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Evolution of Land Use in the Beni-Belaid Wetland Ramsar Site in North-eastern Algeria

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Abstract

Wetlands constitute ecosystems of great biological, ecological and socio-economic value. Despite these multiple functions and services rendered to human societies, wetlands are among the ecosystems most threatened by human activities. The use of cartography with satellite images and multi-date aerial photos allows us to characterize the current state of land use of wetlands in possible management. This study aims to make a characterization of the different ecosystems by type of land used at the level of the Beni-Belaid wetland located in the North-East of Algeria, which presents an important tool for decision-making, as regards the management and preservation of the area, as well as for the prediction of scenarios of 'probable evolution in the future. Three aerial photos (1973, 1988 and 2008) and a Google Earth satellite image (2020) were used. We proceeded to the selection of the study data, cartographic processing (scanning the maps, geo-referencing, assembly and finally the calibration), determination of the different classes of land use, and calculating the areas of the different land occupations using the Arcgis 10.8 software. The results show a fluctuation in the evolution of land use in the Beni-Belaid nature reserve; the surface area of anthropogenic environments (agriculture, dwellings) increased between 1973 and 2020, to the detriment of natural environments (wooded dunes, forests, lakes, etc.), also reveal very significant threats in the short and medium term, which appear mainly to be linked to intensive agro-pastoral practices and the modification of local hydrology by excessive pumping of water from the lake

Keywords : Wet area ; Beni-Belaid ; land use ; cartography ; Arcgis.

ملخص

تشكل الأراضي الرطبة أنظمة بيئية ذات قيمة بيولوجية وإيكولوجية واجتماعية اقتصادية كبيرة. على الرغم من هذه الوظائف والخدمات المتعددة المقدمة للمجتمعات البشرية، فإن الأراضي الرطبة هي من بين النظم البيئية الأكثر تهديدًا من قبل الأنشطة البشرية. يسمح استخدام رسم الخرائط مع صور الأقمار الصناعية والصور الجوية متعددة التواريخ بتوصيف الحالة الحالية للأراضي الرطبة الهدف من هذه الدراسة توصيف النظم البيئية المختلفة حسب نوع استخدام الأرض. على مستوى أرض بني بلعيد الرطبة الواقعة في شمال شرق الجزائر، رسم الخرائط والذي يمثل أداة مهمة لصنع القرار، فيما يتعلق بإدارة المنطقة والحفاظ عليها، وكذلك للتنبؤ بسيناريوهات `` التطور المحتمل. فى المستقبل. تم استخدام ثلاث صور جوية (1973 و198 و2008) وصورة القمر الصناعي لبرنامج غوغل الأرضي 2020 شرعنا في اختيار بيانات الدراسة، ومعالجة الخرائط (مسح الخرائط، والمراجع الجغرافية، والتجميع، وأخيراً المعايرة)، وتحديد الفئات المختلفة لاستخدام الأراضي، وحساب مساحة المناطق المختلفة للأراضي باستخدام برنامج اركجيس 10.8 تظهر النتائج تذبذبًا في تطور استخدام الأراضي في محمية بني بلعيد الطبيعية، في الواقع ازدادت مساحة التدخل البشري (الزراعة، المساكن) بين عامي 1973 و2020، على حساب الطبيعة (كثبان مشجرة، غابات، بحيرة، وما إلى ذلك) .تكشف النتائج التي تم الحصول عليها أيضًا عن تهديدات كبيرة جدًا على المدى القصير والمتوسط، والتي يبدو أنها مرتبطة بشكل أساسي بالممارسات الزراعية الرعوية المكثفة وتعديل الهيدرولوجيا المحلية عن طريق الضخ المفرط للمياه من البحيرة.

الكلمات المفتاحية: منطقة رطبة؛ بني بلعيد؛ استخدام الأراضي؛ رسم الخرائط تنوع بيولوجي

Introduction

Wetlands contain major ecological, socio-economic, and landscape functions (Westlake *et al.* 2009), including groundwater recharge, flood control, the ability to accumulate toxic chemicals and nutrient recycling (Reddy and Delaune, 2008; Cronk and Fennessy, 2001; Guittonny-Philippe *et al*. 2014). They host in their various habitats biological diversity and rare or threatened species (Médail *et al.* 1998). They condition the exercise of economic activities in the primary sectors (agriculture, animal husbandry, production and distribution of water), secondary (consumption of water in the industry), or tertiary sectors centered on leisure and outdoor activities and drinking water consumption (Barbier *et al.* 1997; Westlake *et al.* 2009). Today, the loss of benefits resulting from the destruction of wetlands is increasingly felt (Médail et al. 1998; Quézel 1998). In Algeria, wetlands are mainly concentrated in the north-east of the country, near the Mediterranean coast. Despite the enormous ecological and economic services, they are recognized for, they are unfortunately not exempt from an unparalleled dynamic of destruction that calls into question the existence of a large number of floristic and faunistic species.

During colonization, this was the case for many wetlands in Algeria, Lake Haloulla in Mitidja, which has completely disappeared, or the marshes of Macta, Lake Fetzara and Lake Tonga that have undergone several attempts to dry up, which fortunately all failed (D.G.F 2004). Many wetlands are also open receptacles for wastewater discharges. This has caused a break in the ecological balance, depriving thousands of water birds of their usual wintering and nesting habitats. Thus, Algeria is currently experiencing serious problems of alteration of its natural sites; this degradation is due to various anthropogenic factors, including inappropriate cultural practices, poaching, and water pumping. In addition, the Commission will continue its work in the field of grazing and the establishment of equipment and infrastructure for the development of the industry. Wetland alteration is also exacerbated by other unfavorable natural conditions, such as soil fragility and climate aggressiveness, which initially contribute to changing land cover and biodiversity (Samraoui *et al.* 1992; De Belair and Samraoui, 1994; Bouldjedri et al. 2011).

Much of the damage is also related to the lack of awareness of the status of wetlands and the challenges associated with these same wetlands. The preservation of these habitats, therefore, involves informing the stakeholders concerned, implementing appropriate management measures, and integrating wetlands into locally planned projects. The wetland of Lake Beni-Belaid on the coast of Kabylia in northeastern Algeria, declared a Ramsar site in 2003, is a freshwater site on the edge of the sea, consisting of an open water body of 10 ha, surrounded by lake vegetation consisting of Tamarix, Aulne glutineux, Fraxinus angustifolia, Phragmite and Typha, a poplar grove (Populus alba), a dune cord, a flood zone (dried in summer), a wadi and finally a beach and a marine zone. This site is the subject of significant and growing anthropogenic use (water pumping, pollution, extension of agricultural land, overgrazing which led to the invasion of the lake by sand, etc.) Thus, important threats are revealed and proven at the level of Lake Beni-Belaid. Indeed, the work of (Bouldjedri *et al.* 2011; Goumidi 2007) as well as several visits that we carried out confirmed the reduction of several parts of the site. However, little management and conservation action has been taken. Other than the installation of a fence in 2008 on the south shore of the lake, nothing has been done. However, in 1997, the site was classified as a nature reserve, under the authority of Forest Conservation, in which the prohibition of all harmful activities was decreed.

This worrying situation has motivated the present study to establish an inventory of the current land use of the Beni-Belaid wetland, in order to consider programs for the restoration and sustainable management of this natural environment.

Material and methods

Study Site

The nature reserve of Beni-Belaid was created by decree of the Jijel province. This protected area is 600 ha, located east of Jijel and 45 km away from it as the crow flies. Administratively, it belongs to the municipality of Oued Adjoul, the department of El Ancer at about 4 m above sea level. The geographical coordinates of the Beni Belaid Nature Reserve are (6° 08 09 E; 36° 54 70 N). This area is limited to the north by the Mediterranean Sea, to the east by djebel Aourar, to the west by Oued El-Kebir and to the south by the agricultural plain of Belghimouz (fig. 1). It is fed by Oued Adjoul which originates in the djebel Aourar (Aidem). It is accessible by wilaya road number 132 connecting El-Ancer to Oued Adjoul.

The Beni-Belaid wetland has a diversity of ecosystems (marine, dune, lake, forest, agrosystem, etc.). The water depth of the lake is between 0.5 and 3 m. During drought years, the eastern part of the lake dries up during the summer season. The water in the lake is fresh. From a hydrological point of view, the site is an extension of the alluvial plain of Belghimouz, with an area of about 1800 ha, drained by a hydrographic network characterized by the high frequency of confluences, rapid, and powerful floods. The lake is fed, in stormy weather by the seawater via the estuary of Oued El-Kébir, by Oued Adjoul, as well as by the rainwater and the resurgence of the water table (Boumezbeur 2002; D.G.F 2004).

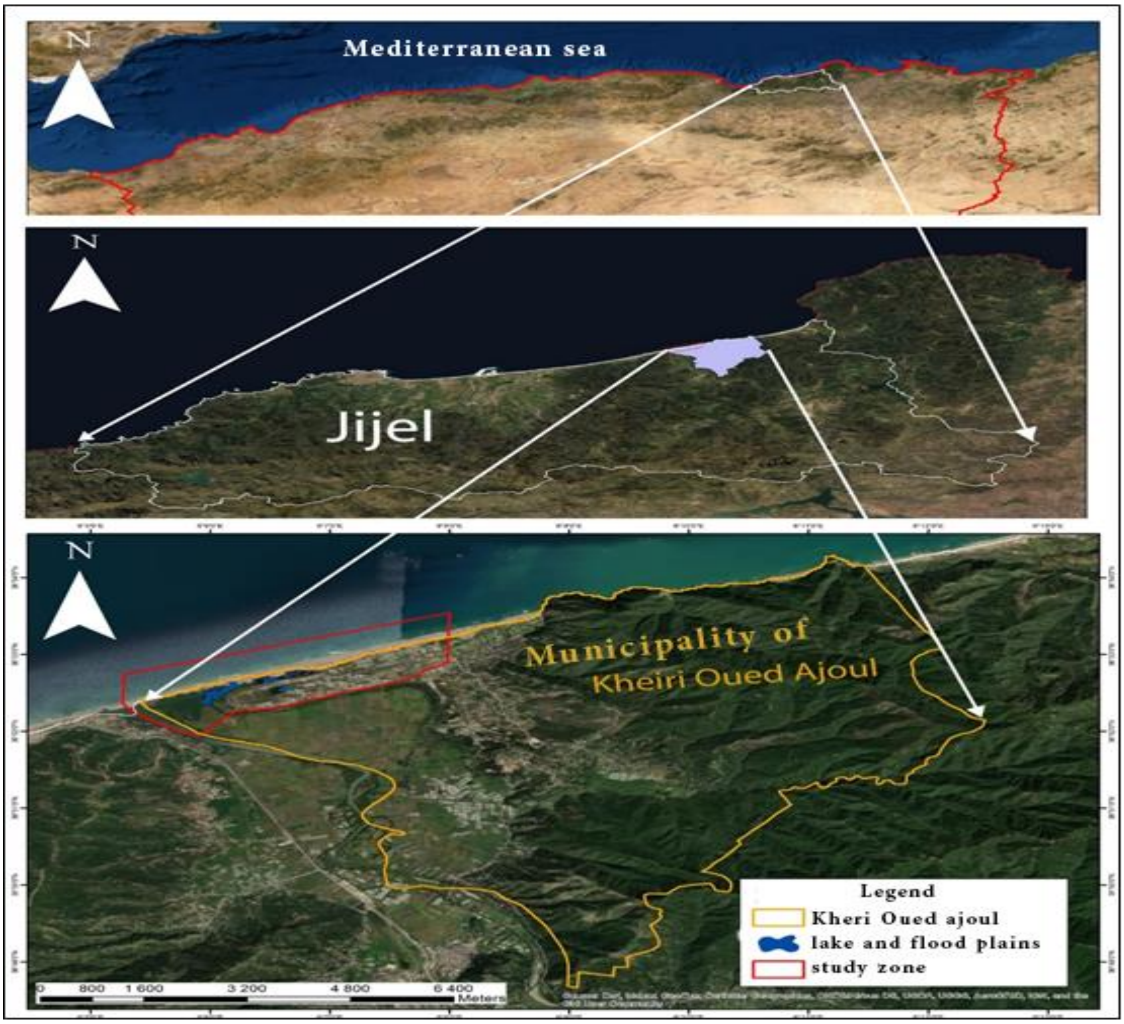

Figure. 1. Situation map of the Beni-Belaid (Jijel) zone (author's treatment)

During rainy years, excess water from the lake is discharged to the Oued El-Kébir by a canal designed by the hydraulic services as part of the development of Lake Beni-Belaid. From a climatic point of view, the Beni-Belaid wetland is located in a humid bioclimatic stage with a temperate winter; it acquires an annual rainfall range of around 1000mm and an annual average temperature of 18°C (ANRH 2020). This area is home to a large number of rare plant species and various biogeographical origins (Mediterranean species, temperate paleo species, tropical species, etc.) as well as an original fauna was identified in the area in fact it was chosen as the pilot site of the MedW2 project, but which unfortunately has never been applied for reasons that remain unknown, this choice is based on the national and international ecological interest of the wetland. Despite its modest size, the Beni-Belaid reserve offers several types of rare habitats on a Mediterranean scale (wet meadows, freshwater lake, temporary pools, dunes,ripisylves, etc.).

The methodological approach is reduced to six (6) main steps. The study data selection, cartographic processing, and statistical analysis.

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Data Selection

The data that were used for the study of the evolution of the land use of the nature reserve of Lake Beni-Belaid are aerial photos of the years 1973, 1988, and 2008, Staff Map 1964, and the satellite image Google Earth of the year 2020. Their characteristics are given in Table 1. These dates were chosen in order to compare the state of the Beni Belaid wetland before and after the emergence of agriculture (greenhouse, and strawberry cultivation) and urbanization. The year 1973 allowed us to have the natural appearance of Beni Belaid before its urbanization. 1988 coincides with the emergence of agriculture. The year 2008 was marked by the emergence of strawberry cultivation. Finally, the year 2020 provides a representation of the recent situation of land use.

Table 1. Spatial data characteristics used for mapping

Years	Scale	Aerial photos	Ortho-photos
1973	1/10.000	2	Not available
1988	1/10.000	2	1
2008	1/20.000	2	1
1964 Staff mape	1/25.000	4	
	Resolution	Number	
2020 Google Earth image	50 centimetre	1	

Map Processing

Data acquisition is followed by data processing; Data processing takes place in 3 steps:

-The first step is to scan (paper media) with a high-resolution scanner to obtain raster images over 1200 dpi.

-After we have geo-referenced and assembled (Mosaic) the four Staff Maps essential steps for the calibration of Ortho-Aerial Photographs, these staff maps were geometrically corrected and projected into the UTM/WGS 84/ZONE 31 North mapping projection system. Using ERDAS V2014 Software (Fig. 2).

- The last stage of processing is to the caller the Ortho-aerial photographs with the ERDAS 2014 software and the four staff cards assembled previously (Image by Image) (Fig. 3).

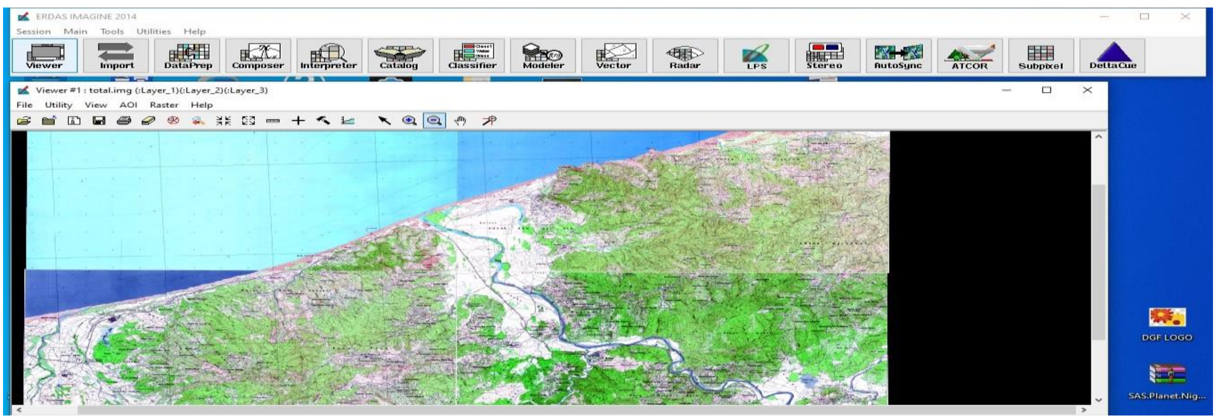

Figure. 2. Screen view of ERDAS V2014 software and Georeferencing and Staff Map Assemblies

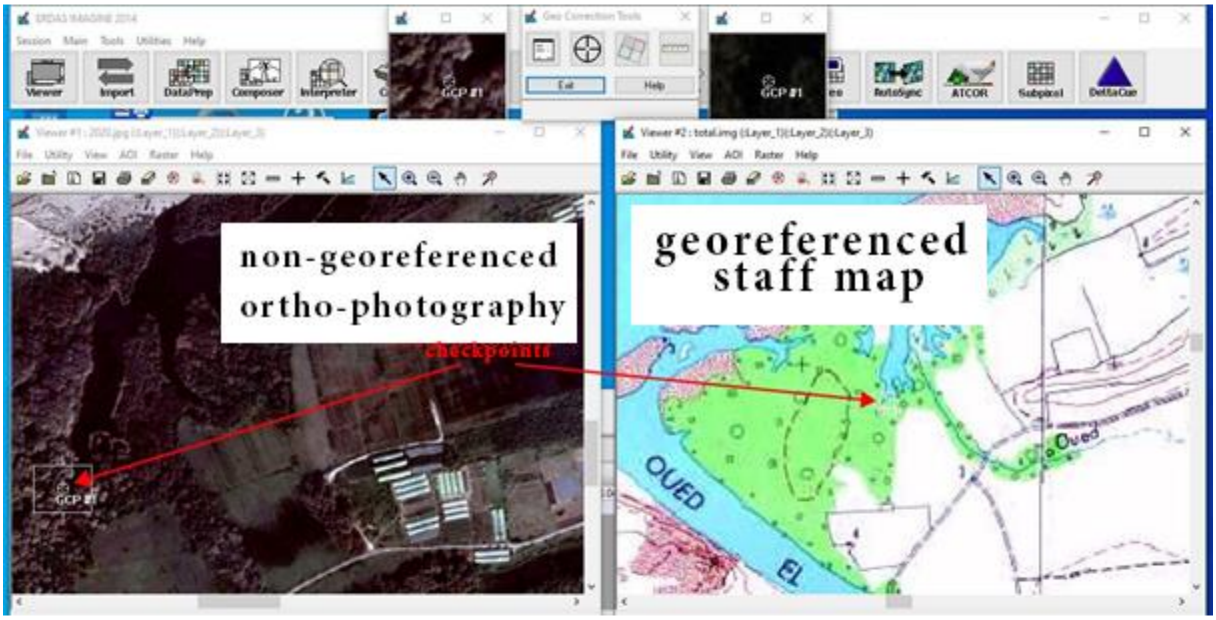

Figure. 3. Screen view of ERDAS V2014 software and geo-referencing of ortho-photos (Image by image)

Identification of Land Use Classes

This step consists in identifying the different occupations of the existing soils at the time of the aerial photography (1973, 1988, 2008) using a stereoscope that allowed us to have a stereoscopic view of our region. On the other hand, with regard to the Google Earth 2020 satellite image, field trips were necessary to verify and confirm the data on maps. However, visual interpretation of the 10,000-scale aerial photographs and field trips identified six (6) classes of land use (Table 2). These different classes are presented in Table 2 below.

Table 2. Study area Land use class descriptions

land use classes	Description	Colour
Lake and flood plains	Open water areas	Deep blue
Forests	Poplar forest	Deep green
Agricultural land	Greenhouses and cultivated land	Light green and orange-green
Wadi	Relatively large watercourses	Light blue
Wooded Dunes	Dune covered with Retama monosperma	Grey-green
Mobile or Bare Dunes	Bare sand dunes	Grey
Housing or buildings	Houses and stables	Orange

Digitalisation (Vectorisation of the Different Types of Land Use)

This step consists in vectorizing the geo-referenced Ortho-aerial photographs using Arcgis 10.8 software while respecting the land use classes described in Table 2 and referring to aerial photographs using a stereoscope.

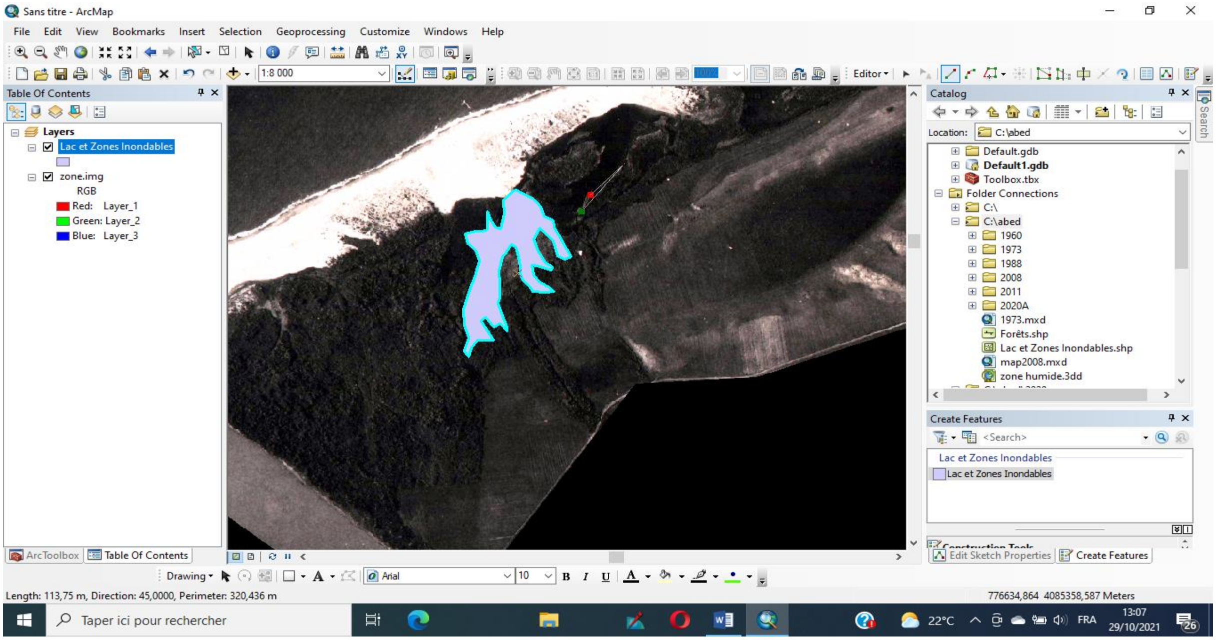

Figure. 4. Screen view of Arcgis 10.8 software vectorization of deferential land use types

Calculate Areas of Different Land Uses

Again in Arcgis 10.8 and the table for each layer (land use class) that we vectorized adds an area field and calculates the area in hectares in "calculates Geometry" by choosing the unit of measure "hectare" (Fig. 5).

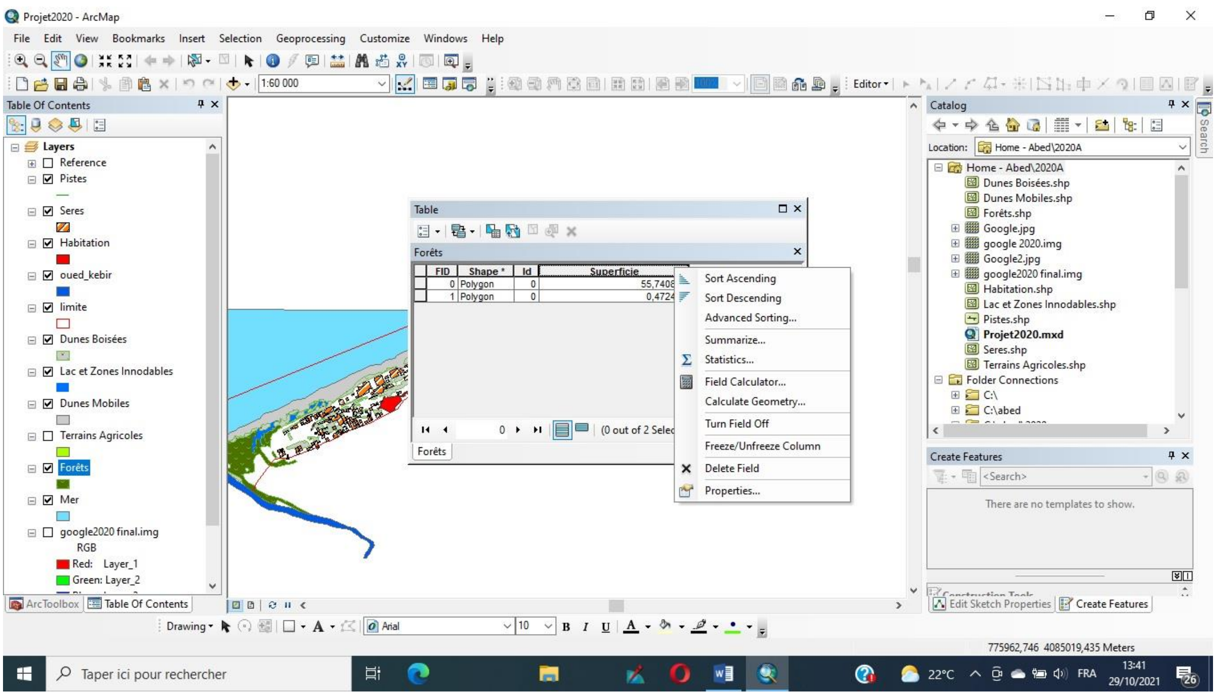

Figure. 5. Calculating areas of different land uses

Statistical Analysis

The analysis of the areas of the land cover classes obtained was done with the calculation of the Expansion Rate (T) given by the formula proposed by the Food and Agriculture Organization of the United Nations (FAO) in 1996 (CSE 2012): T = S1-S2 where S1 and S2 respectively represent the percentage of the area of a land use class in the most recent and oldest year. Positive values of T means an increase in the area of the land cover class and negative values of T means an increase or decrease in area. A value close to zero reflects the relative stability of the occupation class. The expansion rate made it possible to detect changes for each land use class for different periods. The graphical representation of the expansion rate for each period was then made with Excel software.

Results

This work resulted in the production of four land use maps of our study area, each corresponding to a date; namely: 1973, 1988, 2008, and 2020 of different periods, a first of 1973, a second of 1988, a third of 2008 and a fourth of 2020 (Fig. 6) provide an understanding of the dynamics of land use in the Beni-Belaid wetland.

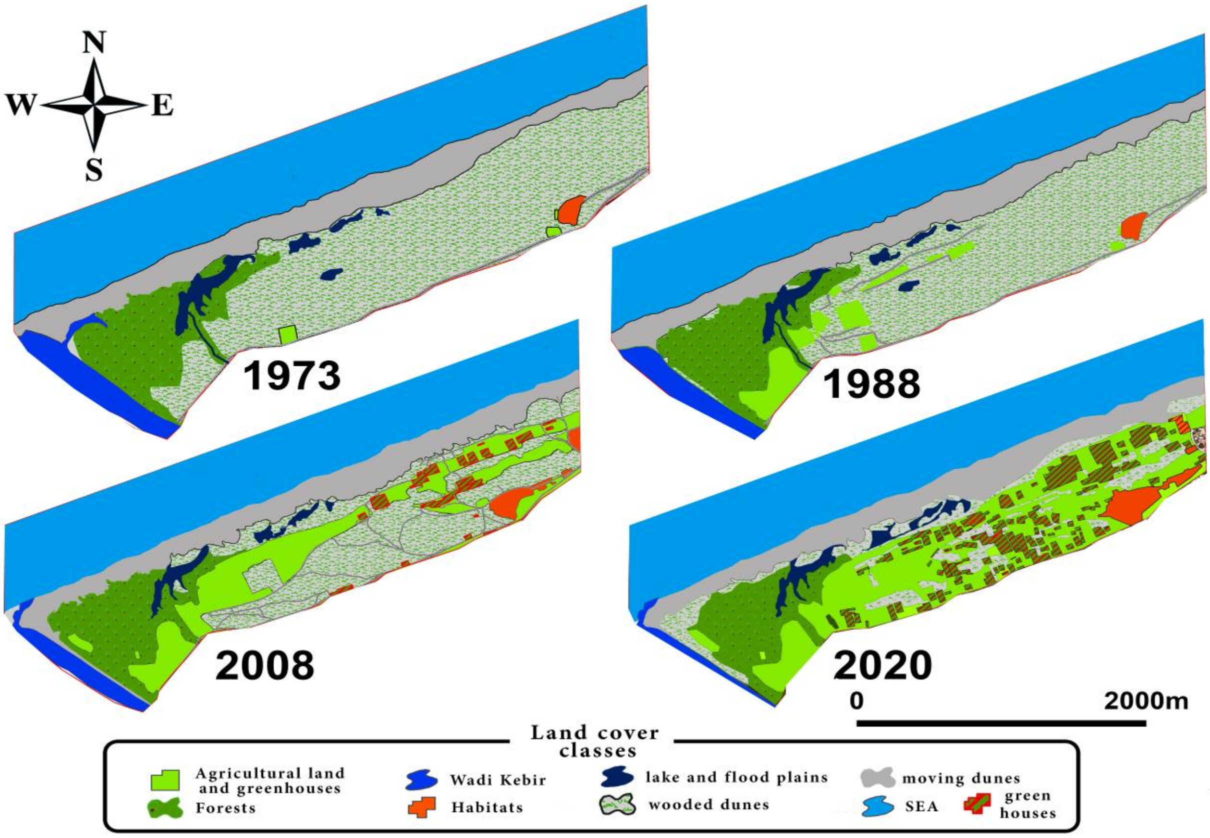

Figure. 6. Land use in the Beni-Belaid wetland from 1973 to 2020

Changes in the Areas under the Different Land Use Categories

The trends in land use in the Lake Beni Belaid wetland between 1973 and 2020 are summarized in Tables 3, 4, and Figure 7.

Table. 3. An area of land cover classes mapped from 1973 to 2020

land use classes	Area (ha) 1973	Area (ha) 1988	Area (ha) 2008	Area (ha) 2020
Lake and flood plains	15.13	8.53	6.90	9.75
Forests	54.84	54.98	47.40	45.27
Agricultural land	2.30	9.75	90.50	159,18
Wooded Dunes	203.92	193.92	129.03	55.27
Mobile or Bare Dunes	71.62	83.06	74	73.29
Housing or buildings	2.25	3.51	5.62	11
Total %	354.08	353.76	353.47	353.77

Table. 4. Rates of different land use categories

land use classes	Area (%) 1973	Area (%) 1988	Area (%) 2008	Area (%) 2020
Lake and flood plains	4.27	2.41	1.95	2.75
Forests	16.61	15.54	13.41	12.79
Agricultural land	0.64	2.75	25.60	44.99
Wooded Dunes	57.79	54.81	36.50	15.62
Mobile or Bare Dunes	20.22	23.48	20.93	20.71
Housing or buildings	0.63	0.99	1.59	3.10
Total (%)	100	100	100	100

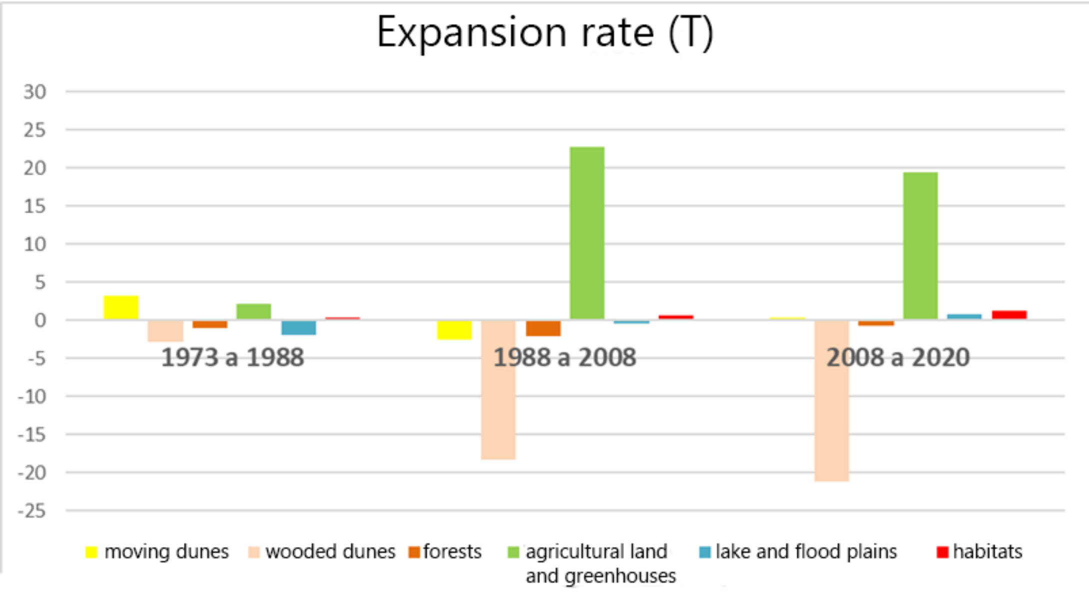

Figure. 7. Changes in the rate of expansion of land occupation classes

Over a period of 47 years, Tables 13, 14, and Figure 7 show a regressive change in the area of wooded dunes from 203.92 ha in 1973 to about 55.27 ha in 2020, the disappearance of 148.65 ha and an expansion rate of -41.97%. This disappearance occurred on behalf of the mobile dunes, whose surface area increased from 71.62 ha in 1973 to 83.06 ha in 1988, with a positive expansion rate of 3.56% to 74 ha in 2008 with a negative expansion rate of -2.55%, and the end of 73.29 ha marked in 2020 with an expansion rate of -0.22%, as well as on behalf of agricultural land and greenhouses which, in turn, saw their surface area increases from 2.3 ha in 1973 to 159.18 ha in 2020, a progressive increase in the area of 156,88 ha and with a very remarkable expansion rate of 44.35%. On the other hand, and in parallel with the decline of wooded dunes and the increase of agricultural areas and the surface of mobile dunes, the surface of the water body (the lake itself) and flood zones recorded a significant decrease; from 15.13 ha in 1973 to 8.53 ha in 1988; or a loss in surface area of 6.6 ha which represents a negative expansion rate of -1.86%, from 1988 to 2008 losses are estimated at 1,63 ha which represents a still negative expansion rate of -0.46%, from 2008 to 2020 we noticed an area gain estimated at 2.85 ha and with a positive expansion rate of 0.80%.

For the forest ecosystem, which is represented by a white poplar grove, we found a continuous decline of this ecosystem, in fact the area of the poplar grove went from 58.84 ha in 1973 to 45.27 ha in 2020, a loss of 13,57 ha and a negative growth rate of -3.82%. Finally, urbanization marked its presence to the detriment of natural ecosystems with a gradual evolution over time in fact the area of inhabitations has increased from 2.25 ha in 1973 to 11 ha in 2020, an advance of 8,75 ha is an expansion rate of 2.47%.

Discussion

The very important agricultural development of the last decades has resulted in the clearing of vast areas in the Maghreb in the plains and the Collinean regions, to the detriment of forest ecosystems (especially Oleo-Lentiscetum) and wetlands (Médail and Diadema, 2006).

According to (Gherzouli 2013; Bouldjedri 2012) anthropogenic pressure remains the primary threat to this site, in the form of irrational use of the lake's water resource through excessive pumping during dry periods. The use of speculative crops (strawberry cultivation) from 2004 onwards and the extension of agricultural land (the emergence of greenhouse crops in 1988) in the region to the detriment of natural formations that contain a high biological diversity, sand removal, and tourism activities. To this are added the problems of extension of constructions of houses of individuals and uncontrolled grazing (above all cattle breeding).

According to (Bouldjedri *et al.* 2011; Bouldjedri 2012) the silting of the body of water on the north side, especially on the east side following the de-vegetation of the dune cord, which allowed the sand to advance towards the lake, being the embryonic dune disappeared under the effect of winds (wind erosion). The disappearance of the initial form of the water body in the southern part, which was delta-shaped. Change in the shape of the mouth of Oued El Kabir, hence the diversion of the wadi to the west (Djenah), which can influence the water supply to the lake significantly even for the irrigation of the poplar grove.

These threats are all the more worrying since there is currently no regular monitoring of the current state of the ecosystems of this wetland, of animal and plant communities, nor any management of human practices (agropastoralism, hunting, fishing, irrigation. . .), in or around the wetland.

According to (Bouldjedri 2012), In addition to their systematic destruction, wetlands in North Africa also suffer from the accumulation of pesticides and fertilizers, which result in increased pollution and eutrophication of fresh water. The protection of the Beni-Belaid wetland implies, in the first instance, preserving it from the direct influence of crops by repopulating the deforested dunes from their original vegetation (Retama monosperma bovei. Diotis maritima or Echinophora spinosa remarkable and rare species). This belt could also act as a barrier to the advancement of sand towards the lake and the penetration of potentially invasive alien species and promote the maintenance of macrofauna (otters, birds) subservient to riparian habitats. However, this restoration cannot be achieved without at least a temporary exclusion from grazing, and thus the defense of large portions of the wetland perimeter, including the surrounding dune complexes.

Conclusion

The mapping techniques used have made it possible to highlight the mutations experienced by the nature reserve of Lake Béni-Belaid under the influence of anthropogenic pressures. The evolution of land cover shows that despite its status as a Ramsar site, it was subject to substantial changes during the period 1973-2020. A significant decline in the area of natural habitats, including forested sand dunes, poplar, lake and flood-prone areas, has been observed, leading to their fragmentation and fragmentation of ecosystems. Human activities have also physically and functionally interrupted a large number of ecological corridors, thus reducing the links between the wetland's biodiversity reservoirs. There is an increase in the area used by artificialized spaces (living quarters, agriculture and greenhouses, etc.). This progression is always mainly at the expense of natural spaces.

Diachronic study through the mapping of changes is an effective approach, allowing a rapid assessment through a mapping highlighting the dynamics of land use and its impacts on natural ecosystems. The supports (aerial photographs, satellite images...) old and recent, are of great utility in this approach. The results of this study can be taken into account for the development of a management plan for the Lake Béni-Belaid wetland, the implementation of which would effectively safeguard its natural wealth.

In the face of this situation, the alternative is to take on a number of actions of extreme urgency, notably by carrying out: (i)A diagnosis of the current state of biodiversity of the Beni-Belaid wetland, (ii) The preparation of intervention and development plans to combat the spread of this scourge, involving all actors, researchers, local authorities and the populations concerned, (iii) The development of an information system on degraded wetlands for decision-making and extensive public information on this major risk to wetlands in general and coastal lagoons in particular.

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Conflict of Interest

The authors declare no conflict no interest.

Author's Contributions

All authors have read and agreed to the published version of the manuscript.

References

ANRH 2020. Agence nationale des ressources hydriques (Jijel).

Centre de suivi écologique du Sénégal (CSE). United States Agency for International Développement (USAID) et Coastal Resource Center (CRC) 2012. Dynamique de l'occupation des sols, cartographie des CLPA, des zones de pêche et mise en place d'un système d'information géographique, Gestion concertée pour une pêche durable au Sénégal, Rapport d'exécution du Projet USAID/COMFISH, 61 p.

Barbier E.B. Acreman M. Knowler D 1997. Economic valuation of wetlands: a guide for policy makers and planners; The Ramsar Library, Ramsar Convention Bureau, Gland, Switzerland,116p.

Quézel P 1998. La végétation des mares transitoires à isoètes en région méditerranéenne, intérêt patrimoniale et conservation. Ecologia Mediterranea, 24:111-117.

D.GF. DIRECTION GENERALE DES FORETS. 2004. Atlas IV des Zones Humides Algériennes d'importance internationale. Ed. Direction générale des forêts, Ben Aknoun, 89 p.

Samraoui B. De Belair G. Benyacoub S 1992. A much threatened lake: Lac des Oiseaux (N.E. Algeria), Environmental Conservation, Vol. 19, N°3, pp. 264-267+276.

De Belair G. Samraoui B 1994. Death of a lake : Lac Noir in Northeastern Algeria, Environmental Conservation, Vol. 21, N°2 (1994), pp. 169-172.

Bouldjedri M. De Belair G. Mayacha B. Muller S.D 2011. Menaces et conservation des zones humides d'Afrique du Nord: le cas du site Ramsar de Beni-Belaid (NE algérien). C.R. Biologies, 557- 772. https://doi.org/10.1016/j.crvi.2011.06.009

Bouldjedri M 2012. Contribution à l'Etude Ecologique d'un Hydro-système de la région de Jijel : cas de la zone humide de Béni-Bélaid, Th.Doc. en écologie végétale, Univ. Badji Mokhtar, Annaba, 152p.

Boumezbeur 2002. Atlas ses 26 zones humides algériennes d'importance internationale. Rapport : Direction de la protection de la flore et de la faune Alger, 89p.

Goumidi A 2007. Etude de l'adaptation et de la biodiversité sur les dunes de sable côtières de sidi Abdelaziz et Béni-Bélaid, mémoire d'ingénieur. Université Jijel, 65p.

Cronk J.K. Fennessy M.S 2001. Wetland plants: biology and ecology.Lewis Publishers, CRC Press, Boca Raton, F.L.,USA, 440 p.

Guittonny-Philippe A. Masotti V. Höhener P. Boudenne J.L. Viglione J. Laffont-Schwob I 2014. Constructed wetlands to reduce metal pollution from industrial catchments in aquatic Mediterranean ecosystems: A review to overcome obstacles and suggest potential solutions. Environment International, 64: 1–16. doi:10.1016/j.envint.2013.11.016.

Médail F. Roche P. Tatoni T 1998. Functional groups in phytoecology: an application to the study of isolated plant communities in Mediterranean France. Acta Oecologica, 19(3): 263-274.

Médail F. Diadema K 2006. Biodiversité végétale méditerranéenne et anthropisation : approches macro- et micro-régionales Ann. Geogr., 651 (2006), pp. 618-640.

Reddy K.R. Delaune R.D 2008. Biogeochemistry of wetlands Science and Applications. CRC Press, Boca Raton, FL, 800 p. doi: 10.1016/j.ecoleng.2010.01.001.

Quézel P 2020. Réflexions sur l'évolution de la flore et de la végétation au Maghreb méditerranéen Ibis Press, Paris.

Gherzouli Ch 2013. Anthropisation et dynamique des zones humides dans le nord-est algérien: apport des études palynologiques pour une gestion conservatoire. Th. Doc. en Géographie. Université de Toulouse. Français, 206p

Westlake D.F. Kvet J. Szczepanski A 2009. The Production Ecology of WetlandsThe IBP Synthesis, Cambridge University Press, London, UK, 568 p.