Acta Geographica Silesiana, 17/1 (49)
INoZ UŚ, Sosnowiec, 2023, s. 5–18

ISSN 1897–5100

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Diachronic evolution of the urban space of Guelma by supervised classification of multispectral images

Boulahia L. **Diachroniczna ewolucja przestrzeni miejskiej Guelmy poprzez nadzorowaną klasyfikację obrazów wielospektralnych**. Celem niniejszej pracy badawczej jest dokonanie analizy ewolucji użytkowania ziemi regionu Guelma w północno-wschodniej Algierii w okresie 40 lat. Techniki teledetekcji przestrzennej związane z systemami informacji geograficznej (GIS) są niezbędne do ułatwienia diachronicznej analizy użytkowania gruntów w naszym regionie, poprzez zastosowanie nadzorowanej klasyfikacji z algorytmem największego prawdopodobieństwa i metodą porównań diachronicznych.

Uzyskane wyniki pozwoliły zidentyfikować i scharakteryzować przestrzenno-czasowe zmiany użytkowania ziemi w czasie 40 lat (1980–2020) na podstawie analizy obrazów wielospektralnych: scen Landsat (MSS 1980, ETM 1999 i OLI 2020) oraz weryfikacji terenowej.

Uzyskane informacje wskazują, że w latach 1980–2020 istniało ujemne tempo zmian roślinności rzędu -34,10%, -34,33% w obszarze wodnym i -25,77% na gruntach rolnych. Z kolei obszary zurbanizowane powiększyły się w ciągu 40 lat o 195,60%.

Analiza zmian użytkowania gruntów wykazała generalnie, że badany obszar uległ znacznej transformacji, związanej głównie z oddziaływaniami antropogenicznymi i presją demograficzną.

Боулахиа *Л.* ***Диахроническая эволюция городского пространства г. Гуэльма путем контролируемой классификации мультиспектральных изображений***. Целью данной исследовательской работы является анализ эволюции землепользования региона Гуэльма на северо-востоке Алжира за 40 лет. Методы пространственного дистанционного зондирования, связанные с географическими информационными системами (ГИС), необходимы для облегчения диахронического анализа землепользования в нашем изучаемом регионе с использованием контролируемой классификации с алгоритмом максимального правдоподобия и методом диахронического сравнения.

Полученные результаты позволили выявить и охарактеризовать пространственно-временную эволюцию землепользования за сорокалетний период (с 1980 по 2020 г.) на основании обработки набора мультиспектральных изображений: сцены Landsat (MSS 1980, ETM 1999 и OLI 2020 г.) и проверочных полевых наблюдений.

По полученным результатам в период с 1980 по 2020 год имели место отрицательные темпы изменения растительности: -34,10%, -34,33% на акватории и -25,77% на сельскохозяйственных угодьях. В свою очередь, площадь урбанизированных территорий увеличилась за 40 лет на 195,60%.

Анализ изменений землепользования в целом показал, что изучаемая территория претерпела значительные преобразования, связанные в основном с антропогенными нарушениями и демографической нагрузкой.

Boulahia L. **Altatawur ghayr almutazamin lilfada' alhadarii liqalimat min khilal altasnif alkhadie lil'iishraf lilsuwar mutaeadidat al'atyafi.** Alhadaf min hadha aleamal albahthii hu 'iijra' tahlil litatawur aistikhdam al'aradi fi mintaqat Guelma fi shamal sharq aljazayir ealaa madaa 40 eaman. taqniaat alaistishear ean bued almakaniat almurtabitat binuzm almaelumat aljughrafia (GIS) daruriat litashil altahlil ghayr almutazamin liaistikhdam al'aradi fi mintaqat dirasatina, biaistikhdam altasnif alkhadie lil'iishraf mae khawarizmiat alaihtimaliat alquswaa watariqat almuqaranat ghayr almutazaminati.samahat alnatayij alati tama alhusul ealayha bitahdid watawsif altatawur almakanii walzamanii liaistikhdam al'aradi ealaa madaa 'arbaein eaman bayn (1980 w 2020), walati tama min khilaliha muealajat majmueat min alsuwar mutaeadidat al'atyafi: mashahid liandisat (MSS 1980، ETM 1999 w OLI 2020) ، 'akmilatuh baeathat altahaquq ealaa al'arda. bayn eami 1980 w 2020, 'asharat alnatayij 'iilaa mueadal tugh ayur salbiin fi alghita' alnabatii binisbat -34,10%, -34.33% fi misahat almiah w -25.77% lil'aradi alziraeiati. min nahiat 'ukhraa, sajalat almanatiq alhadariat ziadatan fi altaghtiat binisbat 195.60% khilal 40 eaman. 'azhar tahlil altaghayur fi aistikh dam al'aradi bishakl eamin 'ana mintaqat aldirasat qad khadaeat litahawul kabir murtabit bishakl 'asasiin bialaidtirabat albashariat waldaght aldiymughrafi.

Key words: remote sensing, geographic information systems (GIS), Guelma, multispectral images, land cover change

Słowa kluczowe: teledetekcja, systemy informacji geograficznej (GIS), Guelma, obrazy multispektralne, zmiana pokrycia terenu

Ключевые слова: дистанционное зондирование, геоинформационные системы (ГИС), Гуэльма, мультиспектральные изображения, изменение земного покрова

Alkalimat almuftahiatu: aliastishear ean bued, nazm almaelumat aljughrafia (GIS), Guelma, mutaea did al'atyaf, tughayir alghita' al'ardi

Abstract

The objective of this research work is to make an analysis of the evolution of the land use of the region of Guelma in North East Algeria over a period of 40 years. Spatial remote sensing techniques associated with geographic information systems (GIS) are necessary to facilitate the diachronic analysis of land use in our study region, by using the supervised classification with the maximum likelihood algorithm and the diachronic comparison method.

The results obtained, allowed to identify and characterize the spatio-temporal evolution of land use over a period of forty years between (1980 and 2020), from which a set of multispectral images was processed: Landsat scenes (MSS 1980, ETM 1999 and OLI 2020), completed by verification missions on the ground.

Between 1980 and 2020, the results indicate a negative vegetation change rate of -34.10%, -34.33% in water area and -25.77% for agricultural land. On the other hand, urbanized areas recorded an increase in coverage of 195.60% in 40 years.

The analysis of land use change has shown in general that the study area has undergone a significant transformation linked mainly to anthropogenic disturbances and demographic pressure.

Introduction

A country essentially rural during the colonial period (1830–1962), which will know a process of urbanization upsetting which will transform a great part of the Algerian space during independence. The country was less urbanized than Morocco and Tunisia, but the war of national

liberation had accelerated this process, as the rate of urbanization rose from 13.9% in 1886 to 25% in 1954 (KATEB, 2003).

In the 1998, there was a reversal of the situation, the Algerian population became predominantly urban (58%), in the same year this proportion was 44.8% in Morocco, 56.7% in Tunisia, 46% in Egypt, 23% in Nigeria and 51% in Iran (CHADLI, HADJIEDJ, 2003). The Algerian population has increased in 50 years from 12 to 40 million inhabitants between 1966 and 2015, with an average growth rate of 2% (*ONS*, 2011).

From this situation, it seems necessary to recall some criteria related to types of Algerian cities; according to M. CÔTE (2005), there are four: port cities determined by their function and not by the coastline, inland cities of ancient origins (eg Tlemcen and Constantine), inland cities of colonial origin (eg Sidi Bel Abbes, Setif, Guelma and Souk Ahras) and Saharan cities (eg Ghardaia, Touggourt, Al Oued and Biskra).

Taking the city of Guelma is an example of the third type, the capital of the "Wilaya" that bears the same name, has experienced since its existence, developments that have cost the consumption of a large part of its agricultural space and have generated several problems due to the lack of rational urban planning. Its population is estimated at 157,315 inhabitants, for a density of 3,157 inhabitants/km², or nearly 30% of the population of the "Wilaya" (518,918 inhabitants) (*DPAT*, 2019).

In the same context, spatial remote sensing data in connection with geographic information systems (GIS) are one of the most important sources for the study of spatial and temporal changes of land use in a given space. "Remote sensing offers several advantages over conventional ground methods used to map and monitor urban growth" (BADLANI et al., 2017).

They allow the mapping of landscape changes, giving an effective support for planning and sustainable management of the environment. It is a tool for decision support. "They are able to manage integrated information, with multiple dimensions, representing complex areas, in addition to being able to model planning scenarios" (PREVIL, THÉRIAULT, ROUFFIGNAT, 2003).

This article aims to map the urban morphology of the city of Guelma, through the evolution of land use; based on the diachronic analysis of Landsat images for the dates 1980, 1999 and 2020, for which we have approximate information regarding the population. "The availability of time series dataset is essential to understand and monitor the urban expansion process, in order to characterise and locate the evolution trends at a detailed level" (FICHERA et al., 2012, p1).

During the last decades, a good number of works were realized on the diachronic evolution of the urban area in Algeria among them we can mention (BOUZEKRI, BENMESSAOUD, 2014; BENYAHIA, DRIDI, 2017; BOUACHA, MAATOUG, KHARYTONOVA, 2018; SMAHI, RAMOUN, 2019; DJAKJAK et al., 2020).

Area of study

Created in 1974, the "Wilaya" of Guelma is located in the north-east of Algeria, limited in the north by the plains of the Oued Seybousse, in the south by Djebel Haloufa at 950 m a.s.l. of altitudes, in the west by the high plains of the Seybousse and in the east by the plains of the valley of the Seybousse. It constitutes a crossroads between the "Wilaya"s of the north (Annaba – Skikda) and those of the south (Oum-El-Bouaghi and Tébessa), connecting several national roads (RN20, RN80).

The territory of the "Wilaya" highlights four regions: the region of Guelma, that of Bouchegouf, that of Oued Zénati and that of Tamlouka. The region of Guelma includes the entire median part of the north to the south of the territory of the "Wilaya". It is formed by the chief town of the "Wilaya" and the small towns and villages

nearby, that of Belkhir, Heliopolis, El Fedjoudj, Boumahara and Ben Djerah (Fig. 1).

The prevailing climate is sub-humid in the center and north and semi-arid towards the south, quite favorable to agricultural and livestock activities. The relief of the "Wilaya" is broken down into 37.82% of mountains, the main ones are: Mahouna (Ben Djerrah): 1,397 m a.s.l. altitude, Houara (Ain Ben Beidha): 1,292 m altitude, Taya (Bouhamdane): 1,208 m altitude and D'bagh (Hammam Debagh): 1,060 m altitude. The plains and plateaus represent 27.22%, hills and foothills – 26.29% and 8.67% others (*DPAT*, 2019).

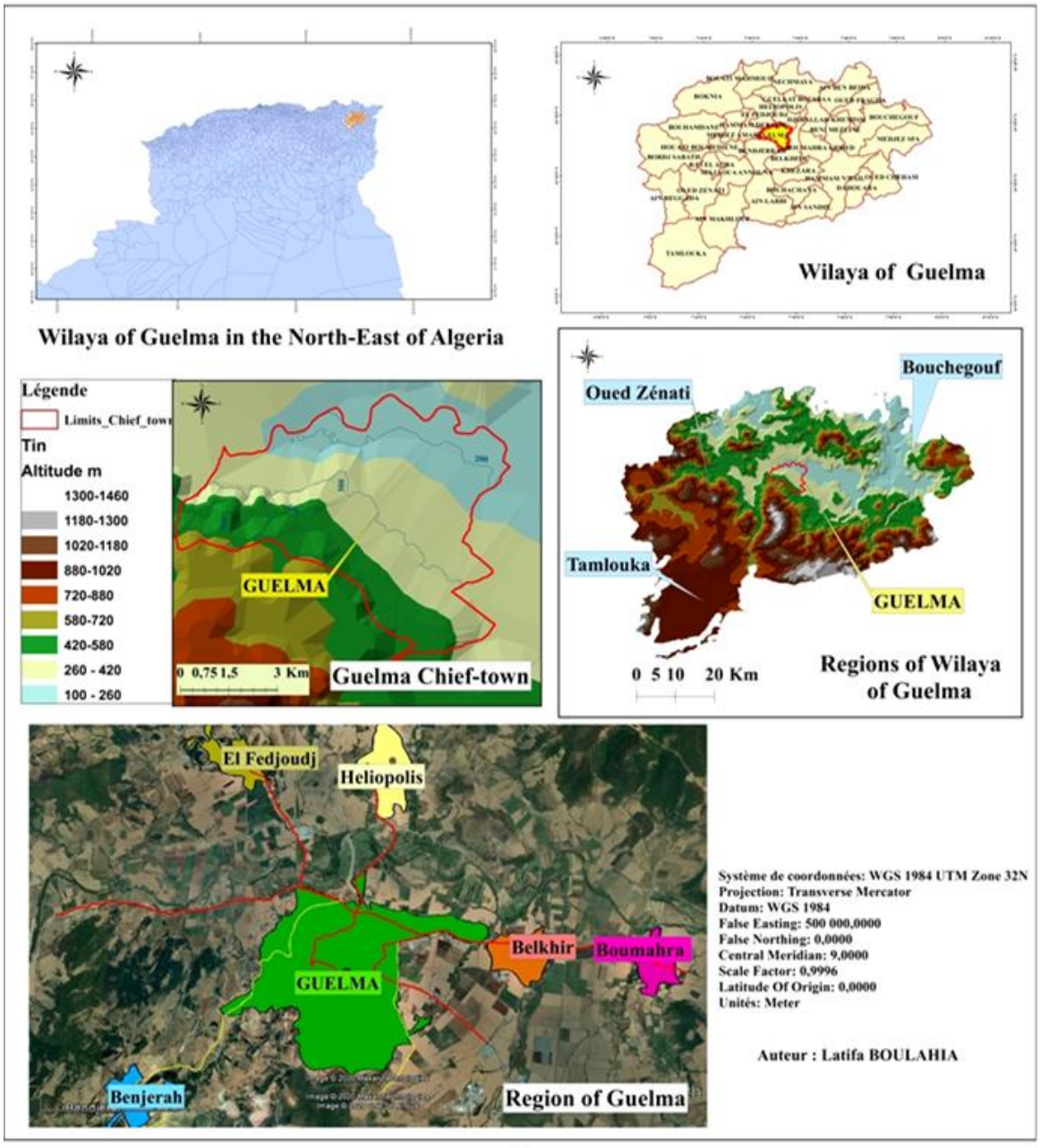

Fig. 1. Localisation of Guelma
Rys. 1. Położenie m. Guelma
Рис. 1. Местоположение г. Гуэльма

It is also characterized by an important forest cover in the north and east. The main forests are those of Beni Salah: national cork reserve (12,745 ha), that of Mahouna with a recreational vocation covering 1,035 ha, the forest of Houara with an area of 2,374 ha and that of Beni Medjaled in Bouhamdane with 3,506 ha. On the other hand, the southern part suffers from lack of vegetation, despite its mountainous character where a great vulnerability to erosion. As for the rivers, the Seybousse passage in the north, represents the most important wadi in the region, next to Oued Bouhamdène, Oued Mellah and Oued Charef.

Materials and methods

The methodology adopted for this work, consists of two main steps, the first is summarized in the acquisition and processing of satellite images and the second is to perform supervised classification on the images processed in the first step. These operations allowed us not only to operate in a georeferenced environment, but also to use images with no visual defects (DJAKJAK et al., 2020). Thus, these classified images will undergo a Post-classification, and then they will be exploited through a GIS, whose purpose is to analyze the evolution in time and space of the urbanization process in our study area (Fig. 2).

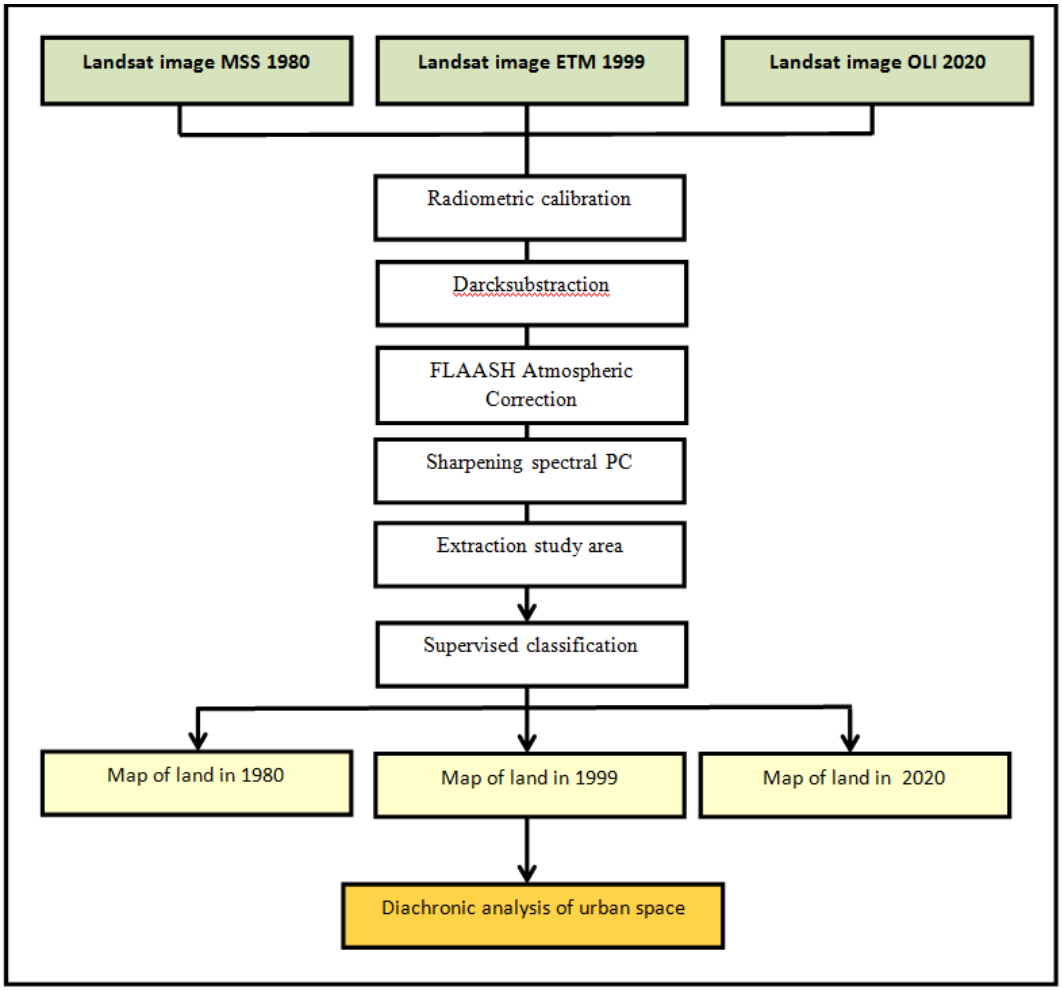

Fig. 2. Methodological flowchart
Rys. 2. Schemat metodologiczny
Рис. 2. Методологическая схема

Image preprocessing process

The image pre-processing is an essential step that aims to obtain good values of the energy reflected or emitted on any point of the Earth's surface.

The most common treatments are geometric correction, radiometric correction and atmospheric correction.

Geometric correction was done by selecting reference points. The geometric correction is validated once the root means square error isless than or equal to 0.5 pixel (BOUACHA, MAATOUG, KHARYTONOVA, 2018).

The selection of images in our study area was made between a period of June and August. The data that have just been stored in an image obtained by means of an optical sensor, are digital level values.

These digital values do not represent in a direct way any biophysical values; therefore we will not be able to obtain any spectral index from these raw values

The reason for not doing so is very simple: what we call "spectral indices" was developed to work with the spectral reflectance values of the Earth's surface and the raw numerical values do not provide this information. It is therefore necessary to convert them into reflectance values. This process is performed in two steps: the radiometric calibration and the atmospheric correction.

Using spectral sharpening (PC spectral sharpening) to sharpen a low spatial resolution multiband image using a high spatial resolution panchromatic band (DERDJINI, 2017). Once the corrections are complete, a trimming according to the boundaries of the study area is performed to fit the size of the selected region. The reduction was done using the administrative boundary vector file which is in Shape format (ESRI vector format) (Tab.1).

Table 1. Characteristics of the satellite scenes used from the Landsat series
Tabela 1. Charakterystyka scen satelitarnych z serii Landsat
Таблица 1. Характеристика спутниковых сцен из серии Landsat

Satellites data	Dated	Resolutions	Source
		Spatiale	
Landsat 3 MSS WRS_PATH = 193 WRS_ROW = 35	1980-06-13	60 x 60 m for all bandes	https://earthexplorer.usgs.gov/
Landsat 7 ETM WRS_PATH = 193 WRS_ROW = 35	1999-07-11	30 x 30 m for all bands except band 8 which has 15 x 15 m resolution	https://earthexplorer.usgs.gov/
Landsat 8 Oli WRS_PATH = 193 WRS_ROW = 35	2020-07-12	30 x 30 m for all bands except band 8 which has 15 x 15 m resolution	https://earthexplorer.usgs.gov/
Pre-processing	Radiometric calibration +Darcksubstraction+ FLAASH Atmospheric Correction+ Sharpening spectral PC Division according to the dimensions of the study area		

Supervised processing and classification

To determine the diachronic evolution of land use in the Guelma region, we opted for supervised classification by image comparison, which consists of interpreting a multi-temporal series of satellite images and then comparing the areas assign to each spectral class an information class, which are pixels related to the features that we seek to demonstrate in the image (CHERELL, 2010).

We must first identify regions of interest (Kings), select samples of formations that are deemed representative of the classes to which we want to assign them (e.g., habitat, vegetation, water, bare soil, etc.).

This formula assumes that we have prior knowledge of our study area. Then, apply a most common classification algorithm (Maximum Likelihood) which, according to a number of statistical rules, will assign each pixel of the image to a defined class (MIDEKOR, WELLENS, 2013).

This method requires that the same classification system be applied for each of the selected images. Thus, the 1980, 1999 and 2020 Landsat images were classified on the same methodological basis. The supervised classification was performed using ENVI 5.3 software. Afterwards, the data were integrated into the GIS for the realization of the maps (ArcGis for desktop software with version 10.8.1).

The first, we used multi-spectral composite images that assemble the different bands of the image in order to visualize them based on the spectral characteristics of the landsat sensor bands (SMAHI, RAMOUN, 2019).

For the Landsat 3 (1980) scene, we used a color composition of "3-2-1", for the Landsat 7 (1999) scene, we used the combination of bands "4-3-2" and for the Landsat 8 (2020) scene, we used the combination of bands (5-4-3) (DJAGNIKPO KPEDENOU et al., 2016).

The thematic layer information for each image was exported from the attribute tables. We used the symbology of the respective colors of the different elements of the land use present in our terrain. Then the land use maps of 1980, 1999 and 2020 of the urban space of Guelma were realized.

Results and discussions

Urban growth of the city of Guelma

The urban evolution of the city of Guelma is characterized, like all Algerian cities, by three important periods of urbanization: pre-colonial, colonial and post-colonial.

The city center of Guelma developed around the old colonial core, with an orthogonal layout, housing small businesses. The first extensions were from 1850 to 1914, to the north of the current city center by the districts of the station and the former slaughterhouse. Between 1918 and 1939, new districts appeared in the eastern and southern parts of the city, such as “Bon Accueil” and “Les Jardins” (*DUC*, 2016).

In 1931, the arrondissement of Guelma had 10,400 French citizens, 162,941 French subjects (Algerians) and 2,037 foreigners, making a total population of 176,757 inhabitants on an area of 444,201 ha. Since the Senatus Consulate of 1863, if Algerians are considered French, they do not have for the majority the same rights as the French: they are subjects and not citizens) (BOUCHAREB, 2006).

In 1954, following the outbreak of the national revolution, the application of the resettlement policy had given birth to the district of Ain Defla (El Hafsi currently, in the west of the city). During this period, illegal constructions were installed on the banks of Oued Sekhoun, by rural populations who flocked to the chief town in search of security following the scorched earth policy, cantonment, exclusion and dispossession of the natives from their land (BENZERARI, 2013).

During independence, promulgated by Ordinance 74-69 of July 2, 1974 on the recasting of the territorial organization of "Wilaya", Guelma has experienced an accelerated growth in urbanization, following its promotion to the rank of chief town of "Wilaya". The second four-year plan of 1974/1977, saw the promulgation of three laws relating to urban planning: the law of land reserves in 1974, the law of building and subdivision permits in 1975, the law of real estate cooperatives in 1976 and the law 76/48 of 25/05/1976 which determines the expropriation of property for public utility.

Article 10 of Ordinance 74-26 of February 20, 1974, indicates the constitution of communal land reserves intended to serve as a basis for investments of any kind by the State, public communities and local authorities. Thus, following the example of the agrarian revolution, a communal land reserve fund was created belonging to private individuals it was transferred by the declaration of public utility with prior compensation, which facilitated the realization of major projects of public interest, housing estates, ZHUNs and socialist villages.

To ensure a harmonious organization and better management of space, several studies have been launched in the "Wilaya" of Guelma among which the development plan of the "Wilaya" (P.A.W.), a Master Plan of Development and Urbanism (P.D.A.U) and 10 plans of land use.

From the 1980s, in front of the housing crisis that began to be felt, several cities were built, namely: Agabi, Champ manoeuvre, Rahabi, Bara, Ain Defla and Guehdour. A very important housing program was carried out during 1970 and 1986, which was illustrated by the creation of several ZHUN (Zone d'Habitat Urbaine Nouvelle), such as the city of Fougerolles (Ain Defla), Brothers Rehabi, city Guehdour, city Bara Ali, city Emir Abdelkader etc. (*DUC*, 2016).

The consequences of this voluntarist policy have led to: the increase of spontaneous housing, the extension on agricultural land (Cité frères Rehabi) and the irrational extension of the peripheries, favored by the ordinance of land reserves for each municipality within the master plan of urbanism (PUD).

In summary, the period from 1858 to 1963, the expansion of the city was made towards the east. Between 1963 and 1977, the growth of the city took place towards the north and the east by the establishment of industrial units (in 1970 ceramics, motorcycles 1971, sugar factory in 1973) towards the east. Between 1977 and 1987, a development of the city was made towards the west and the south-west, especially the creation of the university of 08 May 1945.

Since 1987 to the present day, a remarkable extension has been developed towards the south, namely the appearance of the Oued El-Maiz neighborhoods in collective housing and Ain Defla in the north in individual housing. The period from 1990 to 2006, was characterized by an excessive urbanization in terms of collective housing and especially individual localized in the various subdivisions (Fig. 3).

Analysis of the evolution of land use in the urban space of Guelma

The classification of Landsat images has allowed us to produce three land use maps with 4 classes each (Tab. 2).

Afterwards, we calculated the areas of the land use units in order to evaluate the changes that occurred in each selected year. The confusion matrix will be able to give us the global result of the classification (TRAORE et al., 2020).

The overall rates of change and the areas of land use classes between the years 1980 and 2020 were calculated through the equation proposed by FAO (1996) (MAMA, OLOUKOI, 2003). "Positive values represent an increase in the area of the class during the period analyzed, while ne-

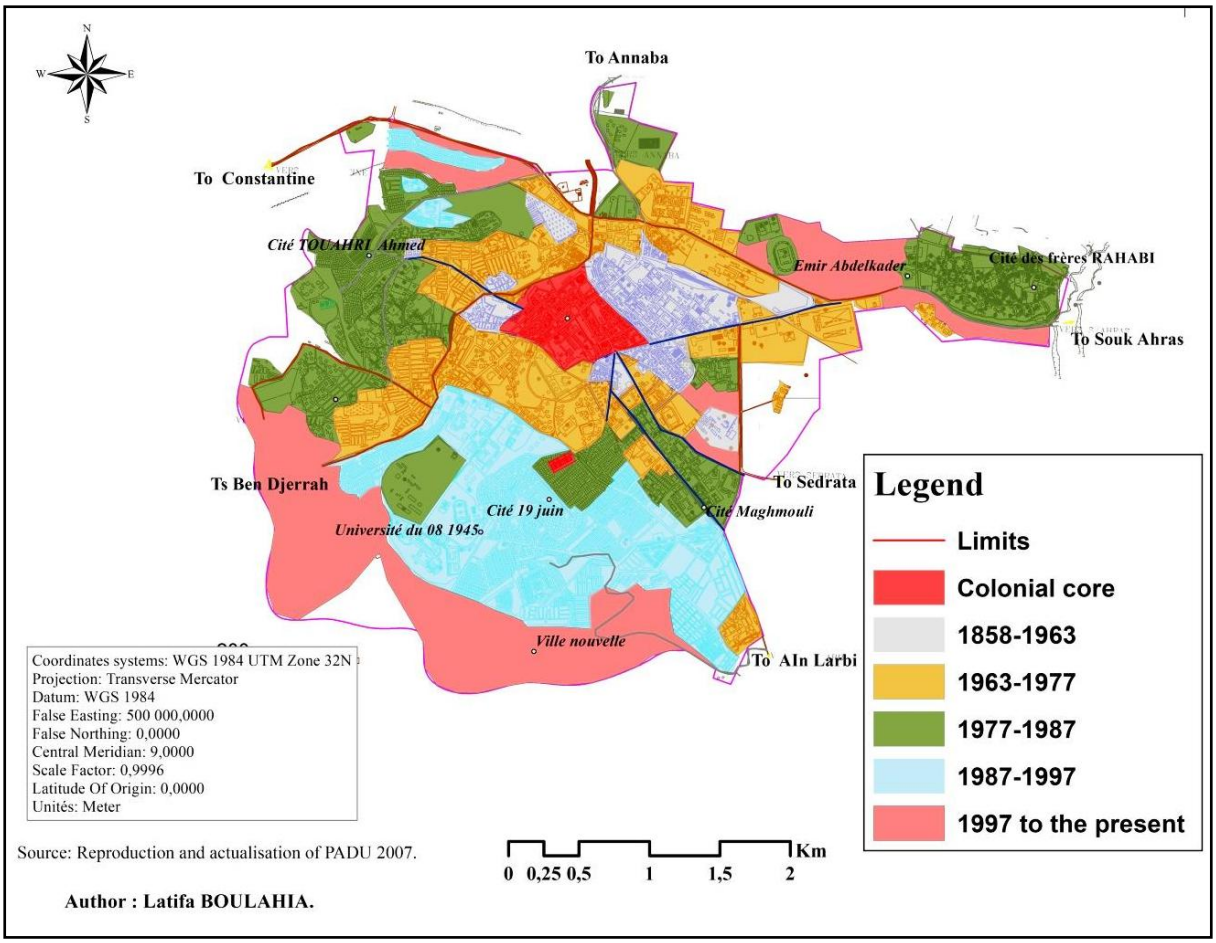

Fig. 3. Urban evolution of the city of Guelma
Rys. 3. Zmiany obszaru miasta Guelma
Рис. 3. Изменения территории г. Гуэльма

Table 2. The classes retained for the classification
Tabela 2. Klasy użytkowania gruntów użyte do klasyfikacji
Таблица 2. Типы использования земли примененные для классификации

Class	Designation	Description
1	Vegetation	Dense forests and clear forests
2	Water	Bringing together rivers and hill reservoirs, are identifiable by their light blue color. Joining this category is an important drainage network.
3	Roads, hosing and bare soil	Areas of housing and human settlements generally comprising portions of vegetation between the buildings and the bare ground.
4	Farm Land	It is an area formed by fields of cultivation in the form of mosaics and geometric figures. Vegetable crops are found to the north of the city and cereal crops all around.

gative values indicate the loss of area of a class between the two dates.

As for values close to zero, they express a relative stability of the class between the two periods." (Idem).

$$Tg = (S2-S1/S1) \times 100$$

Tg – Global Change Rate
S1 – The area of unit class at date T1
S2 – The area of the same area unit class at date T2

The analysis of the evolution of land use from Landsat images allowed us to detect the changes that occurred in the urban space of Guelma during the study period. This analysis was carried out on the basis of statistical data on the rates of change of land use entities between successively 1980, 1999 and 2020 (Tab. 3).

Table 3. Change of land use in the urban space of Guelma in 1980, 1999 and 2020
Tabela 3. Zmiany użytkowania ziemi w m. Guelma w okresie 1980, 1999 i 2020
Таблица 3. Изменения использования земли г. Гуэльма в 1980, 1999, 2020 гг.

Class	1980		1999		Tg 99/80	2020		Tg 20/99	Tg 20/80
	Area (ha)	%	Area (ha)	%	%	Area (ha)	%	%	%
Vegetation	328	8	304	7	-7,48	216	5	-28,77	-34,10
Water	464	11	333	8	-28,19	305	7	-8,56	-34,33
Roads, hosing and bare soil	539	12	950	22	76,29	1 593	36	67,68	195,60
Farm Land	3 043	70	2 786	64	-8,45	2 259	52	-18,92	-25,77
Total	4 373	100	4 373	100		4 373	100		

The study area covers an area of 4,373 ha. The 1980 land use map shows a vegetation cover of 328 ha, or 8% of the total area. The residential area and bare soil, would cover only 539 ha or 10% of the total area of the study area.

The agricultural land occupied an area of 3,043 ha, or 83% of the total area studied, they were spread around the city. As for the water class, it covered 464 ha, or 11% of the total. It can be said that in 1980, the city of Guelma was not undergoing a major change, as the area's production systems were in the process of being modified.

In 1999, almost twenty years later, we notice that the area of vegetation cover has not changed much, still accounting for 7% of the total area. On the other hand, the inhabited area has experienced a remarkable increase compared to the previous period, reaching 945 ha, i.e. 22% of the total area of the territory with an overall rate of change between 1980 and 1999 of 76.29%.

This explains that the area of agricultural land has become 2,786 ha, or 64% of the total, so it has

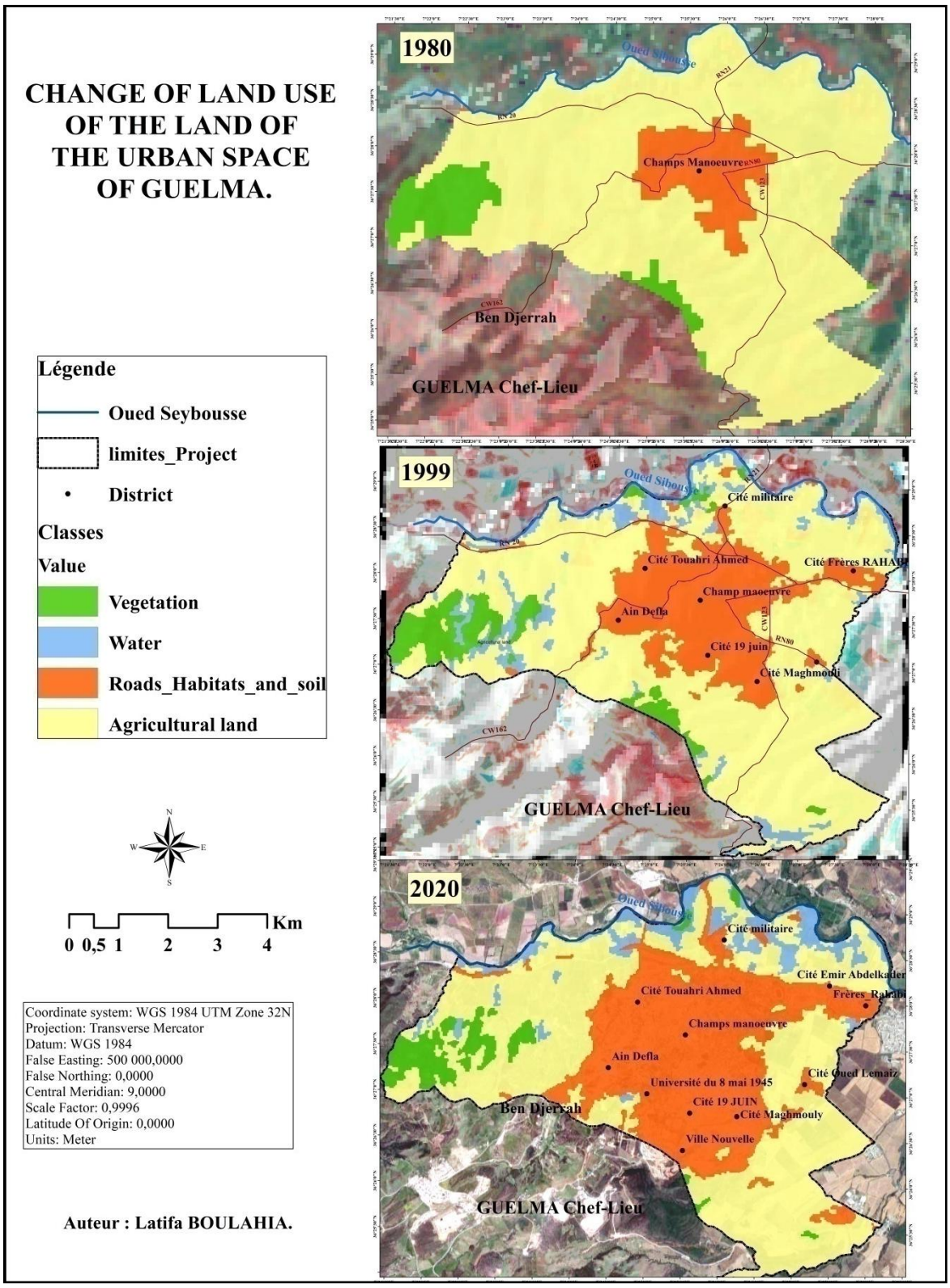

Fig. 4. Land occupation in Guelma in 1980, 1999 and 2020
Rys. 4. Użytkowanie gruntów w m Guelma w latach 1980, 1999 i 2020
Рис. 4. Землепользование на территории г. Гуэльма в 1980, 1999 и 2020 гг.

experienced a shrinkage of -8.45% for the same period.

In 2020, the greatest loss of area is recorded in the vegetation unit, which has continued to decline. The area of vegetation cover has gradually decreased to 216 ha, or 5% of the area of the entire study area thus with a rate of change of -34.10% between 1980 and 2020. Agricultural areas have also been reduced, with an area of 2,577 ha or 52% of the overall area studied.

It has recorded an overall rate of change between 1980 and 2020 of -25.77%. This decrease is explained by the expansion of the city. The inhabited areas are expanding from 432 ha in 1980 to 1,593 ha in 2020, or 36% of the overall area studied. The rate of change recorded for this class reached 195.60% (Fig. 4).

Conclusion

The objective of this research is to address the changes in land use in the city of Guelma through Landsat satellite images of different generations during distinct periods, including 1980, 1999 and 2020.

Before proceeding to the supervised classification by the "Maximum Likelihood" algorithm, the images underwent a preliminary pre-processing to remove radiometric and atmospheric distortions, then an enhancement of the image quality through the "Pansharpening" algorithm to increase the resolution of the image to 15 m across the panchromatic band and to make at the end a "Resize data" to cut out the studied area.

Classification is an essential step in any satellite image processing. However, supervised classification remains complex and uncertain and requires prior knowledge of the terrain. To get reliable results, it is necessary to go through specific steps, because it is based on statistical formulas above all.

Once the results are obtained, a post classification is necessary to bring more precision to the generated images (majority filter, smoothing of class boundaries, generalization of the output by removing small isolated regions, etc.). Despite this, the results deserve a much more quantitative than qualitative evaluation.

The low spatial resolution (60 m) of the 1980 image (those of 1999 and 2020 have undergone quality enhancements of 15 m), these images have allowed to identify the general trend of land use dynamics of the urban space of Guelma.

This trend reveals the increase in inhabited areas to the detriment of the agricultural land surrounding the city as well as in the spaces of the neighboring villages. This dynamic is the consequence of the increase in population which has generated a growth in the built environment that shows a strong urban development of the city.

Glossary:

- Wilaya: Department
  ZHUNs: New urban hosing zones in Algeria.

Conflicts of interest

– The author declare no conflicts of interest.

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Received: 15 October 2022
Wpłynął do redakcji: 15 października 2022
Поступила в редакцию: 15 октября 2022