AJLP & GS
African Journal on Land Policy and Geospatial Sciences

e-ISSN : 2657-2664, Vol. 6, Issue 2, March 2023

https://revues.imist.ma/index.php/AJLP-GS/index

https://doi.org/10.48346/IMIST.PRSM/ajlp-gs.v6i2.34413 ***Category of the manuscript : Articles***

Received in: 10 September 2022 **Revised in:** 05 February 2023 ***Accepted in:*** 11 February 2023

Impact of urbanization on the dune ecosystem
case of the city of ECHATT and sidi Mbarek (EL TARF)

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ABSTRACT

Context and background

Throughout history, the severity of coastal impacts has varied depending on social and environmental factors. Human activities in general have caused large-scale environmental and morphological changes, and our study area is not outside this context.

Goal and Objectives:

This study aims to reveal the evolution of urban fabric of the city of Echatt and sidimbarek and their degree of influence on the state of dune cordon last 37 years.

Methodology:

The methodology followed during this study is based on satellite and topographic data as well as on measurements and observations made in the field. In order to study the evolution of urban fabric of the study area. The approach adopted is based on a study of several satellite images and google Earth pro images at different dates in order to determine the extent of changes that occurred between 1984 and 2021.

Results:

The results show an increase in coastal urbanization at varying rates amounting to 11.92 ha/year between (1984-2000), 4.95 ha/year between (2000; 2010) and 9. 92 ha/year between (2010,2021); and landscape changes that have developed at different rates over time due to the exploitation of the dune cordon of the city of echatt and sidimbarek in an irrational way that can lead to a total removal of vegetation cover, because according to the results obtained, more than half of the vegetation cover of the coastal dunes has been removed in 37 years Thematic maps and results obtained at different periods show that the forest landscape has gradually converted into dry land despite the entry into force of the Algerian Coastal Law 02-02 on the protection and enhancement of the coast, which aimed at the protection of the coast and sustainable use of its resources.

Keywords

SIG , Algeria, Télédétection, , littoral, , couverture végétale, pression anthropique.

1. INTRODUCTION

Coastal urbanization is expanding at an unprecedented scale and rate (Salgado, Martínez et al. 2022). From 1970 to 2000, the average rate of urban expansion was higher in low-lying coastal areas (less than 10 m above sea level) (Seto, Fragkias et al. 2011) than that observed inland (Barragán and De Andrés 2015). The vulnerability of coastal ecosystems to natural disturbances has increased due to anthropogenic pressure (García-Mora, Gallego-Fernández et al. 2001; Benavente, Del Río et al. 2006). Thus, the increasing urbanization of the coastline has caused the destruction of coastal dunes and the alteration of coastal sediment dynamics. Currently, 11% of the total worldwide urban land is located in low elevation coastal zones, with nearly 400 million inhabitants (McGranahan, Balk et al. 2007; Brondizio, Settele et al. 2019). Indeed, coastal urbanization is a global trend, as was demonstrated by Barragán and De Andrés (2015), who showed that coastal cities and agglomerations have multiplied by4.5 in the last seven decades. In the last decade, nearly seven times more people live in coastal cities than in the mid-20th century. This means that the coastlines are becoming more densely populated as time goes by (Salgado, Martínez et al. 2022(. The growing economic needs of the coasts has led to continuous and mostly haphazard urban sprawl, resulting in habitat degradation or loss, as well as pollution, both on land and in the ocean (Finkl and Charlier 2003). Specifically, coastal dunes are being destroyed by excessive trampling, off-road vehicle use, dune remodeling, vegetation removal, and even massive sand mining (Hesp, Schmutz et al. 2010).

In Algeria, 2/3 of the population are concentrated on the coastline, which represents 5% of the country's area (Bouroumi 2014). Our study take the coastline of the wilaya of EL TARF and particularly the city of ECHATT and SidiMbarek (located in the extreme east of Algeria) as an example because it know an extension of urban fabric quite important in recent years. With so much progress, remote sensing has become a very appropriate tool to study and monitor the evolution, in time and space, of the occupation and use of the land of a large area thanks to the different sensors embedded in satellites (Boulaassal, Anaki et al. 2020). The multi-date nature of satellite images allows us to highlight changes and analyze urban and peri-urban dynamics (Masek, Lindsay et al. 2000; Han, Ren-Chao et al. 2007; Hu and Lo 2007; Jin-Song, Ke et al. 2009). The evolution of sensor technology since the 1990s has resulted in advances in spatial, spectral, and radiometric resolution. With the availability of high resolution data, Spot (XS and P) and Landsat ETM+ images are increasingly used in urban remote sensing (Ackermann, Mering et al. 2003; FAURE, TRAN et al. 2004; Lacroix, Idrissa et al. 2006; Durieux, Lagabrielle et al. 2008; Park and Stenstrom 2008; Jin-Song, Ke et al. 2009; Skupinski, BinhTran et al. 2009). Our objective was to study urban sprawl trends and landscape changes along the coast of Echatt and sidiMbarek city between 1984 and 2021 based on remote sensing and Geographic Information System (GIS), the latter is a tool that will allow monitoring of spatio-temporal evolution of land use/land cover, landslide risk assessment (Abdikan, Sekertekin et al. 2018).

2. MATÉRIEL ET MÉTHODE

2.1 Study area

The study area (Figure 1) is located in the northern part of the wilaya of El Tarf on the western side of the region; bounded by the Mediterranean Sea to the north; and the wilaya of Annaba to the west,

to the east by oued el mafragh and to the south by the road W109, The study area covers more than 1800 ha of land.

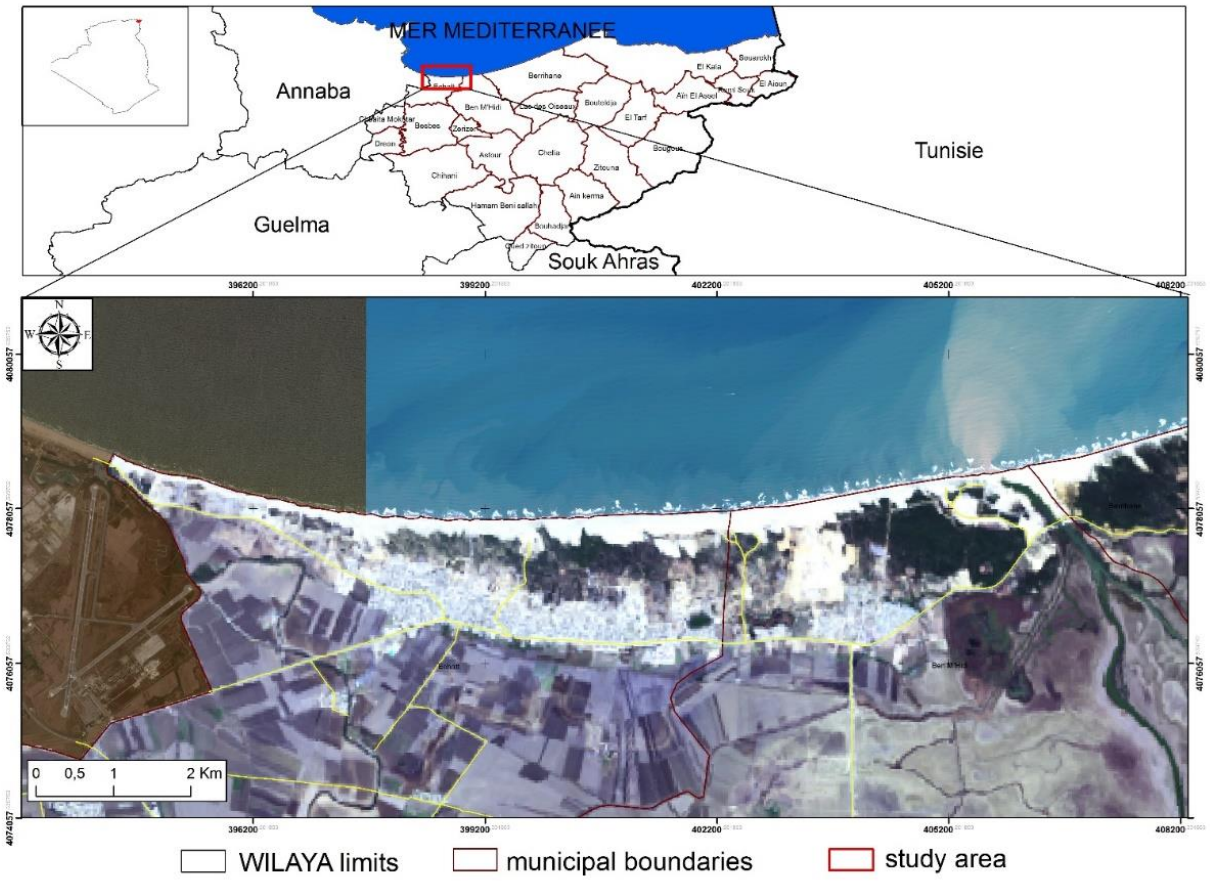

Fig. 1: location map of the study area

The study area belongs to the coastal area, the general relief consists of a dune belt in the north with a steep slope and an altitude ranging from 10 to 18m and full south the climate of the area is Mediterranean type subhumid, this type of climate is characterized by its favorable conditions especially in terms of mild temperatures and precipitation in winter season or the rainfall range exceeds 600mm (ONM). Positive temperatures throughout the year except for rare days in winter (January and February) during which a minimum of -.8°C is recorded, a low seasonal thermal amplitude of about 7°C, very high absolute summer temperatures reaching 46°C and a mild winter (average winter temperature of 13°C). The study area characterized by the presence of three wadis are: OUED SAYBOUSSE in the west which is permanent, OUED BOUKHLIDI in the center and OUED BOUHLALLA in the east. So the area is located between the watershed of OUED SAYBOUSSE which flows over a length of 8km and the watershed of MEFRAGH WEST which ends in the sea (8km east).

The geological structure of the study area composed mainly of undifferentiated Quartenaire, which is defined by alluvial outcrops in scree slopes resulting from successive erosion, alteration, transport and deposition of scree Numidian sandstone or silt, sand on the banks of wadis, estuaries and lakes ; The soil of the study area is composed mainly of dune soil in the maritime facade and alluvial soil inside the area separated by the saline soil.

The climatic characteristics and the fertile soil of the region offer many alternatives for agricultural activities.

2.2 Data analysis

All downloaded images and maps used in the study (table 1) have been georeferenced in order to allow a correct digitization of the different layers (urban, vegetation cover and coastal dune)

2.2.1. The delimitation of the coastal dune of the city of echatt and sidimbarek..

The delimitation of the coastal dunes of the city of Echatt and sidimbarek is carried out with the help of superposition of 02 maps, one on the other in particular the map of recognition of ground of Algeria sheet of BÔNE_ N° 9, of scale 1:200000 drawn up, engraved and published by the geographical service of the armé (1930), and the map of staff sheet Bone, 1:50000, drawn up, engraved and published by the geographical service of the armé (revision of 1929). Using ArcMap v 10.8 software, the contours of these lands were extracted by digitizing in order to obtain a delineation of the dune, in a vector format with a WGS-84 coordinate system and a UTM zone 32N projection. The delineation of coastal dunes shows that most of the city of echatt and sidimbarek lies above them.

2.2.2. Extraction of urban tissue.

For the years 2000, 2010, 2021 the extraction of urban spots was made from satellite images of google earth pro (visual identification of urban spots) which is a software, property of the company google allowing a visualization of the earth with an assembly of aerial or satellite photographs of high resolution moreover, it has the capacity to go back to a precise moment. Due to the lack of high resolution images for the year 1984 on google earth pro, we were forced to use a topographic map as a source to determine the urban fabric boundaries. The topographic map used the one with a scale of 1:50000 made and published by the National Institute of Cartography in 1984 encompasses the study area. The urban fabric extracted by a simple digitizing using Arc Map 10.8 software

2.2.3. Extraction of the vegetation cover

The Landsat images used in this study were downloaded from the USGS archive (http://earthexplorer.usgs.gov and http://glovis.usgs.gov) (table2). Images were selected to have less than 20% cloud cover over the entire scene and less than one pixel spatial offset for each reference year: 1984, 2000, 2010,2021. The products of Landsat 5 (for 1984 - 2010) , Landsat 7 ETM+ (for 2010), and Landsat 8 OLI (for 2021). In order to be able to use the Landsat satellite images efficiently, we have carried out pre-processing to reduce the errors likely to occur. The pre-processing of these images mainly involves radiometric calibration and atmospheric corrections using the GIS software ArcMap 10.8. To make the extraction of the vegetation cover multi dates we used The normalized difference vegetation index, also called NDVI proposed by Rouse et al (1974) is built from the red (R) and near infrared (PIR) channels and realization of a colored composition "false color infrared" is widely used in remote sensing because it is quite suitable for the study of vegetation, it associates the red color to the near IR band, the green color to the red band and the blue color to the green band.

The normalized vegetation index emphasizes the difference between the visible red band and the near infrared band. NDVI=(PIR-R)/PIR+R)(Tucker 1979; Kustas, Daughtry et al. 1993; Leprieur, Kerr et al. 2000; Tucker, Pinzon et al. 2005). NDVI values range from -1 to +1, with negative values corresponding to surfaces other than vegetation cover, such as snow, water or clouds, for which the

red reflectance is greater than that of the near infrared. For bare soil, the reflectance is about the same in the red and near infrared, so the NDVI has values close to 0.

Vegetation formations have positive NDVI values, generally between 0.1 and 0.7. The highest values correspond to the densest cover. The main steps carried out to realize this study are illustrated in figure 2.

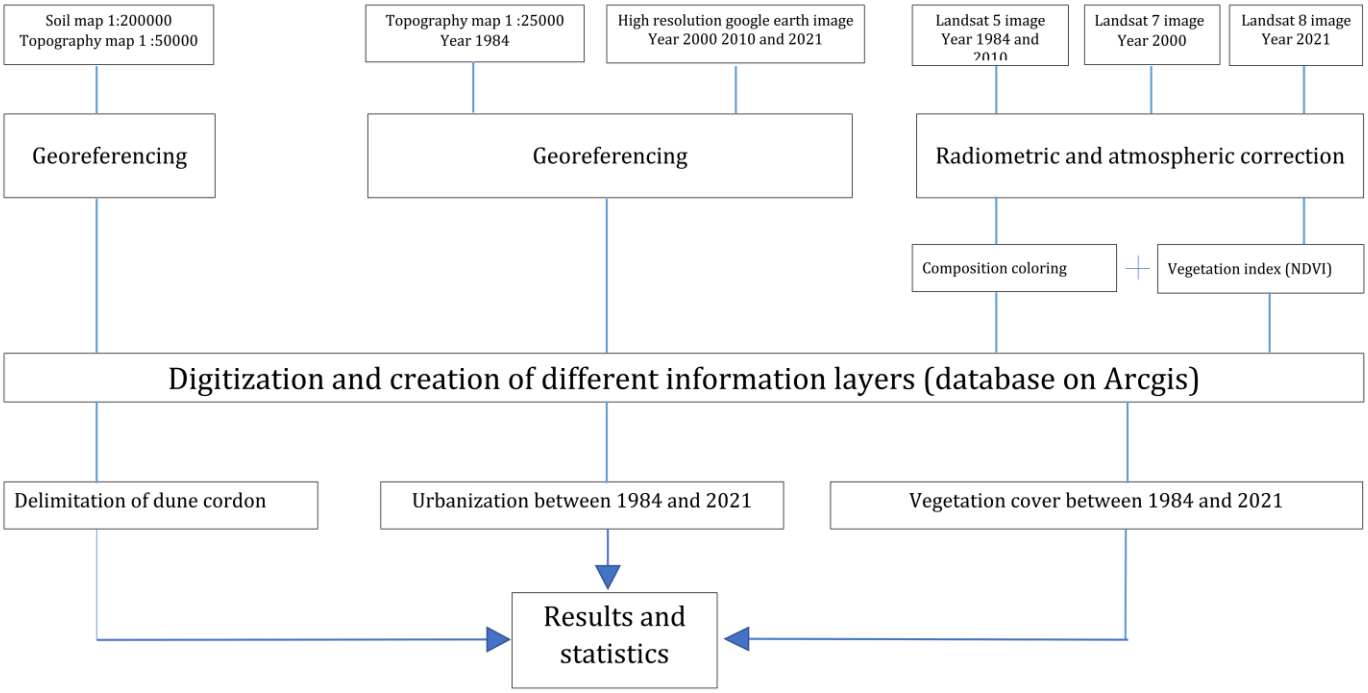

Fig. 2 : Diagram illustrating the main steps of the study

Table 1 : the data used in the study.

data	years	Echelle
Topographic map	1984	1 :50000
Soil map	1929	1 :200000
Image google earthe pro	2000 2010 2021	High resolution
Landsat image	1984 2000 2010 2021	Spatial resolution (30m)

Table 2 : characteristics of the Landsat images used

Date of acquisition	Sensor	Spectral band (µm)	Spatial resolution
27.09.1984 17.07.2010	Landsat 5 TM	Blue (B1): 0.45-0.52 Green(B2) : 0.52-0.6 Red(B3) :0.63-0.69 Infrared(B4) :0.76-0.9	Multispectral=30m Panchromatic =15m
19.09.2000	Landsat 7 ETM+	Blue (B1): 0.45-0.52 Green(B2) : 0.52-0.6 Red(B3) :0.63-0.69 Infrared(B4) :0.76-0.9	Multispectral=30m Panchromatic =15m

16.08.2021	Landsat 8 OLI	Bleu (B2) :0,45-0, 515 Vert(B3) :0,525- 0,6 Rouge(B4) :0,63-0,68 Infrared (B5) :0.845-0.885	Multispectral=30m Panchromatic =15m

3. RÉSULTATS

We used Arc_Map V 10.8 to quantify landscape changes. We visually identified the land use and manually plotted each corresponding polygon.

A spatial overlay of the different layers of information (urbanization, vegetation and dune cordon) on a GIS platform (Figure 3); allowed us to see the evolution of the surface occupation on the dune cordon; the results show an urban sprawl along the dune cordon with a parallel degradation of vegetation cover, Table 3, summarizes the main statistics of the occupation of the dune surface.

Table 3: The percentage of ground cover and urban tissue in relation to the total surface of the coastal dune

	1984	2000	2010	2021
Ground cover	44%	33%	30%	24%
Urban tissue	4%	12%	18%	25%

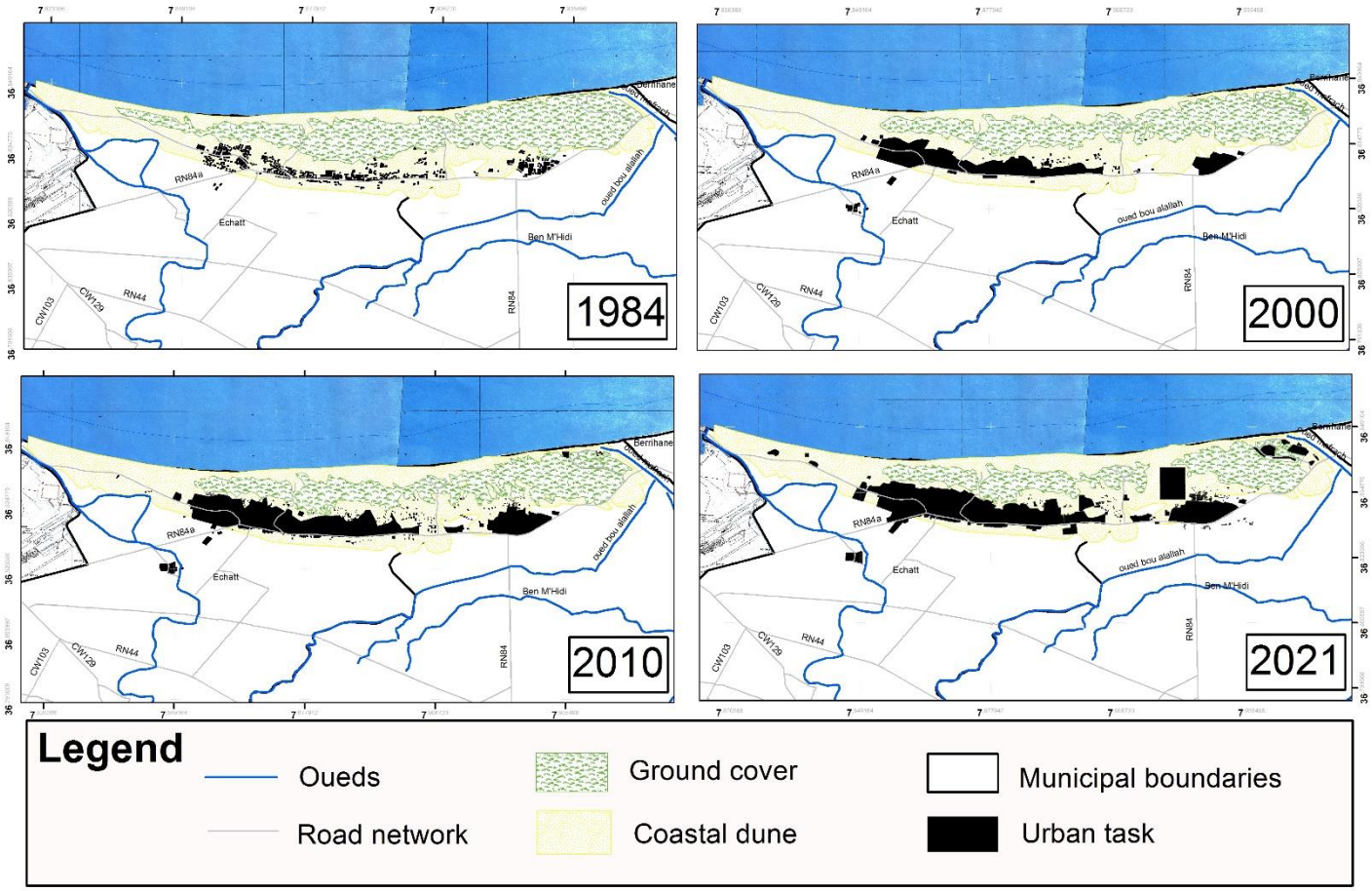

Fig. 3 : evolution of the ground cover and urban tissue of the study area between 1984 and 2021

In 1984, the urban area was 61.62 hectares and it reached 428.6 hectares in 2021, which means that it increased by 366.95 hectares. The annual increase rate of the urban area is 10 hectares/year.

Upon observing the results, we found that the urban area has multiplied by 7 times in 37 years. (Table 4).

Between 1984 and 2000, we recorded an increase in the urban area by 208.56 hectares (multiplied 3 times). Between 2000 and 2010, the increase in the urban area was 301.84 hectares, and between 2010 and 2021, it was 428.6 hectares. (Table 4).

Table 4: urbanized area and land cover between 1984-2021

Year	1984	2000	2010	2021
Urbanized area (ha)	61,62	208,56	301,84	428,58
Land cover area (ha)	752,74	562,06	512,55	413,45

The notable thing in these results is that there is a significant increase in the rate of urban area expansion between 2010-2021 where it reached 11.5 ha/year.

Between the periods of 1984-2000 and 2000-2021, the rate of expansion was 9.2 and 9.3 ha/year, respectively. (Table 5).

Table 5: the urbanization rate for each period

Period	Urbanized area (ha)	Urbanization rate (ha/year)
1984-2000	146,93	9,2
2000-2010	93,28	9,3
2010-2021	126,73	11,5

In parallel, the clearing of vegetation cover recorded in the study area between 1984 and 2021 reached 339.29ha, i.e. an average of 9.42ha/year, while between 1984 and 2000 the area of cleared vegetation cover reached 190.69ha, i.e. an average of 11.92ha/year. This result is consistent with the population growth recorded in the region during this period (Table 6).

Table 6: the land cover clearing rate for each period

Period	Surface clearing (ha)	Clearing rate (ha/an)
1984-2000	190,69	11,92
2000-2010	49,51	4,95
2010-2021	99,09	9,91

Between 2000 and 2010, we recorded a decrease in the degraded forest area (49.51 hectares). This decrease was mainly due to changes in the state's housing policy, which shifted from building individual homes to constructing residential complexes, in accordance with Law 02-02 of February 5, 2002, related to the protection and enhancement of the coastline as it considered coastal dunes a fragile area in need of preservation and protection.

From 2010 to 2021, deforestation of vegetation cover reached 99.09 hectares, averaging 9.91 hectares per year. This was mainly due to large state projects, including the marine military base and investment projects in the El BATTAH tourism activities zone. (Figure 4).

Fig. 4 : photos showing some projects in the study area (B.bilal 5-12-2021)

4. DISCUSSIONS

It is clear that urban expansion is heading towards the north (Mediterranean Sea) (Figure 3), at the expense of the forest cover of the dune cord. The geological nature of the region (dune cord) has

accelerated the urbanization process due to the ease of leveling the land for construction. This increase in urban expansion is mainly due to the increasing housing needs of the population. According to statistical data from the monograph of the El_Tarf province for the year 2020, the population of the coastal region of El_Tarf province is estimated to be around 136,450 inhabitants in 2020, representing 28% of the total population of the province.

The high demographic pressure observed in the city of El-Chatt is due mainly to its privileged location, offering its residents easy access to the wilaya of Annaba (located only 5 km away), which represents the third economic pole in Algeria.

There is also a significant development and increase in urban fabric through individual constructions, either under the Algerian state's policy of accompanying and providing housing in rural areas or through illegal private individual constructions (Figure 5).

Fig. 5: Buildings for individual and collective housing (B.bilal 17-10-2021)

This urban expansion has remained uncontrolled for a long time (Kacemi 2011) to the detriment of the land cover of the coastal dune (Figure 6) despite the existence of legislative instruments prohibiting urbanization on the dune cordon and strips of easements including the Coastal Law 02-2002.

Fig. 6 : land use change between 2009 and 2021(google earth pro)

The destruction of vegetation and the mobilization of sandbanks can have significant consequences on the stability and integrity of the dune belt in our study area. Indeed, vegetation plays a crucial role

in fixing the dunes by limiting their movement and erosion. The destruction of this vegetation, through trampling and overgrazing, can therefore lead to an acceleration of dune erosion and an increase in their mobility.

Similarly, the mobilization of sandbanks due to quarrying or sand extraction on the beaches (especially between the years 2000 -2004) (Figure 7), can have repercussions on the morphology of the dune cordon by modifying the regime of coastal currents and by causing variations in the height and shape of the dunes.

Mechanical beach cleaning, carried out on a regular basis on all the beaches in the dune belt, can have a negative impact on the dune ecosystem. This type of cleaning often involves the use of heavy machinery such as tractors or bulldozers, which can cause physical damage to the dune structure.

The passage of these machines can crush and destroy the dune vegetation that stabilizes the dunes, thus disrupting the fragile ecosystem of these areas. In addition, mechanical clearing can also disrupt dune-dwelling animal populations, such as birds and reptiles, by destroying their habitats and nesting areas.

Finally, mechanical cleaning can also alter the morphology of the dune ridge by removing sand from certain areas and moving it to others. This can cause imbalances in the coastal current regime, which can affect the natural evolution of the dune ridge.

In summary, mechanical cleaning of beaches can contribute to the degradation of the ecosystems within a dune ridge. That is why it is recommended to limit the use of heavy machinery as much as possible and to prioritize manual or light cleaning methods to preserve the biodiversity and stability of the dune ridge.

Regular routes, such as trails and access roads, can influence the equilibrium of the dune cord (De la Vega, 2012). Therefore, regular routes can affect dune vegetation by causing physical and mechanical disturbances. The repeated passage of people and vehicles on these routes can trample and crush the vegetation, leading to a decrease in biodiversity and a loss of the vegetation's ability to fix sand and stabilize the dunes.

Regular routes can also alter the morphology of the dune system by creating depressed or elevated areas that can affect wind and current circulation. If these changes are significant, they can disrupt the balance of the dune ecosystem by altering natural habitats and promoting dune erosion.

Equally, regular routes can have an impact on human use of dunes and beaches, which can influence biodiversity conservation and dune ecosystem management. If courses are poorly designed or located, they can encourage excessive use of dunes and beaches, resulting in negative impacts on dune flora and fauna.

As a result, the destruction of vegetation and mobilization of sandbanks can contribute to the weakening of the dune belt and its vulnerability to natural hazards, such as storms and flooding, as well as to the impact of human activities. It is therefore essential to put in place appropriate protection and management measures to preserve the biodiversity and ecosystems of these fragile areas.

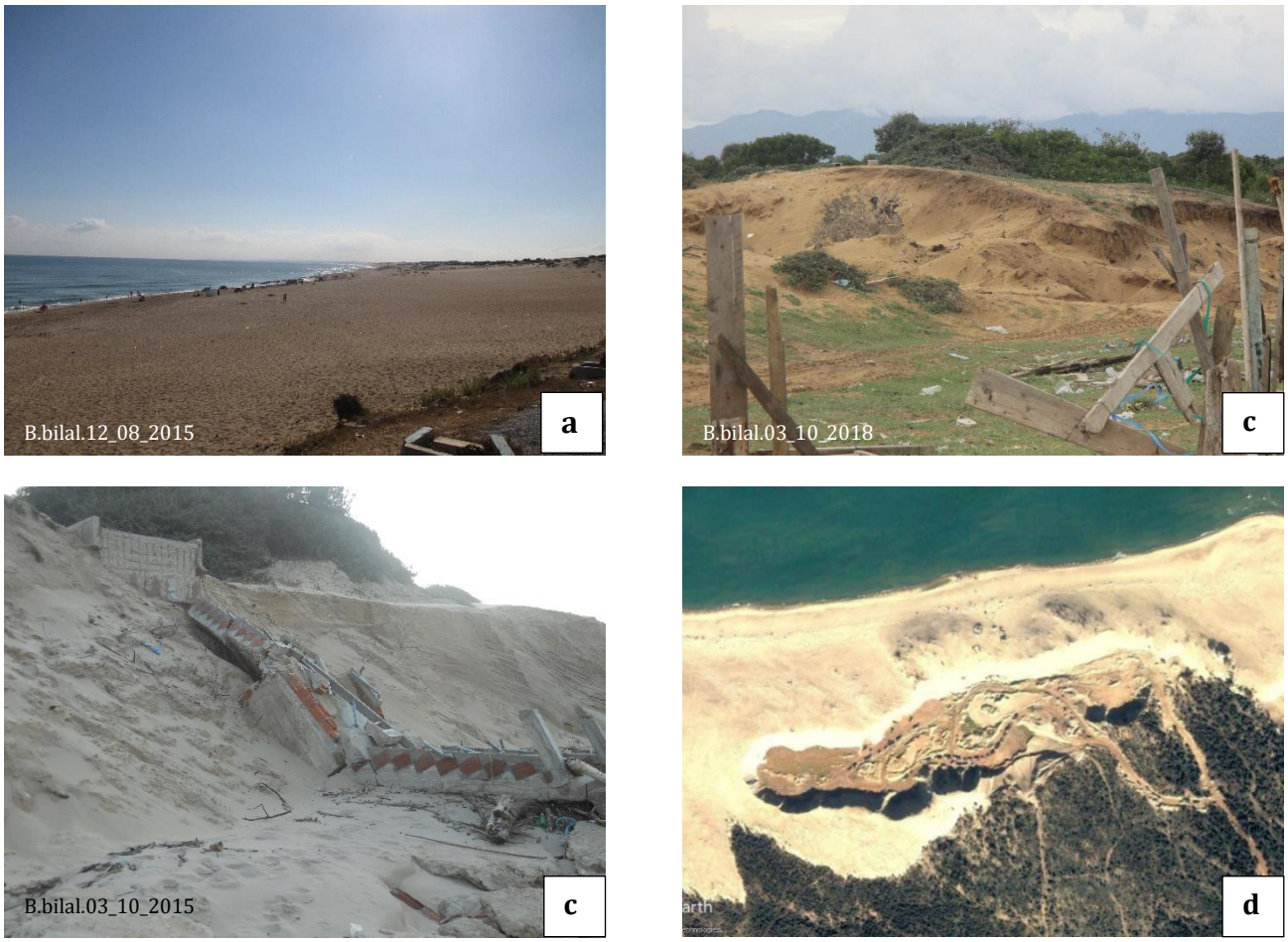

Fig. 7 : (a) beach authorized for swimming, (b) degradation of the coastal dune, (c) coastal erosion, (d) sand extraction (google earth dated 4-2004)

Over the past ten years, the work carried out in the area and the expansion of tourism (total area of 1150 ha with 355 ha developable) (Figure 8) have had a negative impact on the dunes and vegetation cover of the area as pressure is exerted on the dune system caused by construction and development work (Figure 4), traffic of machinery, and trucks.

These activities cause physical and mechanical disturbances to the dune system, leading to destabilization of the dunes and increased erosion.

Thus, the increase in the number of visitors and vacationers on the beaches and coastal dune especially during the summer season (reached 1million according to the civil protection of the wilaya of El Tarf during the summer season 2018) has led to further deterioration through:

- Trampling which destroyed the vegetation cover and harmed the formation of new dunes.
- Waste left on the dunes, which harmed the local flora and fauna.
- Parking, which causes physical damage to the dunes and impairs their ability to resist erosion.

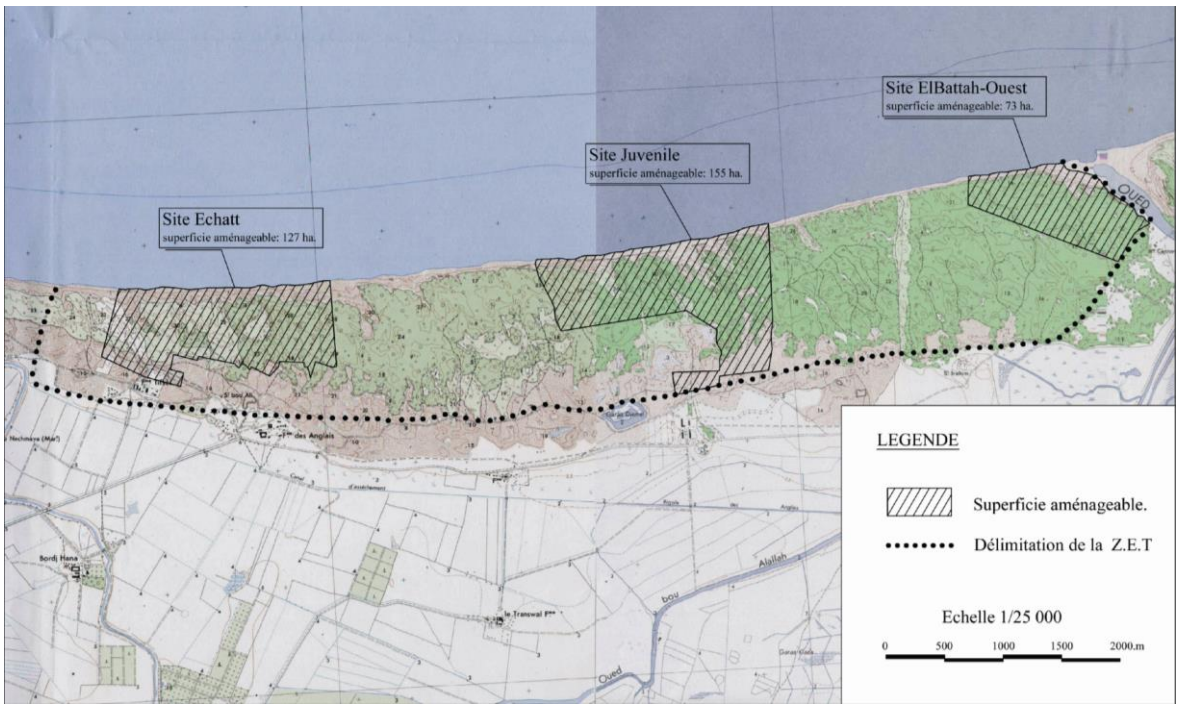

Fig. 8 : Map of the MAFREGH WEST tourist expansion zone (source: Tourism Department)

The agricultural potential and the proximity of the city of echatt to the sea has made it economically attractive, therefore, the urban population has increased rapidly due to migration from nearby rural areas to the city. The population has almost been tripled between 1984 and 2021. This phenomenon has led to an increase in the number of buildings throughout the city. This development of the urban fabric has forced the breeders of the area to exploit the coastal dunes by building stables to house these animals and to practice livestock outside the urban fabric, especially after the communal decision that prohibits this activity in the city (figure 8).

Fig. 8 : barns to shelter the animals inside the coastal dune. (B.bilal 17-10-2021)

The trampling of animals causes soil erosion and compaction, altering the vegetation, which reduces the ability of plants to intercept sand (Figure 9). Direct cultivation on the dunes also impacts coastal dune systems by destroying vegetation and altering the landforms, severely altering the characteristics of the soil through plowing, and altering the characteristics of the underlying water table through the use of fertilizers and pesticides.

Fig. 9 : grazing activity. (B.bilal 5-12-2021)

It is well known that invasive species can displace and locally eliminate natives (Gaertner, Den Breeyen et al. 2009). However, in our case, the presence of two invasive species (Carpobrotus edulis, a South African invasive alien species, Oenothera drumondii, an invasive alien species of American origin) does not seem to have had a significant impact so far, as they were relatively rare(figure 11). Nevertheless, precautions must be taken to prevent any potential unwanted expansion of these alien species. Such monitoring is especially relevant because coastal urbanization can promote the arrival of alien species, which are often introduced as ornamentals and then become naturalized invasive species (Carboni, Santoro et al. 2010). In addition, exotic species (such as Casuarina) are also used for protection against natural coastal hazards such as storms. This species can eventually become problematic as it appears to inhibit the growth of native plants (Moreno-Casasola, Martínez et al. 2013).

Fig. 10 : (a) Carpobrotus edulis, (b) Oenothera drumondii (B.bilal 17_10_2021)

The coastal dunes of the city of Echatt and Sidimbarek are considered a protected area according to the provisions of Law 02-02 on the protection and enhancement of the coastline as a fragile area that must be preserved and protected according to their natural destination, but what we notice on the ground is the opposite.

5. Conclusion

Rapid urban sprawling can indeed have a significant impact on the landscape of the dune cord, which is a fragile and protected area due to its biodiversity and its role in preventing coastal erosion.

When urban development occurs on the dune cord, it can lead to the destruction of natural habitat, fragmentation of ecosystems, and disturbance of local wildlife and flora. Additionally, the construction of roads, buildings, and other infrastructure can alter the natural topography of the dune cord, resulting in increased coastal erosion and flood risks.

A key approach is to concentrate urban development in already urbanized areas rather than allowing uncontrolled expansion on the outskirts of cities. This can be achieved by using land-use policies that encourage the reuse of vacant or underutilized urban land, densification of existing urban areas, and development of more sustainable buildings and housing.

It is also important to consider biodiversity preservation in urban planning by identifying high-value ecological areas such as wetlands, forests, and sensitive natural habitats and protecting them. This can be achieved by creating conservation zones, establishing ecological corridors to allow wildlife movement, and using landscaping practices that preserve native vegetation.

Thus, the challenge we are facing today is whether we combine urbanization with the preservation of natural ecosystems. This is only possible through sustainable land-use planning approaches. By combining these approaches, it is possible to design more sustainable cities that take into account the preservation of natural ecosystems, while meeting the growing needs of urban populations.

Finally, cities can also adopt sustainable land-use practices to minimize negative impacts on the environment, such as waste and water management, use of renewable energy sources, and promotion of public transportation and active modes of transportation such as walking and biking.

The use of Geographic Information Systems (GIS) and remote sensing to study the evolution of the dune system of the city of Echatt and Sidi Mubarek allowed us to make an accurate and comprehensive analysis of changes in the composition, structure and distribution of dune areas, and it also allowed us to determine the degradation recorded in this ecosystem between 1984 and 2021.

In 37 years the surface of the dune cordon vegetation cover decreased by 55% due to intense clearing due to urbanization and the high demand of residential structures for the local population.

The urban area of the city of Chatt and Sidi Mubarak has grown considerably over the past ten years due to rapid population growth despite the existence of the coastal law _02-02_ relating to the protection and enhancement of the coastline, which prohibits new construction on the dune strips and requires all relevant departments to take all necessary measures to rehabilitate and preserve because of their weakness and fragility of this system.

It was also clear that the expansion of urban fabric was made at the expense of the dune ecosystem of the area, which means the depletion of vegetation cover which increased the risk of erosion and desertification.

This practice is a systematic action to sabotage this ecosystem taking the local development of the area as a pretext and cover.

6. ACKNOWLEDGMENT

The authors thank all persons who have contributed anything to this research. In particular, those who provided data and information for data collection.

A big thank you is also addressed to all the team of the National Commissariat of the littoral _Antenne of El Tarf_ for the precious collaboration without which this work would not have been possible.

7. FUNDING

This work was carried out with the contribution of the laboratory of marine and coastal ecosystems (EcoSysMarl) of the École Nationale Supérieure des Sciences de la Mer et de l'Aménagement du Littoral (ENSSMAL).

8. CONFLICT OF INTEREST

The authors have declared that no competing interests exist.

9. AUTHORS' CONTRIBUTION

- BELLOULOU BILAL: Conceptualization (lead); Execution of the investigation (lead); Data analysis and interpretation (lead); Methodology (lead); Project administration (lead); maps establishment (lead); redaction (lead).
- FOUZIA BACHARI HOUMA: Conceptualization (lead); Data analysis and interpretation (supporting); Methodology (supporting); Redaction (supporting).
- SMAIL GEUBABI: Data analysis and interpretation (supporting).

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11. ADDITIONAL REFERENCES: legal texts

Law n° 2002-02 of 22 Dhou El Kaada 1422 corresponding to February 5th, 2002 relating to the protection and the development of the littoral.

Executive decree n° 2006-351 of 12 Ramadhan 1427 corresponding to October 5th, 2006 fixing the conditions of realization of the new motorways parallel to the shore.

Executive decree n°09-88 of 21 Safar 1430 corresponding to February 17th, 2009 relating to the classification of the critical zones of the littoral.

Executive decree n° 10-31 of 5 Safar 1431 corresponding to January 21st, 2010 fixing the modalities of extension of the protection of the seabed of the coast and determining the industrial activities in offshore.

Executive decree n° 07-206 of 15 Joumada Ethania 1428 corresponding to June 30th, 2007 fixing the conditions and the modalities of construction and occupation of the ground on the littoral band, of the occupation of the natural parts bordering the beaches and of the extension of the zone object of non-ædificandi.

Executive Decree No. 14-264 of 27 Dhou El Kaada 1435 corresponding to September 22, 2014 relating to the organization of the fight against marine pollution and institution of emergency plans.

Law n° 03-03 of 16 Dhou El Hidja 1423 corresponding to February 17, 2003 relating to the zones of expansion and tourist sites

12. KEY TERMS AND DEFINITIONS

Coastal dune: a tongue of sand formed (in a gulf or bay) from debris deposited by a coastal current and on which specific vegetation can develop (Art. 2 of law n°02-02).

Dune: a mound or hill of fine sand formed on the coastal zone (Art. 2 of Law 02-02).

An invasive alien species (IAS): is a species introduced by man voluntarily or involuntarily in a territory outside its natural range, and which threatens ecosystems, natural habitats or local species.

ONM: National Office of Meteorology in Algeria.

Tourist Expansion Zone (ZET): any region or area of land with natural, cultural, human and creative qualities or features conducive to tourism, suitable for the establishment or development of a tourist infrastructure and capable of being used for the development of at least one or more profitable forms of tourism (Art. 2 of law n°03-03).