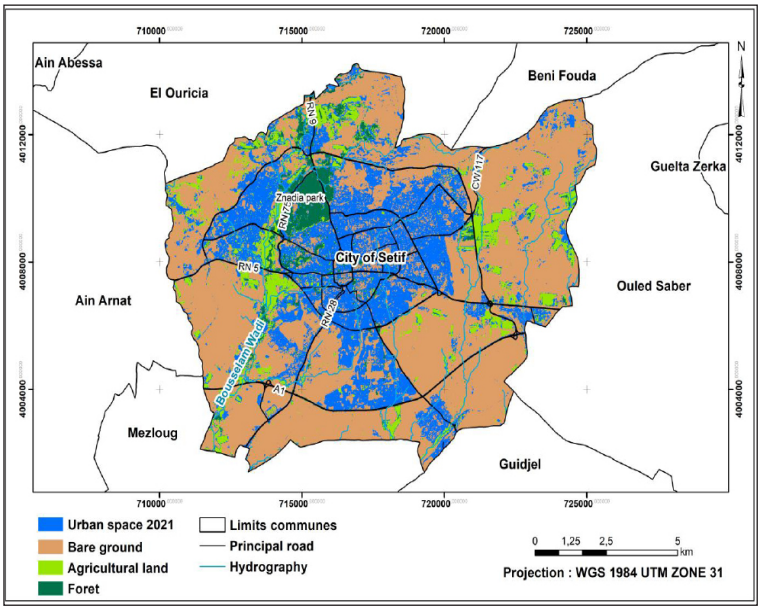

Figure 6. Land use map of Setif city in 2021

Table 5. Confusion matrix of the 2021 SVM classification

Classes / 2021		Urban space	forest	Agricultural land	Bare ground	total	percentage precision
		1	2	3	4		%
1	Urban space	1179	1	14	78	1272	92.68
2	Forest	0	718	98	33	849	84.57
3	Agricultural land	0	16	998	92	1106	90.23
4	Bare ground	1	0	2	946	949	99.68
Total		1180	735	1112	1149	4176	91.97 %
Kappa index		0.8923					

The change detection approach helps to better assess the socio-spatial mutations that occur in a territory.To do this, the vectorization and the superposition of the different multi-date classifications constitute an excellent source of information to determine the size and the trend of the urban dynamics of the city of Serif.(figure7)

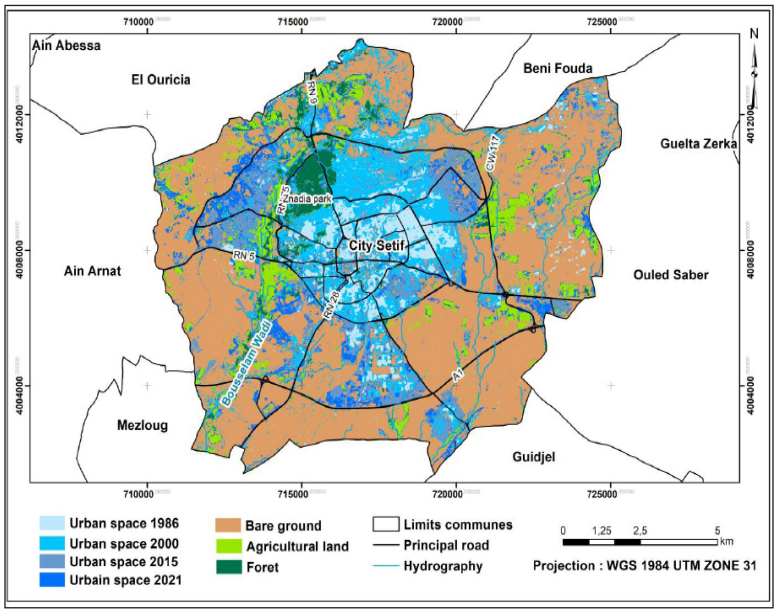

Figure 7. Diachronic monitoring og the urban sprawl phenomenon

The analysis of the classification results confirms the progression of the urbanized surface between the two periods; we record a development in the surface of the urban spot of 1505.75 hectares between 1986 and 2000 .In the period between 2000 and 2015 this surface has developed with 731.7 hectares. The period between 2015 and 2021 a development of the urban surface of 655.68 hectares. (Table 6).

Setif city has experienced urban sprawl; and the use of data provided by remote sensing allows us to follow the dynamics of this sprawl and its effects on spatial planning and sustainable urban development. To this end, we take the main axes of sustainable urban development in this case, the urban environment which constitutes a condition for development, the economy as a means and the societal component as an objective (Jacques, L. 2010; Brigitte, N.2011; Aguejdad, 2009). These three main axes constituted indicators for the analysis and evaluation of the various consequences of the urban sprawl phenomenon.

Table 6 . Evolution of land occupation surfaces

Classes		Classification1986		Classification 2000		Classification 2015		Classification 2021	
		Surface hectare	%	hect	%	hect	%	hect	**%**
1	Urban space	822.69	6.28	2328.44	17.78	3060.21	23.37	3715.89	28.37
2	Forest	1310.20	10	705.38	5.38	546.18	4.17	513.78	3.92
3	Agricultural land	408.99	3.12	865.42	6.60	1704.09	13.01	1104.71	8.43
4	Bare ground	10551.29	80.57	9194.75	70.21	7783.71	59.44	7759.64	59.25

In Setif city, the artificialization of agricultural areas has progressed at a significant pace, a regression of 599.38 hectares between 2015 and 2021.Despite the presence of the regulations of the master plan of development and urban planning which takes into consideration the preservation of agricultural lands and natural spacesbut the chronic disorders that have marked the evolution of land and the absence of a global vision and an urban project mean that this city is developing urgently and under the effect of urban sprawl.

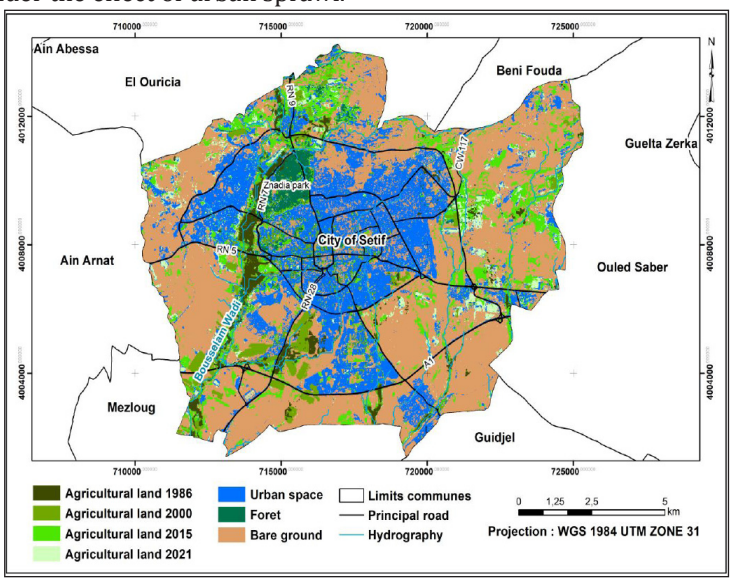

Figure 8. Diachronic monitoring of agricultural land consomption

CONCLUSION

Setif city has experienced an accelerated urban sprawl; the fight against this phenomenon requires finding strategies involving the various actors of development, urban planning, urban planning and the different sectors of administrative coordination.

The use of remote sensing techniques has allowed us to analyze the extent of the phenomenon of sprawl, especially the degradation of agricultural land and the rapprochement between urban space and the industrial zone up to perimeters of major risk.Moreover, the appearance of high-resolution satellite images constitutes a new source of spatial information that combines fine spatial resolutions with possibilities for revisiting.The exploitation of satellite images that offer synoptic views of the studied territories with regular temporality, which allows the updating of spatial information with fewer investments in terms of time and economic cost (Gamba and Dell'acqua, 2016).

The city's development and urban planning actors have tried to tackle the problem on an intermunicipal scale of study and collaboration, including the vision which requires the revision and study of the master plan for development and urban planning PDAU of the city in an inter-municipal framework which brings together the city of Setif and the neighboring municipalities, but the in application of the PDAU regulations on the ground by the authorities constitutes the first cause of urban sprawl.

Despite all the efforts submitted by the local authorities in the direction of dealing with the phenomenon of sprawl in the city.But the consequences remain to be taken consciously, especially with regard to the management of natural and industrial risks.Hence the need to integrate the consequences of urban sprawl into strategic environmental assessment studies and natural and technological risk prevention plans.

REFERENCES

1. Armand, M. (2016). Satellite images and planning of Third World cities. Developing Worlds, 44(176), 168 169. https://doi.org/10.3917/med.176.0169
2. 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 (Algeria).French journal of photogrammetry and remote sensing 222,41-51.https://www.sfpt.fr/rfpt/index.php/RFPT/article/view/486/267

3. Aguejdad, R (2011). Urban sprawl and assessment of its impact on biodiversity, from the reconstruction of trajectories to prospective modeling. Application to a medium-sized agglomeration: Rennes Métropole.Geography .thesis University Rennes 2 high Brittany p 07. https://tel.archives-ouvertes.fr/tel-00553665 Submitted on 7 Jan 2011

4. Boulahbal, B (2008), The Algeria of tomorrow: meeting the challenges to win the future, Social needs by 2025

5. Boubacar, A., Balla D, Moussa T, Djibrilla A and Bougadarid (2020), "Urban sprawl in Bamako: explanatory factors and implications" Africa SCIENCE 17(6) (2020) 58 – 75.

6. Bouhata R. , Kalla M., Driddi H (2014), use of landsat TM for mapping land use in the endorheic area –case of gadaine plain (eastern Algeria), Analele Universităţii din Oradea, Seria Geografie, pp. 101-107 .

7. Brigitte N., (2011), «Which spatial solutions to integrate agriculture in sustainable town? The case of "hameaux agricoles" in the Hérault. Norois *n*° 221 p. 53-66, https://doi.org/10.4000/norois.3775

8. Ban, Y., Yousif, O. (2016).Techniques De Détection Des Changements: Une Revue. Dans: Y. Ban (Ed.), Méthodes et Applications de télédétection multi temporelle. Cham: Springer International Publishing, pp. 19 43. https: / / doi. Org / 10.1007 / 978-3-319-47037-5_2

9. CNES. (2002). Urbanization and natural and industrial risks in Algeria: Current and future concerns. Study report, CNES Algiers..

1. http://www.cnes.dz/cnes/wpcontent/uploads/Rapport-sur-l'urbanisation-et-lesrisques-naturels-et-industriels-en-Algérie.pdf

10. Collet, C, Caloz, R. (2001). Precise remote sensing: digital processing of remote sensing images. Vol 3. University of Quebec Press. 386p.

11. 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

12. Congalton, R. Green, K. (2008). Assessing the accuracy of remotely sensed data: principles and practices. Boca Raton: CRC press (2nd Éd). 200p

13. Cooren,Y., Clerc,M., Siarry,P. (2009) "Performance evaluation of TRIBES, an adaptive particle swarm optimization algorithm" Swarm Intelligence, Springer New York, Volume 3, Number 2 / juin 2009. Pages 149-178

14. European Environment Agency (2006). Urban Sprawl in Europe: The Ignored Challenge. Report No: 10/2006, Copenhagen: European Commission, Joint Research Centre

15. Fizazi, H ., Benhabib,W (2012), Tribal approach of SVMs for the classification of satellite images. Journal "Nature & Technology".n° 06/January 2012. Pages 09 to 15

16. Gamba,P. Dell'Acqua, F. (2016). Change Detection in Urban Areas: Spatial and Temporal Scales. In Y. Ban (Éd.), Multitemporal Remote Sensing: Methods and Applications Springer International p. 4561. https://doi. org/10.1007/978-3-319-47037-5_3

17. Jacques Levy (2010) Sustainable urban development between consensus and controversy Geographical Information 2010/3 (Vol. 74), pages 39 to 50.

18. Kateb,K (2003),population and organization of space in; Geographical Space 2003/4 (volume 32), pages 311 to 331

19. Nath, S., Mishra, G., Kar, J., Chakraborty, S., Dey, N. (2014). A survey of image classification methods and techniques. In: Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 International Conference. IEEE, pp 554557

20. ONS 2010 national statistical office) the executive decree n ° 98-169 of May 20, 1998 implementing the general population and housing census of 1998 https://doi.org/10.1080/014311698215748

21. Pohl, C. and van Genderen, J.L. (1998) Multisensor Image Fusion in Remote Sensing: Concepts, Methods and

Applications. International Journal of RemoteSensing, 19, 823-854.https://doi.org/10.1080/014311698215748

22. PDAU (2011), Master Plan of Development and Urban Planning of Setif 2011
23. RGPH 2008: General Census of Population and Housing of 2008
24. Sainteny, G. (2008),"Urban sprawl", responsibility & environment review n° 49 (2008) 7
25. Seddiki. H et al (2009), "Setif: the wilaya", Ed al bayazin: 2nd edition, Algiers, p 102
26. Stehman, S. (1996).Estimating the kappa coefficient and its variance under stratified random sampling. Photogrammetric Engineering and Remote Sensing, 62(4), 401–407https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.9979&rep=rep1&type=pdf
27. Sunitha A ,Suresh,B (2015) . Satellite Image Classification Methods and Techniques: A Review. International Journal of Computer Applications (0975 – 8887) Volume 119 – No.8
28. Théodore ,K .,Olivier F., Marie-So., Vincent T. (2012) ,Extraction of structural lineaments from satellite images in precambrian metamorphic hard-rocks and extraction –induced estimation bias , , Revue Télédétection, 2012, vol. 10, n° 4, p. 161-178. HAL Id: hal-01948904 https://hal.archives-ouvertes.fr/hal-01948904
29. Thériault, M., Sparfel,L.,Gourmelon, F., Le Berre, I. (2011). Modeling of changes in land use and occupation.Formal frameworks and application example. International Journal of Geomantic, 21(3), 267 295.https://doi.org/10.3166/rig.15.267-295
30. UNFPA (2007) United National Population Fund http://www.unfpa.org/
31. V.Vapnik (1995). "The nature of statistical learning theory". Springer-Verlag, New York, USA, 1995.
Zidelmal,Z.,Amirou, A., Amirou, M., Djeddi, N., Djouaher (2007) "Application of SVMs based on the SMO algorithm for the detection of cardiac anomalies", 4th International Conference: Sciences of Electronics, Information Technologies and Telecommunications. March 25-29, 2007, Tunisia.

Citation: **Akila Melal, Rabah Bouha*ta, et al*.** *Contribution of Remote Sensing in the Diachronic Monitoring and Analysis of the Urban Sprawl Phenomenon of Setif City (North-East Algeria). Int J Innov Stud Sociol Humanities. 2023;8(1): 112-121. DOI: https://doi.org/10.20431/2456-4931.080111.*