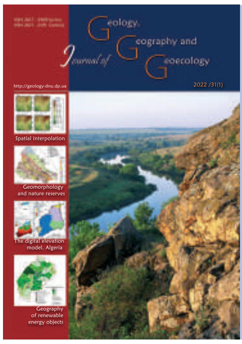

Journal of Geology, Geography and Geoecology

Journal home page: geology-dnu.dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ. Geol. Geograph. Geology, 31(1), 31–44.

doi: 10.15421/112204

Urban sprawl and expansion of road networks and its impacts on the environment using sensor and socio-economic data: Macta watershed, western Algeria

Mohammed Belkebir Hamza[1& 3], Ayache Abbassia[1&3*], Benyahia Mohammed[2&3]

[1]*Biodiversiy vegetale, conservation and valorisation research laboratory*
[2]*Ecodevelopment of spaces research laboratory*
[3]*Djillali Liabes University, Sidi Bel-Abbes, Algeria*
**Corresponding author email:* abayache4@gmail.com

Received: 06.03.2021
Received in revised form: 24.08.2021
Accepted: 02.11.2021

Abstract. Urban sprawl and the road networks have profoundly modified the space of the Macta watershed in western Algeria. The fragmentation of the landscape within this territory is gradually changing in order to meet different socio-economic needs. Damage to natural environments caused by pollution, business development, management of agricultural land and spatial modification of the morphology of urban constructions are remarkable. Our research is part of a complex study of the rate of evolution of urban sprawl and road networks expansion from 1987 to 2018; to better understand the issues of human activities and their impacts on the environment. The methodology adopted consists of using Landsat and Google-Pro images. Their capabilities enable us to trace the influence of human activities in time and space on the environment. The results obtained show a weak trend in urban sprawl during the period 1987/1998, while it reaches significant levels in the years 2010 and 2018. The distribution of the surface area occupied by towns and cities during this study period shows a concentration of the population in the major provinces. In addition, the extension of the East-West motorway shows a weak trend in 2018. The lengths of the roads built are significant and show a 50% growth rate. The digital analysis using sensor data has an important advantage in detecting the evolution and progression of the spaces occupied by urbanization and road networks in the Macta watershed over 31 years, which has been marked by intense demographic growth.

Keys words: urban sprawl, roads networks, remote sensing, expansion, impacts, Macta watershed

Розбудова міст та розвиток мереж доріг та їх вплив на навколишнє середовище за допомогою датчиків та соціально-економічних даних: вододіл Макта на захід від Алжиру

Мохаммед Белкебір Хамза[1&3], Айяче Аббасія[1&3*], Беніахія Мохамед[2&3]

[1]*Лабораторія вегетативного біорізноманіття, консервації та валоризації*
[2]*Лабораторія екологічного розвитку космічних досліджень*
[3]*Університет Сиди-Бель-Аббеса, Сиди-Бель-Аббес, Алжир,* *abayache4@gmail.com

Анотація. Розростання міст та дорожньої мережі глибоко змінюють простір водозбору Макта на заході Алжиру. Фрагментація ландшафту на цій території поступово змінюється за рахунок задоволення різних соціально-економічних потреб. Загрози природному середовища, такі як забруднення, підприємництво, управління сільськогосподарськими угіддями та просторова модифікація морфології міських споруд є надзвичайними. Наш діагноз є складовою частиною визначення швидкості розвитку міської агломерації та дорожньої мережі, встановлених з 1987 по 2018 рік; краще зрозуміти значення людської діяльності та її вплив на навколишнє середовище. Прийнята методологія полягає у використанні даних датчиків Landsat та Google-Pro. Їхні можливості дозволяють нам стежити за впливом людської діяльності в часі та просторі на навколишнє середовище. Отримані результати показують слабку тенденцію до розростання міст у період 1987/1998 рр., В той час як вона досягає значних рівнів у 2010 та 2018 рр. Розподіл площі поверхні, зайнятої містами та містечками протягом цього періоду дослідження, показує концентрацію населення у великих провінціях. Крім того, розширення автомагістралі Схід-Захід демонструє слабку тенденцію у 2018 році. Довжина встановлених доріг значна і демонструє 50% темпів зростання. Цифровий аналіз із використанням датчиків має важливу перевагу у виявленні еволюції та розвитку просторів, зайнятих урбанізацією та дорожніми мережами у вододілі Макти протягом 31 року, що зумовлено інтенсивним демографічним зростанням.

Ключові слова: розростання міст, дорожні мережі, дистанційне зондування, вододіл Макта

Introduction

Urbanization is changing land use in many cities around the world, reducing natural land and increasing areas of impermeable cover (Nga, 2018). This activity has become a recurrent phenomenon (Agbanou, 2015).

In this case; installation of transport infrastructures, industrial evolution, agricultural development, and uncontrolled land uses have been ranked among the most important threats to biodiversity and natural resources due to rapid population growth (Rui Yin, 2019 and Iqbal, 2018).

In Algeria, these activities are influenced by political, socio-economic, ecological and environmental factors which affect the country's dynamics, structures and functions (Avakoudjo, 2015 and Gomesa, 2019). The increase in impermeable cover in urban and rural areas inevitably leads to a reduction in soil fertility, which directly affects plant growth, and a significant reduction in the some populations of plants, even to the point of extinction, changes in river morphology, sedimentation, water quality and volume (Stambouli, 2012 and Tiwari, 2018). Understanding the impacts of urbanization on climate and land use is necessary for the optimal management of natural resources (Atchade, 2015).

Remote sensing is seen as a very effective and rapid tool for monitoring and examining the changes in land use/land cover imposed on our natural environment by providing a technical basis for numerous studies such as how human activity influences land use and land cover in a more thorough and comprehensive way (Ayache, 2015; Elagouz, 2018; Li, 2017).

The watershed of the Macta in western Algeria is a very large area undergoing major changes. These include agricultural land conversions, urban and road extensions, human settlements and eradication of green spaces. Faced with the problems of urbanization and land use in this region, several research questions need to be asked: does demographic and urban evolution have an impact on land use/land cover? Are the river ecosystems in the Macta watershed affected by this evolution? How can the spatial evolution of the Macta

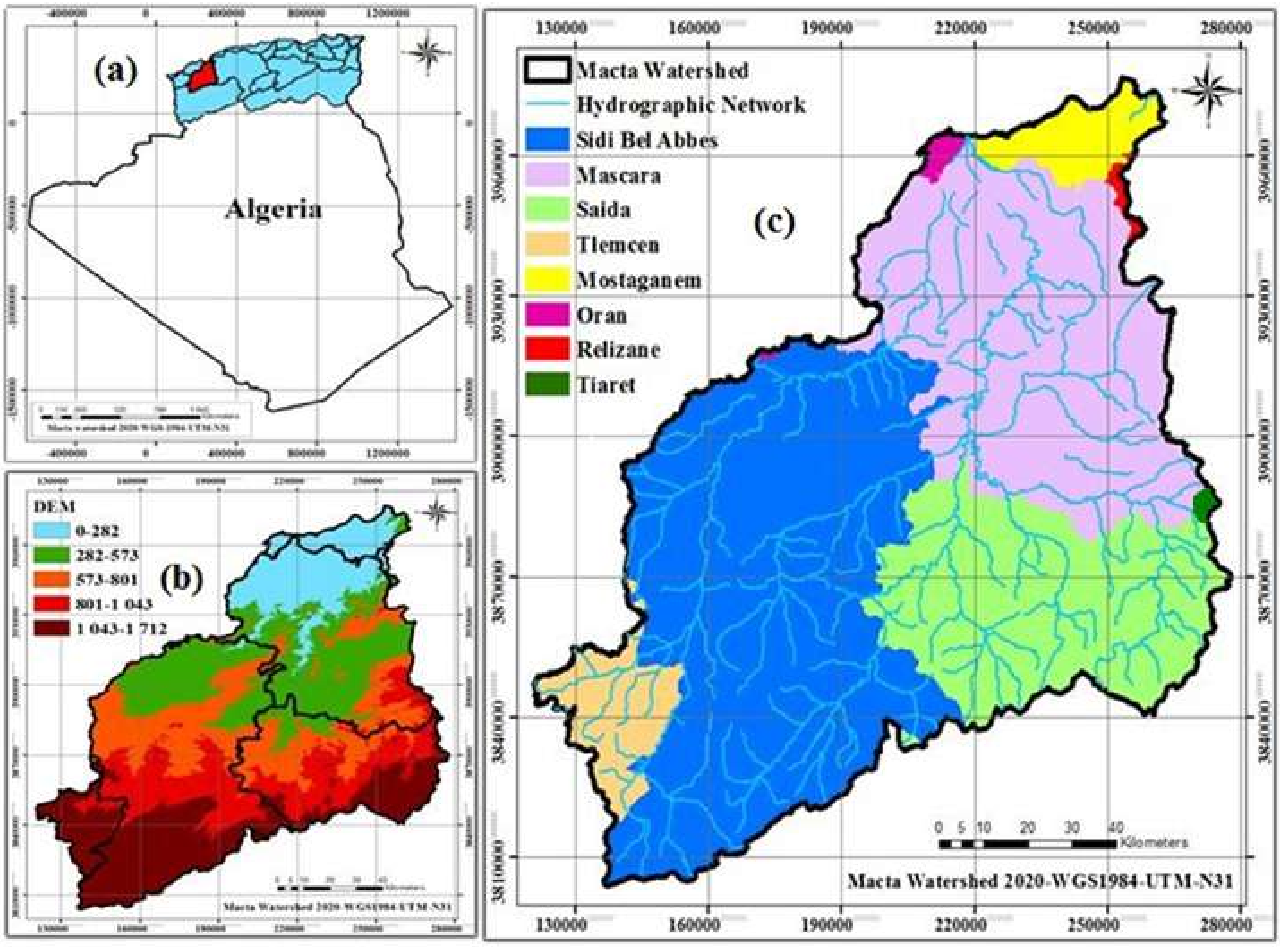

Fig. 1. Localisation of study area: Macta watershed western Algeria (Realized by the authors: *Belkebir H et Ayache A, 2021)*

Legend: (a): Location of the Macta watershed in northern Algeria. (b) The digital elevation model of the Macta watershed, which represents the different altitudes of the study area, ranging from 1712 m maximum to 282m minimum. (c) The limits of the Macta watershed area, which includes eight provinces watershed area be controlled? The main objective of this study is to show the link between urban expansion and the watershed's pollution and degradation, road networks and land use. These activities lead to land degradation and the depletion of natural resources (aquatic and terrestrial ecosystems). It is in this context that our diagnosis is made in order to better understand the impact of human activities and urban dynamics on land use in this area of Western Algeria.

Study area. The Macta watershed is located in the north-west of Algeria. The coordinates of this area according to the UTM projection spindle N31 is 34°18′N to 35°54′N north latitude with a length of approximately 166.76 km, and 1°12′O to 0°34′E longitude with an approximate width of 159.59 km. The surface area is estimated at approximately 14,410 km^2. Most of it is located in the province of Sidi Bel Abbes. It is bounded to the north-west by the Tessala mountain ranges, to the south by the Maalif highlands, to the west by the Telagh plateau and to the east by the Saida Mountains (Elouissi, 2017). It is made up of 16 sub-watersheds and drained by two main rivers: the Oued Mebtouh (Oued Mekerra) in the West, and the Oued El Hammam in the east (Chibane, 2015).In terms of climate, in the north this watershed is subject to a Mediterranean climate, and towards the south a continental trend is asserting itself, which translates into marked aridity, cold winters and particularly hot summers (Tazekrit, 2019).Land use in the Macta area includes agriculture and natural vegetation, the surface area of which has been remarkably degraded in recent decades, mainly due to the action of the climate (drought period) and the increasing anthropozoogenic action on this environment (Sitayeb, 2008).

Table 1. Impact of urban sprawl and road networks on the environment

Type					Description
Positives	Benefits social and economic activities by: improving road safety, meeting traffic demand and transport needs, improving traffic conditions, creating new jobs, developing tourism, etc. (Driss, 2016, Tebani, 2019)				
Negatives	Construction phase	**Soil**	**Degradation**	**Deforestation Erosion Terrain slide**	Because of the consumption of the most profitable and fertile land by earthworks, which causes a reduction in plant cover and the loss of biodiversity, which can be irreversible (Amokrane, 2016).
			Pollution		Washing and spillage of oil from vehicles and construction site machinery could be the cause of possible pollution through the infiltration of toxic products into the soil (Halimi, 2020).
		water			Alteration of riverbeds, increased sediment load, pollution of groundwater by the discharge of construction site water laden with suspended matter, washing of concrete mixers, discharge of concrete waste into watercourses (Hidouci, 2015, Halimi, 2020).
		air			Deforestation and brush clearing for the installation of construction area and the opening of new roads and tracks, increase the particles suspended in the air. Heavy machinery enormously pollutes the atmosphere through the emission of greenhouse gases from fuel combustion and dust (Driss, 2016, Ali, 2018).
		land			Deforestation and changes in land use have contributed to the deterioration of the landscape, which has lost its natural appearance, conversion of land into auxiliary areas for building cities, the presence and circulation of trucks and machinery and the works give the landscape an anthropic form, modification of the natural topography (Amokrane, 2016, Iqbal, 2018).
		Fauna			Fragmentation of the habitat, resulting in the loss of wildlife. Noise and light from the construction sites also affect certain forms of wildlife. Drainage, modification and pollution of surface water cause contamination of aquatic species (Tiwari1, 2018).
		Flora			Disturbances of photosynthesis, respiration and transpiration, as well as affecting the composition and abundance of plant species by the work and circulation of machinery and equipment and their dust (Hartani, 2019, Rahal, 2018).
	Operation phase	**air**			Pollutants released into the air from exhaust fumes. They will be increased in general due to the increase in distances driven and speed of cars (Ali, 2018, Amokrane, 2016).
		water			The infiltration of pollutant-laden runoff into the water table causes groundwater pollution and could generate impacts on groundwater catchments, and risks of changes in their chemical and physical characteristics (Li, 2017, Halimi, 2020).
		Acoustics			By the noise pollution produced by road traffic. According to Algerian regulations (Executive Decree No. 93–184 of 27 July 1993), the maximum permitted noise level is 70 Db during the day (from 6 am to 10 pm) and 45 Db during the night (from 10 pm to 6 am) (Madani, 2012, Amokrane, 2016).
		Agricultural			The loss of crops and farmland. Farms that are on the roadside will suffer from particle pollution and a division of large areas into two parts due to cuts in agricultural space (Gomesa, et al., 2019, Zhonghao, 2016).
		Fauna			Its infrastructures hinder the movement of animals in search of favourable conditions and food, hinder the circulation of species, fragment their territories and reduce exchanges between ecosystems. Increased animal mortality rates due to accidents (Villa, 2015, Iqbal, 2018).
		Soil			The dispersion of the waste thrown away by the passengers (plastic, glass, and paper), the solutions from the settling ponds and de-oilers penetrate the soil and make the affected area uncultivated (Safaei et al., 2019).

The total population of the Macta is 1,428,370 inhabitants (ONS, 2008). It is distributed across 06 provinces counting 106 localities fully integrated into the watershed (Semari, 2016). It is relatively more populated in the north than in the south. Demographic and urban pressure is mainly concentrated in the provinces of Sidi Bel Abbes, Mascara and Saida respectively compared to the other integrated provinces.

Data and Methodology. The three main steps of the study are: identification of anthropogenic activities, extraction of urban areas, road network, and mapping of the evolution between 1987 and 2018. We used remote sensing observation data, which, thanks to their capabilities, allow us to follow the urban evolution in time and space on the agricultural land and vegetation cover of the Macta watershed. In order to achieve the objectives of this work, several types of data were exploited.

Sensor data. For this analysis, the choice of data is based on four criteria: spatial resolution, temporal resolution and coverage. First of all, the images must be of sufficient size to cover the watershed under study. It is therefore preferable to use images such as Landsat's multi-spectral mode images, which have sufficient resolution (30m). Indeed, this resolution is considered acceptable for the methodology adopted in this study to accurately map the contours of large urban units. As the Landsat data is larger than the other types of images (185km/34225km^2), we chose to analyze the Landsat images to reduce the number of data to be processed and to guarantee the homogeneity of the cartographic results. In this way, the entire study area could be covered by a mosaic of four Landsat images. As far as the shooting dates are concerned, four sets of data were chosen: two as old as possible, in 1987 and 1998, and two as recent as possible, in 2010 and 2018. Finally, we have systematically selected the dry season, which generally has a very low rate of cloud and vegetation cover. This choice of image acquisition is best suited to the approach envisaged. The images selected according to these criteria are presented in Table 2.

Table 2. Characteristics of the data used

	Landsat TM5			Landsat OLI8
Path/Row of Data 1: 197/035	12/06/1987	17/06/1998	18/06/2010	17/06/2018
Path/Row of Data 2: 197/036	12/06/1987	17/06/1998	18/06/2010	17/06/2018
Path/Row of Data 3: 198/035	03/06/1987	10/06/1998	27/06/2010	26/06/2018
Path/Row of Data 4: 198/036	19/06/1987	26/06/1998	27/06/2010	26/06/2018

Legend: Area (Km): 185X185, Resolution 30X30m.

Demographic and socio-economic data. A second source of data used to assess demographic change in the watershed area comes from documentary research, mainly the results of the General Population and Housing Census (RGPH, 2018).

Extraction of urban sprawl. Several software packages have been used to process the data, which have multiple functionalities relating to image processing to thematic mapping, and the extraction of the desired information. These are the tools for visualization, pre-processing and processing of sensor data, which have enabled us to carry out vectorization and digitalization operations. Once the image processing is finalized, the different thematic objects have been digitized. Depending on our objective, either closed polygons are used for settlements or polylines for roads. And finally Google Earth Pro, which allows us to see the main geographical and artificial development features such as cities and roads. In this way we have created maps, calculated these areas and drawn up comparison diagrams, so that we can follow the spatial extension and urban development over time (1987–2018), in parallel with population growth.

Extraction of road networks. Since its independence, Algeria has experienced strong population growth, and in order to meet the needs expressed by this population, the development of major road networks is necessary; especially in terms of transport (Driss, 2016).The road network which is part of it represents the majority of the transport sector in Algeria. Land use in the study area is mainly agricultural, and it is not rare to find areas where only agriculture is present on large surfaces (Ouabel, 2012).

The non-agricultural areas are made up of urbanization (buildings, roads, motorways, railways and wooded areas). The development of the latter is increasingly devouring excellent arable land. Road construction and urban sprawl are among the factors that have contributed not only to the destruction of habitats but also to their isolation (Ouabel, 2012).The extraction of Road Networks from sensor data has been the subject of much research for more than twenty years. It is mainly based on the extraction of linear networks: this line extraction consists in searching for pixels or areas presenting the main characteristics of the road in the whole image studied (Hartani, 2019).

They can then be coupled with interpretation algorithms to reconstruct the geometry and topology of the network for better visualization (Jayaseeli, 2018). The aim of this step is to extract exactly the urbanized areas and small roads. There are several methods of road extraction depending on the environment studied, for example: Linear filtering (Wang and Howarth, 1987), Mathematical morphology (Destival, 1987 and Serendero, 1989), Neural networks (Doucette et al… 2001), Dynamic programming (Merlet and Zerubia, 1996, Gruen and Li, 1995), Directional homogeneity (Airault and Jamet, 1995), Kalman filtering (Veran, 1993, Vosselman and De Knech, 1995), Topographic map guided extraction (Deseilligny et al, 1993), Use of multi-spectral channels (Xiaoying and Davis, 2003).

Most of the methods that have been described above are applicable to the rural or peri-urban context, but show their limitations in the urban environment. For our study area, the Module and Graphical Extraction method guided by a topographic map and digital data (Deseilligny et al., 1993) was used to extract a correct topological graph of its networks. This method aims to give correct spatial connections between the different polylines representing the roads as well as information on their location. This graph can come from a database or be extracted automatically. Several complementary sources of information were used to achieve a reliable extraction of the objects of interest (map data, topographic maps and digital data).

In this method, the areas occupied by these objects (road networks, East-West motorway, railways) in the 106 localities of the 6 provinces of the Macta catchment area were determined. The areas in this method were calculated by multiplying the length of the motorway/road/railway by the width it occupies (30m for the motorway, 20m for the roads, and 10m for the railway). The different stages of the methodology adopted throughout this work are represented by the following dendrogram.

Finally, to show the impact of population dynamics and land artificialisation on the decline of vegetation cover, a supervised classification was applied on the different images from 1987, 1998, 2010 and 2018. Chronic maps of urban areas and vegetation cover of the study area are produced.

Results of urban sprawl. At the Macta watershed level, this process shows a low to medium low trend during the two years 1987 and 1998, while it reaches significant levels during the two years 2010 and 2018. The distribution of the surface area occupied by towns and localities during this period (1987–2018) shows a concentration of the population in the main provinces

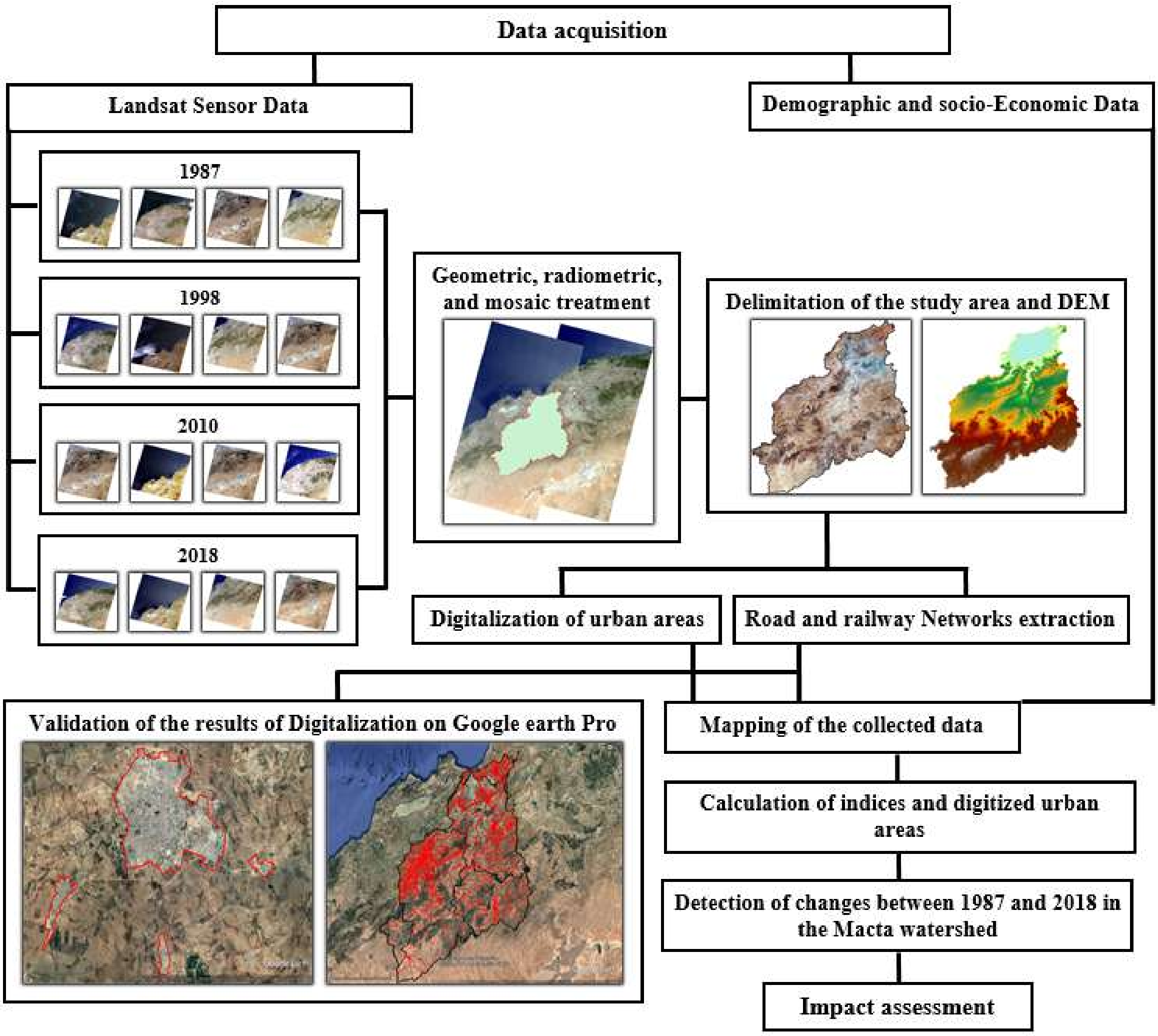

Fig. 2. Dendrogram of methodology used for this study

representing the largest population groupings in the study area: Sidi bel Abbes with an artificial land surface area of more than 4,950 Ha, followed by Mascara and Saida with an artificial land surface area equal to 3,640 Ha and 1,460 Ha respectively.

The dominance of the surface areas of artificial soils in these provinces is mainly due to the economic conditions, the requirement of the demographic growth, and also the rural exodus. The provinces of Mostaganem, Oran and Tlemcen have the smallest artificial surface areas, with 854Ha, 178Ha, and 68Ha.

Road and rail networks. At the level of the Macta watershed, the extension of the east-west motorway shows a low to medium-low trend in 2018. The lengths of roads occupied by the provinces during this period are as follows: Sidi bel Abbes more than 58.3km, Mascara with a section equal to 63.3km, Mostaganem 1.6km and Relizane 3.5km. The road network occupies a very important place with maximum lengths of 6,074.88 km for Sidi Bel Abbes, Saida 1,972.74 km, Mascara 4,691.9 km and finally Mostaganem of 992.36 km.

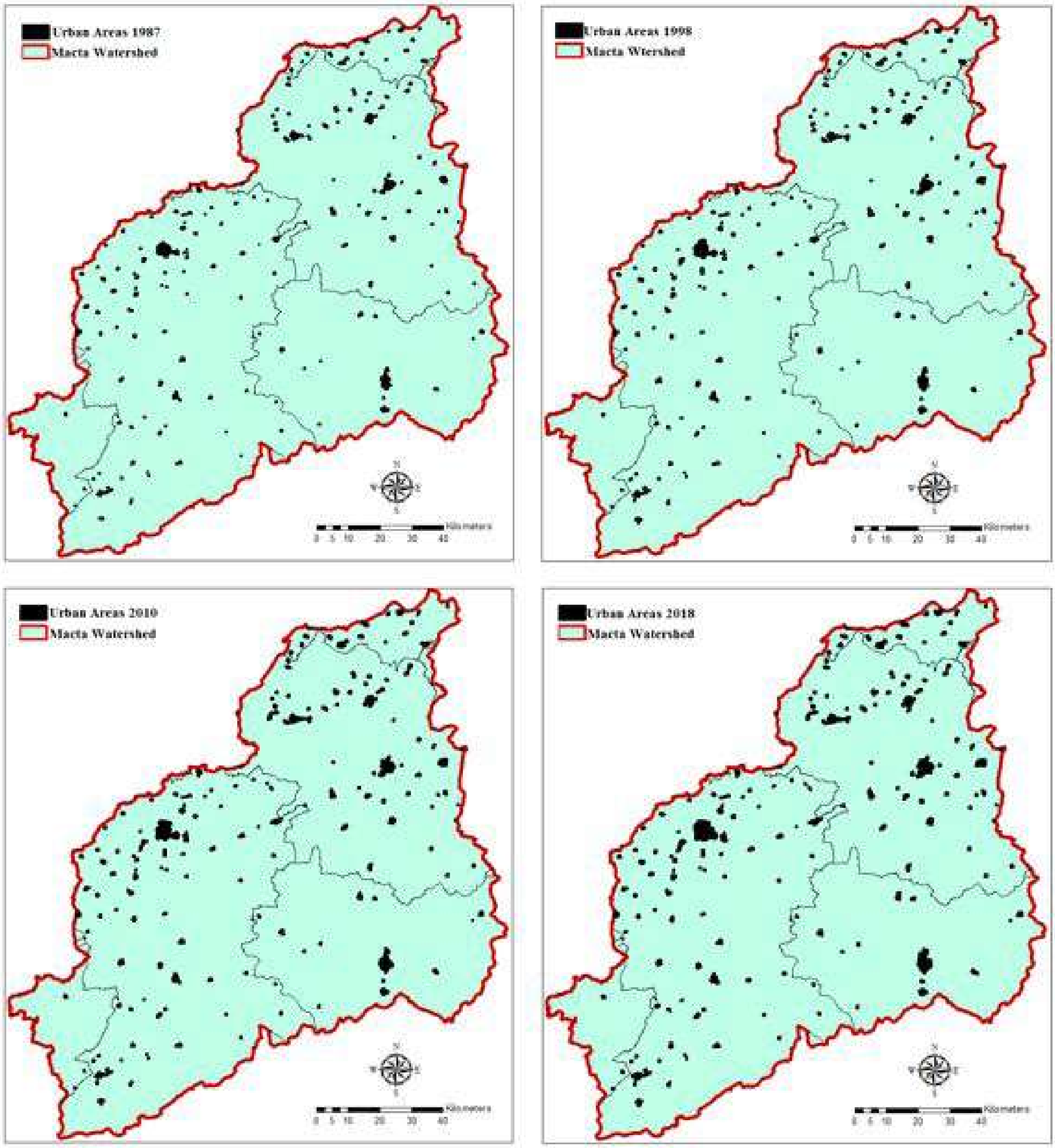

Fig.3. Maps of urban areas in the Macta watershed in the west of Algeria.

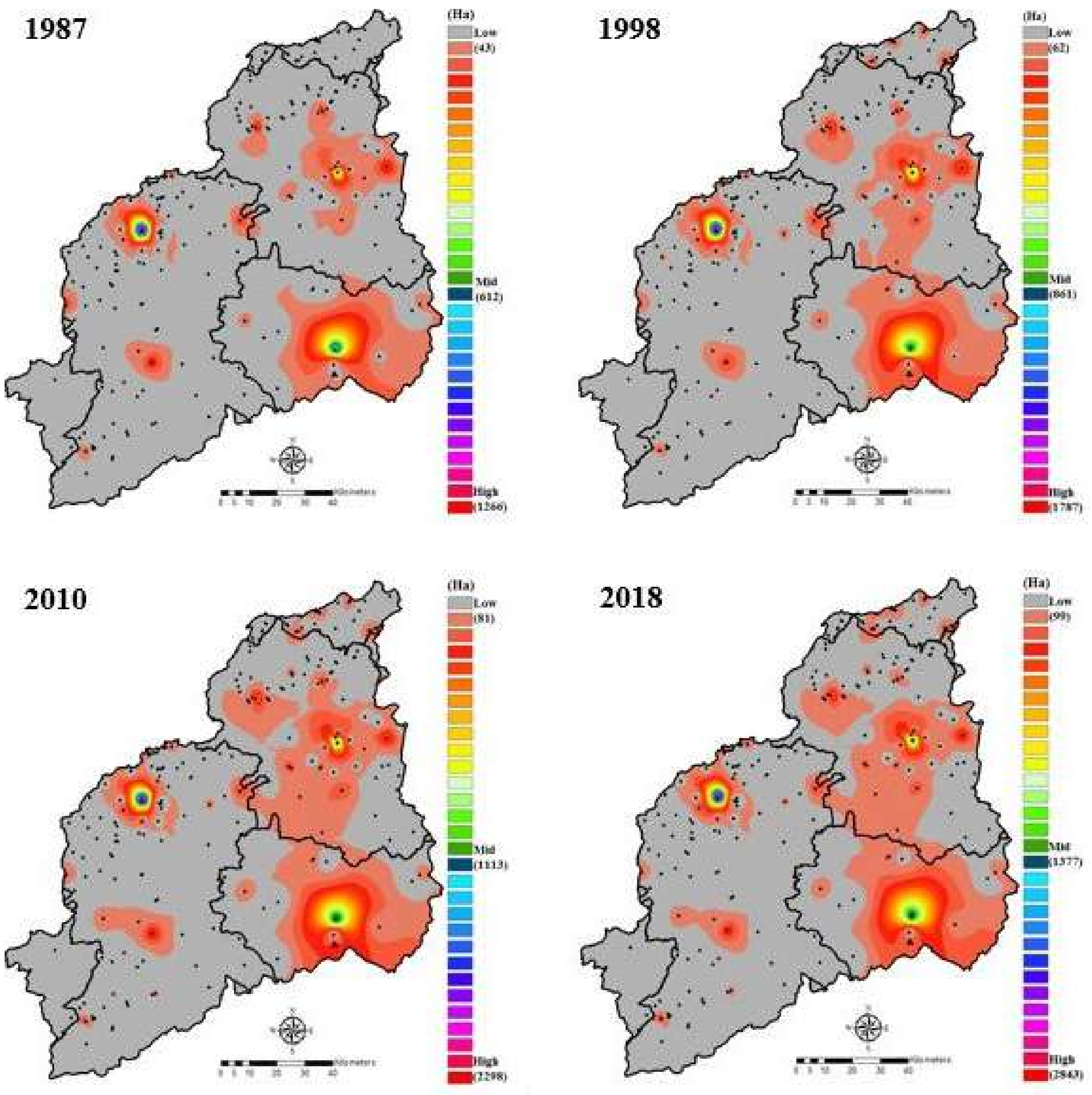

Fig. 4. Maps of urban sprawl evolution in Macta watershed in western Algeria

It should be noted that the railway network is less important than the road network with a maximum length of only 405.59 km.

Urban sprawl and roads' evolution. After a study of the data, we have chosen the capital city (Sidi Bel Abbes) which represents the largest artificial mass in the study area, and the two cities Mascara and Saida which present the highest ratios of the active population to monitor the evolution of the artificial spaces and study the degradation of the agrosystems in the study area. We have chosen to identify and follow the urban expansion in the three cities (Sidi Bel Abbes, Mascara, and Saida) on the images used, which help us to better define the urban contours and allow a quantification of urban extensions. The following figures show the estimated surface areas in each city).

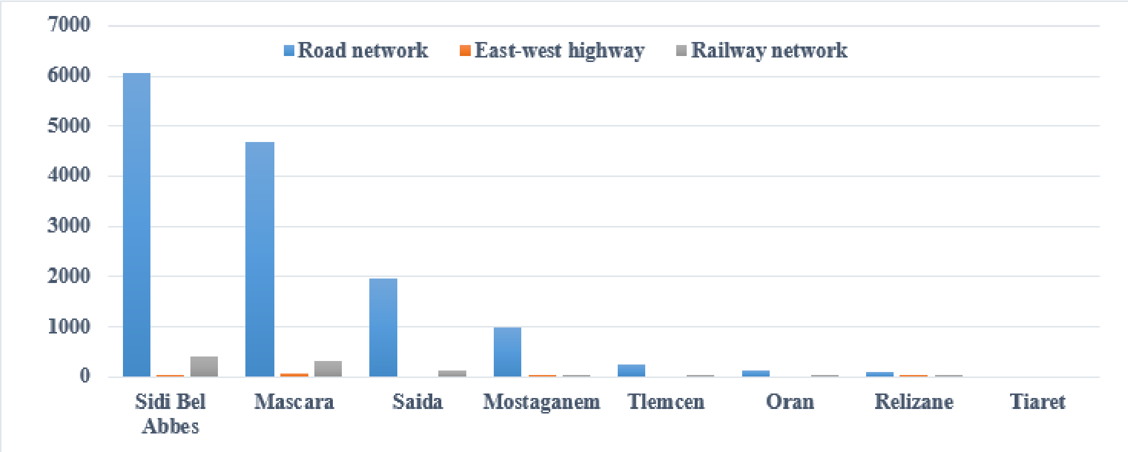

Fig. 5. Road infrastructures length (km) in 2018 in Macta watershed in western Algeria

Four major periods of urban evolution were detected in this study, the first one between 1987 and 1998, the evolution of urbanization was slow and the artificialization of soils represents more than 3,583Ha with an evolution rate of 35.83 %.

In the second period from 1998 to 2010, the urban installations started to take their place again thanks to the sustainable development plans which allowed an increase in urbanization of more than 4,195Ha with an evolution rate of 41.95 %.

A third period from 2010 to 2018 the urban growth was important enough to have an evolution rate of more than 33.80 %, which results in artificialization of more than 3,380Ha of the total surface area of the area.

In the last period from 1987 to 2018 urbanization accelerated remarkably as a result of the rather intense demographic growth during this period. This growth is characterized by an excessive extension of the agglomerations leading to a large consumption of space with a surface area of more than 10,886Ha.

The results illustrate an important progression of the urban fabric which, particularly more intense in certain integrated provinces, is unevenly distributed in space but with different annual growth rates. The

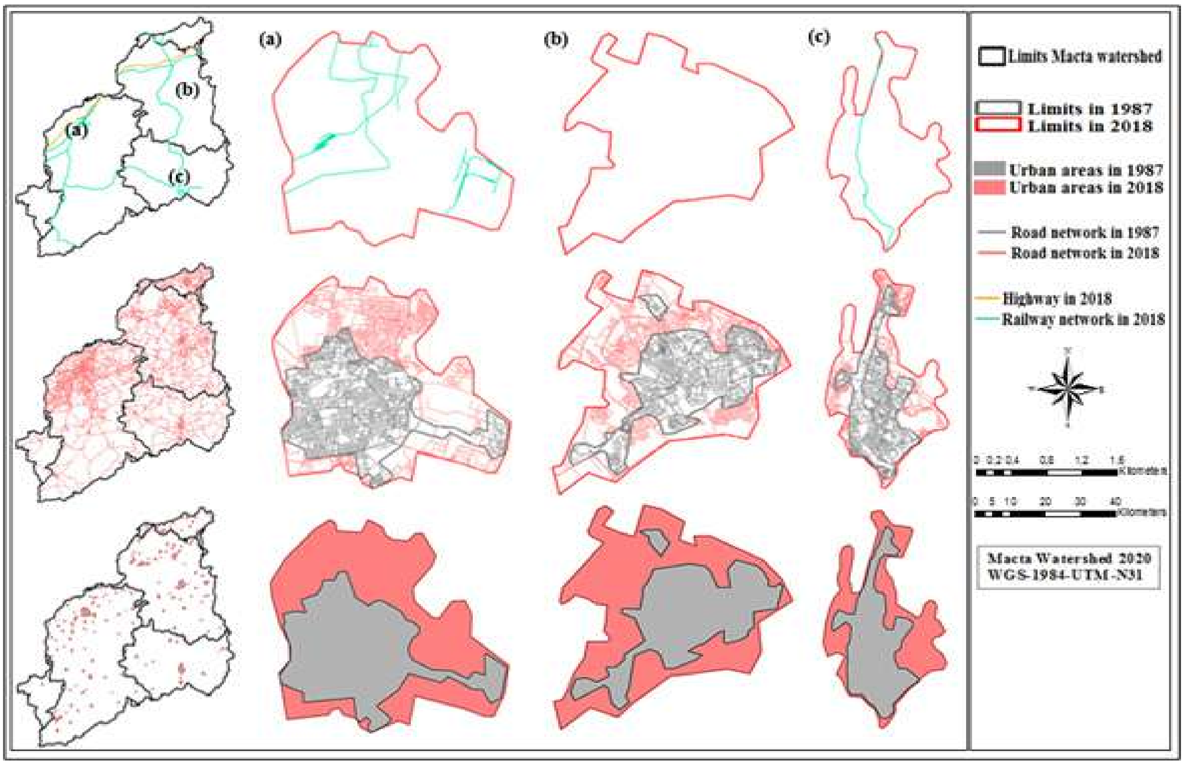

Fig. 6. Urban sprawl and road infrastructures evolution in Macta watershed western of Algeria

Legend: (a) Sidi Bel Abbes province (b) Mascara province (c) Saida province

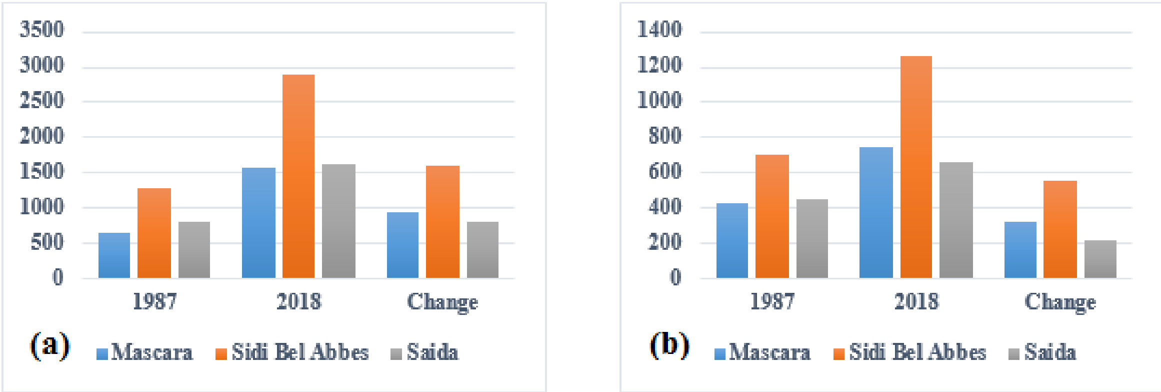

Fig. 7. Urban sprawl area (ha) evolution in Macta watershed in western Algeria

monitoring of urbanization on the scale of the Macta watershed over the last (31) years confirms the strong growth of the urban sprawl. Thus, the urbanized surface areas have increased from 7,149.72Ha in 1987 to 18,305.77Ha in 2018. The urban land, which in 1987 represented 0.50 % of the total surface area of 1,440,000 Ha, reaches 1.28 % in 2018.The results also show urban areas in progression with an annual average of 363Ha/year of agricultural and natural spaces that are disappearing in favour of artificial paces, activity zones and large infrastructures.

The growth and concentration of the population in the urban areas of our study area, which exceeds 1,428,370 inhabitants according to the 2008 census, have generated a large amount of waste, while agricultural activities have eliminated natural areas, and polluted the rest with the products used (pesticides and fertilizers).

In addition, economic growth linked to industries and energy needs, especially in the large cities integrated into the watershed such as Sidi Bel Abbes, Mascara, and Saida, has led to the production of large quantities of pollutants. The environmental consequences of these changes include the loss of natural habitats by eliminating more than 10886Ha in 31 years, the production of solid waste, wastewater, and emissions of pollutants into the atmosphere by road traffic, which occupies more than 30623Ha in 2018.

Urban sprawl impacts on environment. The correlation between population dynamics and land use through urbanization reveals a link between population growth and land use dynamics. In general, there is a strong positive correlation between population growth and the increase of artificial areas and the decrease of vegetation cover.

Spatial and temporal changes show a clear expansion of urban areas into bare land and an excessive decline in vegetation cover.

The reading of the maps (urbanized area and vegetation cover in Fig.8) reveals a clear growth of bare soil and urban areas over the study period, against an equally remarkable decline of vegetation cover.

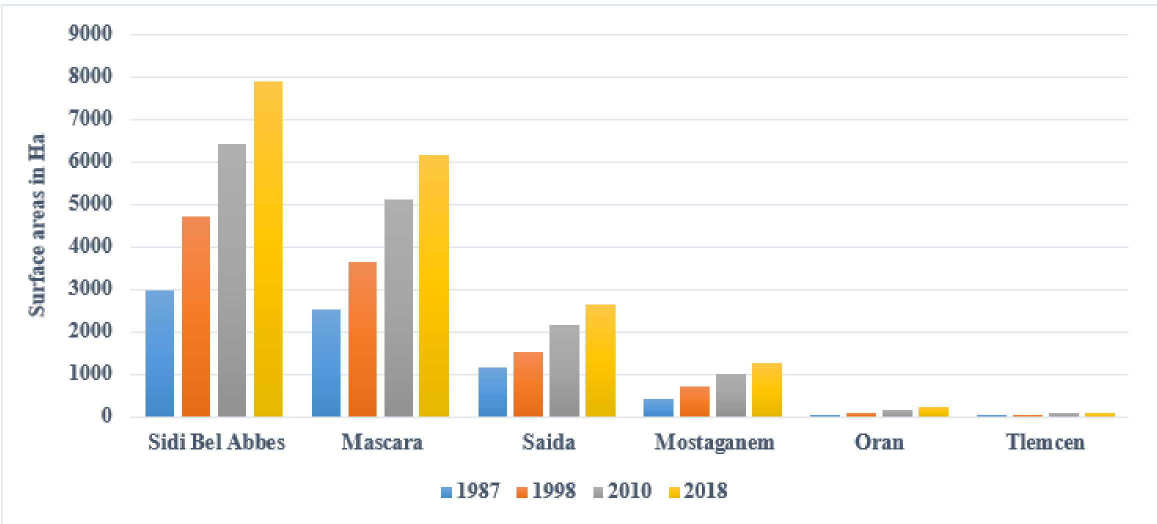

Fig. 8. Urban sprawl and road networks area change in Macta watershed in western Algeria

Legend: (a) urban sprawl area change, (b) road networks area change of the three cities of Sidi Bel Abbes, Mascara, and Saida

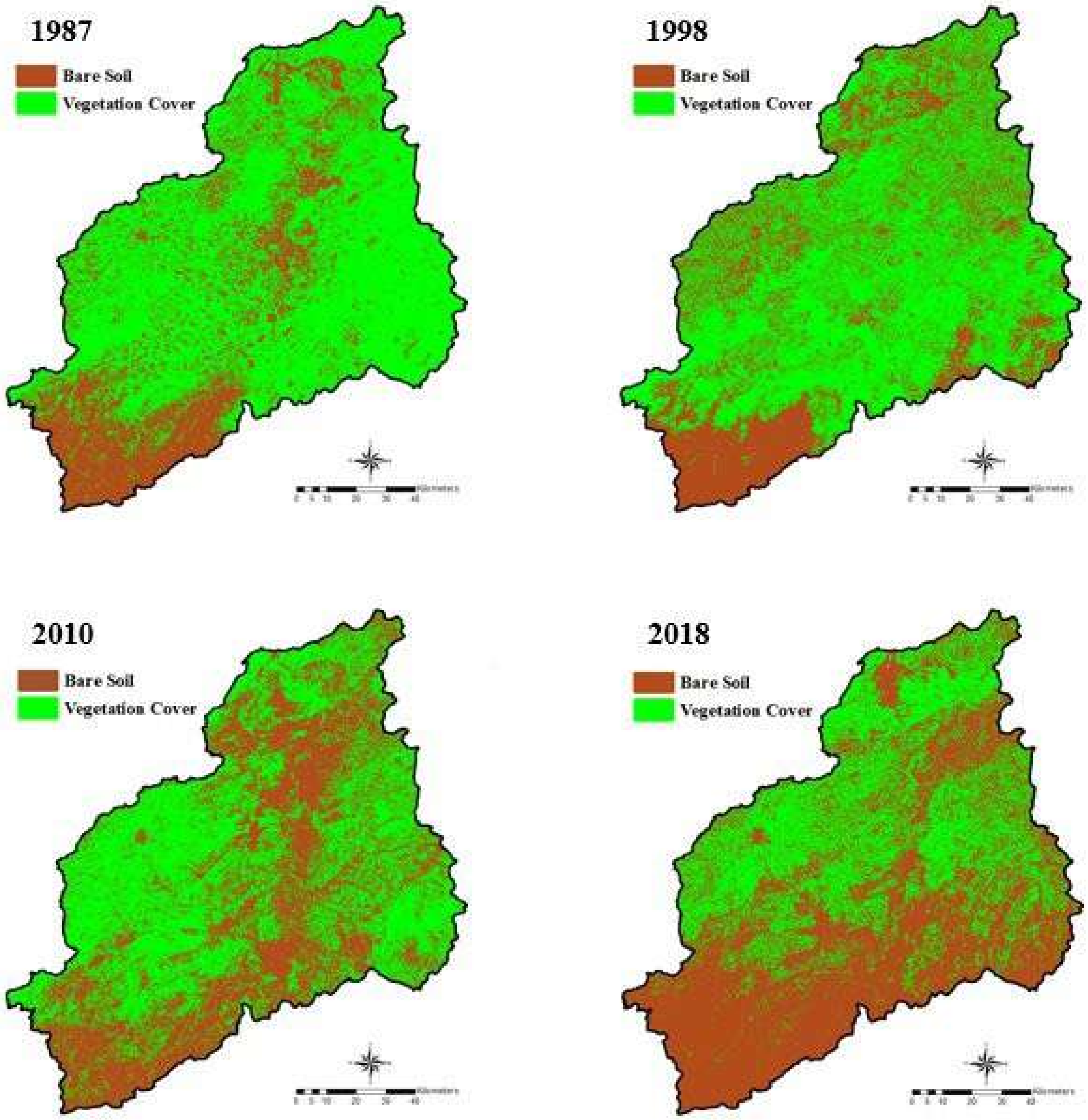

Fig.9. Maps of vegetation cover evolution in Macta watershed in western Algeria

The results showed that over the last three decades (1987–2018), the vegetation cover underwent a progressive decrease from 1,028,364 ha (38.5 %) in 1987 to 894,869 ha (32.95 %) in 1998, and 773,543 ha (28.50 %) in 2010. The urban area registered a dramatic increase from 414,153 ha (15.20 %) to 880,625 ha (33.35 %) between 1987 and 2018. in 1998; the urban area was 19.55 % (530674 ha) and in 2010, it was 24.65 % (669045 ha). This would mean that population growth has had a negative impact on vegetation dynamics. The expansion of urban areas has certainly led to a decrease in vegetation cover.

Discussion. The Macta watershed is one of the north-western regions of Algeria of great agricultural and socio-economic importance (Bouderbala, 2018, Elouissi, 2017, Benzater, 2019), which marks between 1987 and 2018, according to this study, a great spatial dynamic. The landscape measurements analyzed in this study showed that in order to understand the use and occupation of agricultural land, changes in urbanization, its causes and consequences must be taken into account. They were used as an indicator to categorize the different degrees of degradation (low, medium and high) and to simulate it in the future, which can be useful for monitoring and identifying the driving forces behind this change. Our study suggests that measurements of land use are effective measurements for quantifying significant degradation characteristics across different time periods.

The driving forces behind these changes are closely linked to socio-economic development and human activity (Gomesa, 2019), Land policies (Li, 2017), population growth with its increasing needs (Stambouli, 2012), population density, and the intensity of urban land use as expressions of urbanization and spatial planning processes, have a considerable impact on the environment and exert strong anthropogenic pressure on the natural resources of the province (Wellmann, 2018). In the field of remote sensing, urban land use mapping is an important but difficult task, although many of the methods have been developed to obtain information on land use in urban areas (Huang, 2018).

The analysis of urbanization is a step towards understanding the implications of different levels of landscape fragmentation. All these anthropogenic stress factors combined (urbanization, road networks) and their potential interactions have led to an anarchic occupation of space by industrial and agricultural activities (Hafiane, 2016). Since the start of the new motorway project and as a result of the various actions carried out, the study area has undergone several changes affecting all environmental aspects (physical, biological and human environment). From a social and economic point of view the mega-project of the motorway has been called the project of the century because of its prospects and advantages, but from an ecological and environmental point of view it is considered as a disaster affecting more than 24 provinces, of which the Macta watershed is part.

The implementation of such an infrastructure (road networks, railroads, and the East-West highway) will undoubtedly have impacts and harm the various components of the environment during its construction and operation phases. This part consists of identifying and evaluating the impacts that these types of projects could generate on land use and the environment (Rahal, 2018; Madani, 2012; Khelifa, 2016).This watershed contains a wetland covering an area of 44,500 ha and classified by Ramsar in 2001. In addition to its geographical location by the sea and close to urban areas, this ecosystem is also crossed by a fairly dense network of roads and tracks and moreover is affected by the accumulation of industrial and domestic water in the province and the presence of the Marsa El Hadjadj desalination water plant in the interior of the area with a production capacity of 500,000m3 of drinking water.

In the face of climatic fluctuations and above all the pressure of anthropic origin (felling of trees, poaching of protected species, grazing), which is mainly linked to poor management of the wetland, the biodiversity of this zone has been subject to major disturbances on different scales(Kara, 2017; Megharbi, 2017; Sitayeb, 2008; Belgherbi, 2018).The digital analysis using sensor data was of great advantage to detect the evolution and progression of the land resources occupied by urbanization in the study area (Deng, 2019), which was marked by an intense demographic growth (ONS-RGPH, 2018) and a regression of agricultural land due to the extension of the cities (Sitayeb, 2008).We notice in these images, an important evolution on our study area which is spread over 31 years.

Conclusions.

Rapid population growth is associated with rapid growth in urbanisation and land use. The threats to natural resources are currently quite remarkable. On the other hand, land is increasingly degraded due to industrial development, which has become a serious socio-economic problem in agricultural areas. The land use in the Macta watershed includes agriculture and natural vegetation, which has been remarkably degraded in the last decades, mainly due to the action of climate, and increasing anthropozooic action. The results of the study of the expansion of the road network, urbanisation and the spatial state of the vegetation cover showed temporal and spatial changes during the study period. The mapping of urban and road expansion and change during the study period from 1987 to 2018 showed that all the study provinces have experienced considerable expansion over the last 31 years, with urbanised areas increasing from 0.50 % in 1987 to 1.28 % in 2018. The distribution of urban areas over this study period shows a concentration of population in the larger provinces. In contrast, the extension of the East-West motorway shows a weak trend in 2018. The lengths of roads installed are significant and show a growth rate of 50 %. The maps of urbanised areas and land use show a clear growth of bare land and urban areas over the study period, against an equally remarkable decline in land use. The results show that over the last three decades (1987–2018), land cover has gradually decreased from 38.5 % in 1987 to 20.15 % in 2018. Furthermore, the method proposed in this paper of Automated Extraction of urban areas, road, rail and highway networks from sensor data allows for further exploration of models for effective urban management for environmental, commercial and scientific purposes.

References

Achite, M., Buttafuoco, G., Toubal, K.A., Lucea, F., 2017. Precipitation spatial variability and dry areas temporal stability for different elevation classes in the Macta basin (Algeria). Environment Earth Sciences (76).P2–3.DOI 10.1007/s12665–017–6794–3.

Agbanou, T., Tente, B., Djinadou, R., 2015.Cartographie des changements de l'occupation du sol en milieu urbain: cas du 12ème arrondissement de Cotonou (Benin).Cahiers du CBRST, Cotonou (Bénin).VOL3.P331–332.

Airaultn, S., Jamet, O., 1995. Détection et restitution automatique du réseau routier sur des images aériennes. Traitement du signal 12(2).P189–200.

Ali, R., Khuda, B., Muhammad A.Y., 2019. Impact of urbanization on CO_2 emissions in emerging economy: evidence from Pakistan. Sustainable Cities and Society. P4–5.DOI 10.1016/j.scs.2019.101553.

Amokrane, K., Madani, A., Iatu, C., 2016. L'autoroute est-ouest dans la vallée du Cheliff et la modernisation du réseau routier algérien: impacts socio-économiques et environnementaux. vol 43, DOI: 10.15551/lsgdc.v43i0.06, p 79–92.

Atchade, A.A.G., Dossou-Yovo, E.R., Kodja, D.J., Vissin, E.W., Boukari, M., 2015. Dynamique de l'occupation des terres et ressource en eau du bassin versant de la rivière du zou à l'exutoire de domè au bénin. XXVIIIe Colloque de l'Association Internationale de Climatologie, Liège. P1–6.

Avakoudjo, J., Mama, A., Toko, I., Kindomihou, V., Sinsin, B., 2015. Dynamique de l'occupation du sol dans le Parc National du W et sa périphérie au nord-ouest du Bénin.International Journal of Biological and Chemical Sciences 8(6).P2609–2610 doi 10.4314/ijbcs.v8i6.22.

Ayache, A., Hellal, B., Ayad, N., Benhanifia, K., Gacemi, M.A., 2015. Diachronic analysis of the steppe land cover of the department of Sidi Bel-Abbes using the remote sensing (Western Algeria). International journal of geomatics and geosciences Vol 6.N2.P1486–1487.

Bamba I., et al (2008). Influence des actions anthropiques sur la dynamique spatio-temporelle de l'occupation du sol dans la province du Bas-Congo (R.D. Congo). Sciences & Nature Vol 5.N1.P50–58.

Benzater, B., Elouissi, A., Benaricha, B., Habi, M., 2019. Spatio-temporal trends in daily maximum rainfall in northwestern Algeria (Macta watershed case, Algeria). Arabian Journal of Geosciences (12).P2–3.doi 10.1007/s12517–019–4488–8.

Bouderbala, D., Souidi, Z., Hamimed, A., Bouamar, B., 2018. Estimation of rainfall erosivity by mapping at the watershed of macta (Algeria). Revistabrasileira de cartografia vol 71.N1.P276–277. doi 10.14393/rbcv71n1–2218.

Chibane, B., Bentchakal, M., Medjerab, A., Benfares, B., 2015.Etude de la variabilité et de la structure de pluie annuelle dans une région semi-aride: cas du bassin versant de la Macta (nord-ouest algérien).Larhyss Journal.N23.P214–216.

Deng, Z., Zhu, X., He, Q., Tang, L. 2019. Land use/land cover classification using time series Landsat_oli 8 images in a heavily urbanized area. Advances in Space Research. P2–3.doi 10.1016/j.asr.2018.12.005.

Destival, I., 1987. Recherche automatique de réseaux linéaire sur des images spot. Bulletin de la société française de Photogrammétrie et de Télédétection (66).P5–16

Dorathi Jayaseeli, J.D., Malathi, D., Gopika, S., 2018. Road Extraction using Deep Learning. International Journal of Engineering & Technology.P1079–1084.

Doucette, P., Agouris, P., Stefanidis, A., Musavi, M., 2001. Self organized clustering for road extraction in classified imagery. ISPRS Journal of Photogrammetry & Remote Sensing (55). P347–358.

Driss, M., 2016. L'impact de l'environnement routier sur la sécurité routière durable. Thèse de doctorat en Sciences. Université Mustapha Stambouli de Mascara. p89

Elagouz, M.H., Abou-Shleel, S.M., Belal, A.A., El-Mohandes, M.A.O., 2018. Detection of land use/cover change in Egyptian Nile Delta using remote sensing. The Egyptian Journal of Remote Sensing and Space Sciences.P1–6. doi 10.1016/j.ejrs.2018.10.004.

Elouissi, A., Habi, M., Benaricha, B., Boualem, S.A., 2017. Climate change impact on rainfall spatio-temporal variability (Macta watershed case, Algeria). Arabian Journal of Geosciences (10).p1–3.doi 10.1007/s12517–017–3264-x.

Elzerey, W., 2015. Diachronic study of the forest cover regression in the Telagh plain (Algeria): approach by remote sensing and GIS.Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Vie.N36.P 25–31.

Gomesa, E., 2019. Agricultural land fragmentation analysis in a peri-urban context: From the past into the future. Ecological Indicators (97). p380–381. doi 10.1016/j.ecolind.2018.10.025.

Gruen, A., Li, H., 1995. Road extraction from aerial and satellite images by dynamic programming. ISPRS Journal of Photogrammetry and Remote Sensing (50).P 11–20.

Hafiane, M., 2016. Anthropogenic impacts and their influence on the spatial distribution of the Odonata of Wadi el Harrach (North-central Algeria). Revue d'Ecologie (Terre et Vie), Vol71(3).P239–249.

Halimi, S., 2020. Evaluation of road traffic impact on the aquifers of the crossed areas. Application to Annaba plain crossed by (NR21, NR16 and NR44) Northeastern Algeria.

Hamadouche, M.A., Daikh, F.Z., Chrair, M., Anteur, D., Fekir, Y., 2019. Erosion Sensitivity Mapping Using GIS-Based Multicriteria Analysis-Case Study of the Semiarid Macta Watershed, North-West of Algeria. Recent Advances in Geo-Environmental Engineering, Geomechanics and Geotechnicsand Geohazards, Advances in Science, Technology & Innovation.p1–4. doi 10.1007/978–3–030–01665–4_110.

Hartani, A., 2019. Utilisation de la télédétection dans l'étude de la dégradation des agrosystèmes dans le bassin versant de l'Oued-Chéliff: Artificialisation et dégradation de l'espace rural. Thèse de doctorat en sciences. Université Abdelhamid ibn Badis de Mostaganem.p195.

Hidouci, S., 2015.Impact des rejets urbains et industriels sur la qualité environnementale du littoral d'Annaba. Thèse de doctorat en Sciences.Université Badji Mokhtar Annaba, p75.

Huanga, B., Zhaoa, B., Songa, Y., 2018. Urban land-use mapping using a deep convolutional neural network with high spatial resolution multispectral remote sensing imagery. Remote Sensing of Environment (214).P73–86. DOI 10.1016/j.rse.2018.04.050.

Iqbal, M.A., Shafiq, M., Kabir, M., Farooqi, Z.R., 2018. Impact of anthropogenic activities on biodiversity in

Pakistan: A review. Bioscience Research, 15(1).P481–490.

Jin X., Jin, Y., Mao, X., 2019. Ecological risk assessment of cities on the Tibetan Plateau based on land use/land cover changes Case study of Delingha City. Ecological Indicators (101).P185–191. doi 10.1016/j.ecolind.2018.12.050.

Kara Omar, A., Khaldi, A., 2017.Desalination of seawater and environmental impacts: case of el-Macta station. Journal of Water and Environmental Sciences vol1 (Numérospécial ICWR 2).p1–5.

Kerfouf, A., Mehtougui, M.S., 2018. Environmental Diagnosis of Coastal Wetlands and Analysis of Anthropogenic Activities: Case of the West Coast of Algeria. International Journal of Sciences: Basic and Applied Research (IJSBAR).p48–52.

Khelifa A., Madani, A., Iațu, C., 2016. L'autoroute est-ouest dans la vallée du Cheliff et la modernisation du réseau routier algérien: impacts socio-économiques et environnementaux. Lucrări le seminar ului geografic dimitrie cantemir, N41.p139–151.

Li J., Zhang, Y., Qin, Q., Yan, Y., 2017. Investigating the Impact of Human Activity on Land Use/Cover Change in China's Lijiang River Basin from the Perspective of Flow and Type of Population. MDPI Journal sustainability. p1–16. doi 10.3390/su9030383.

Li, S., Wang, T., Yan, C., 2017. Assessing the Role of Policies on Land-Use/Cover Change from 1965 to 2015 in the Mu Us Sandy Land, Northern China. MDPI Journal sustainability 9(7). p2–15. doi10.3390/su9071164.

Madani, A., Bryant, C., 2012. Développement durable du transport terrestre en Afrique du Nord Quel rôle devra jouer l'Algérie. Revue Kounouz Alhikma.N12.P3–19.

Maref, N., 2019. Démarche méthodologique d'adaptation d'un système de prévision aux risques d'inondation en Algérie, cas du bassin versant de l'Oued Mekerra (N.W Algérien).Thèse de doctorat en sciences. Université Abou Bekr Belkaid de Tlemcen. p199.

Meddi M., Talia, A., Martin, C., 2009.Évolution récente des conditions climatiques et des écoulements sur le bassin versant de la Macta (nord-ouest de l'Algérie). Physio-Géo- Géographie Physique et Environnement, AERES vol3.p61–84.

Megharbi, A., 2017. Approche synécologique et dynamique des groupements des halophytes des maris de la Macta. Thèse de doctorat en sciences, p 243.

Merlet, N., Zérubia, J., 1996. New prospects in line detection by dynamic programming. IEEE Transactions on pattern Analysis and Machine Intelligence (18).P426–430.

Nga, T.T.V., Tam, V.T., 2018. Assessment of urbanization impact on groundwater resources in Hanoi, Vietnam. Journal of Environmental Management (227).P107–108. doi 10.1016/j.jenvman.2018.08.087.

Noyola-Medrano C., Mering, C., Rojas Beltran, M., 2009. Evaluation du changement de l'occupation du sol A l'aide des images landsat et spot: champ Volcanique de la sierra Chichinautzin (mexique).Actes du 26ème colloque international; cartographiqueconférence, Allemagne.p1–12.

Ouabel, H., 2012.Contribution à l'étude des agents de dégradation des ressources en sols et en eaux dans le plateau de Mostaganem.Thèse de doctorat en sciences. Université Abdelhamid ibn Badis de Mostaganem.p121.

Rahal, F., Hadjou, Z., Blond, N., Aguejdad, R., 2018. Croissance urbaine, mobilité et émissions de polluants atmosphériques dans la région d'Oran, Algérie.Cybergeo: European Journal of Geography Aménagement, Urbanisme. p1–15.

Rui, Y., 2019.Climate change does not alter land-use effects on soil fauna communities. Applied Soil Ecology.P1–8. doi 10.1016/j.apsoil.2019.03.026.

Safaei, M, Bashari, H, Mossadigui, M.R, Jafari, R., 2019. Assessing the impacts of land use and land cover changes on soil functions using landscape function analysis and soil quality indicators in semi-arid natural ecosystems. June 2019, Catena 177:260–277, doi:10.1016/j.catena.2019.02.021.

Semari, K., 2016. Forme des lits pour les cours d'eau du bassin versant de la Macta. Thèse de doctorat en sciences. Thèse de doctorat en Sciences. Université Mustapha Stambouli de Mascara.p147.

Serendero, M.A., 1989. Extraction d'Informations Symboliques en Imagerie SPOT: Réseaux de Communication et Agglomérations. Thèse de Doctorat, Université de Nice-Sophia Antipolis, p 198.

Sitayeb, T., Benabdeli, K., 2008.Contribution à l'étude de la dynamique de l'occupation des sols de la plaine de la Macta (Algérie) à l'aide de la télédétection et des systèmes d'information géographique.Science direct. Comptes rendus biologies (331).p466–474. doi 10.1016/j.crvi.2008.03.010.

Stambouli Meziane, H., Bouazaa, M., 2012. Anthropogenic effects on plant cover in the Tlemcen region (western Algeria).Open Journal of Ecology.vol2.N3.P141–146. 10.4236/oje.2012.23017.

Tazekrit, I., 2019. Contribution à la mise en œuvre d'un modèle conceptuel pour la gestion intégrée des ressources en eau en Algérie: cas du bassin versant de la Macta dans l'ouest algérien. Thèse de doctorat en Sciences. Université Mustapha Stambouli de Mascara. p135.

Tebani, M., 2019. Suivi et évaluation de l'impact social, économique etenvironnemental du programme de renouveau del'économie agricole et rural dans la zone de l'Ouarsenis (wilaya de Tissemsilt, Algérie), Thèse de doctorat en sciences.Université Mustapha Stambouli de Mascara, p135.

Tiwari1, S., Mandal, N.R., Saha, K., 2018. A geospatial analysis of anthropogenic activities and their impacts on river Narmada. Available at SSRN. doi10.2139/ssrn.3214250.

Veran, J., 1993.Suivi de broutes dans une image aérienne par filtrage de Kalman, Rapport technique. Rapport technique, Ecole Nationale supérieure des télécommunications. France.p12–15.

Villa, P., Duan, H., Loiselle, S.A., 2015. Using Remote Sensing to Assess the Impact of Human Activities on Water Quality: Case Study of Lake Taihu, Springer International Publishing Switzerland 2015 T. Younos, T.E. Parece (eds.), Advances in Watershed Science and Assessment, The Handbook of Environmental Chemistry 33, DOI 10.1007/978–3–319–14212–8_4.

Vosselman, G., de Knecht, J., 1995. Road tracing by profile matching and Kaiman filtering. Proceedings of Automatic extraction of man-made objects from aerial and space images. p265–274.

Wang, J., Howarth, P., 1987. Automated road network extraction from Landsat TM imagery. Proceedings of the annual ASPRS/ACSMN1, Vol1.p 429–438.

Wellmann T., 2018. Urban land use intensity assessment the potential of spatio-temporal spectral traits with remote sensing. Ecological Indicators (85).p190–203. doi 10.1016/j.ecolind. 2017.10.029.

Xiaoying, J., Davis, C., 2003. Automatic road extraction from high-resolution multispectral IKONOS imagery.IEEE International Geoscience and remote SensingSymposium. vol3.p1730–1732.

Zhonghao, Z., Yaojen, T., Xin, L., 2016.Quantifying the spatiotemporal patterns of urbanization along urban-rural gradient with a roadscape transect approach: a case study in Shanghai, China. August 2016, Sustainability 8(9):862, doi:10.3390/su8090862.

Zhu, X., Zhang, Q., Sun, P., Singh, V., Shi, P., Song, C., 2018. Impact of urbanization on hourly precipitation in Beijing, China: Spatiotemporal patterns and causes. Global and Planetary Change. doi 10.1016/j.gloplacha.2018.10.018.