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Original article

Ecosystem services, vulnerability and threat levels of Ramsar wetlands in the complex of Aurès Sbkhates, North-Eastern Algeria

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ABSTRACT

A socio-economic study were carried out in the wetlands complex of Aurès Sebkhates, in North Eastern Algeria. This study aimed to identify the ecosystem services obtained by local stakeholders, describe the anthropogenic impacts and evaluate the vulnerability and threat levels of three Ramsar wetlands: Garaet Timerganine (freshwater), Garaet Annk Djemel & El Merhsel (brackish water) and Sebkhet Ezzmoul (salt water). A socio-economic survey was conducted of 70 randomly selected households (social group) and 24 people belonging to the local administration (focus group). Vulnerability and threat levels were analyzed. Provisioning and monetary value are the most relevant ecosystem services (water pumping, grazing, agriculture, area for recreation, plant and egg collection, salt mining). Indirect ecosystem services rendered by the studied wetlands (water treatment/flood control) are only known by the focus group. 95% of the surveyed locals believed that the studied wetlands have experienced significant degradation in recent years mainly by human activity. Our results revealed significant threats due to salt mining and the excessive water pumping practiced within the three sites. Natural stressors such as drying out, erosion and siltation also contribute to the disturbance of these wetlands. Analysis of vulnerability (V_t) and threat (T) indices revealed that Garaet Timerganine is highly vulnerable (V_t= 1.48; T = 17.16), Ezzmoul is moderately vulnerable (V_t = 0.23; T = 2.3) and Annk Djemel & El Merhsel are weakly vulnerable (V_t = 0.04; T = 0.28). This study highlighted the most vulnerable wetlands in order to prioritize them and to build a strategy for conservation and their wise use.

KEY WORDS: wetlands, socio-economy, semi-arid environment, threat, vulnerability

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1. Introduction

Wetlands are one of the richest ecosystems on the planet and rank second after tropical forests in terms of biodiversity and natural productivity (VASCHALDE, 2014). Around the world, many people depend on wetlands for their basic needs, especially for a water supply. They have long supplied food, water, building materials and other ecosystem services for humans and their well-being (WALSH ET AL., 2014). Wetlands also have a profound impact on the urban environment, including the hydrological cycle, flood control, shoreline protection, climate regulation, landscaping, and shelter of aquatic species (TANGAO ET AL., 2019). Although they are recognized as major ecosystems in terms of their diversity and functional role, wetlands are often the subject of adjustments and development plans linked to the increase in human activities (ACREMAN, 2000). These modifications are the main cause of the deterioration of these ecosystems (BONNET ET AL., 2005).

DAILY ET AL. (2009) define ecosystem services as the "conditions and processes through which natural

ecosystems and species therein sustain and fulfill human life or have the potential to do so in the future" (sic). The ecosystem services or benefits that humans receive from nature have come to be a main concept and organizing principle for global environmental policy. Ecosystem services were categorized by the ''Millennium Ecosystem Assessment'' into: provisioning, supporting, regulating, and cultural services (FISHER ET AL., 2009). In ecosystem service assessments, wetlands are cited as the most valuable parts of our landscape (COSTANZA ET AL., 1997–2014; MITSCH & GOSELINK, 2000; DEGROOT ET AL., 2012; MCINNES, 2013). COSTANZA ET AL. (1997) showed that wetlands, especially inland swamps and floodplains, were considerably more valuable than lakes and rivers, forests, and grasslands.

For a long time, the Mediterranean wetlands have been damaged, or heavily reclaimed, for agricultural purposes, improvement of tourist areas and perceived health benefits (PARRINELLO & BÉCOT, 2019). During the last twenty years, the Mediterranean region has lost more than half of its wetlands (BONNET ET AL., 2005; TAYLOR ET AL., 2021). Considered as a hot spot area (ADLOFF ET AL., 2015), Mediterranean wetlands and their biodiversity are in sharp decline in recent decades (PERENNOU ET AL., 2012) and their degradation is faster than that of any other ecosystem (DAVIDSON, 2014).

The main threats assigned to Mediterranean wetland loss are anthropogenic due to land use (ZORRILLA-MIRAS ET AL., 2014), water pollution, invasive species, sectorial and unsustainable water management, over-exploitation of certain resources (BLINDA & THIVET, 2009) and climate change (ERNOUL ET AL., 2020; TAYLOR ET AL., 2021). These threats are particularly critical, because of both the lack and irregularity of freshwater resources, and because of the increasing human pressures disturbing them directly or indirectly (OZHM, 2012). Moreover, the loss of wetlands leads not only to the disappearance of species, but it also affects the social and economic benefits of stakeholders who depend on these wetlands for their subsistence (WANZIE, 2002). In this context, TAYLOR ET AL. (2021) studied several issues, which highlight the relationship between Mediterranean wetlands and the overall socioeconomic and political status of a country or a region, such as, urban areas, poverty, tourism etc. To identify the important wetland ecosystem services and the priority areas for wetland conservation, it is important to consider economic valuation techniques and to combine such information with indicators of biodiversity and socioeconomic marginalization (CAMACHO-VALDEZ ET AL., 2020).

Algeria is one of the Mediterranean countries, whose water resources are limited and dependent on the influence of the climate (TOUITOU & AL-AMINB, 2020). In fact, due to the diversity of its climate and its original physical configuration, it is rich in wetlands, which are among the most precious resources in terms of biological diversity and natural productivity. In the last survey carried out by the General Direction of Forests, Algeria records 2,375 wetlands, 2,056 are natural and 319 are artificial including 50 wetlands of international importance (RAMSAR, 2019). These wetlands play an important role in vital processes, maintaining hydrological cycles and housing an important flora and fauna (GHERZOULI, 2013). However, they remain nowadays almost completely ignored and are the subject of very few conservation measures (BOULDJEDRI ET AL., 2011). They are also an important source of life for the riparian population who exercise economic activities such as agricultural actions, livestock rearing (DJENNANE, 1990) and salt mining (HACINI ET AL., 2009). They therefore show an extremely worrying decline, under the influence of various anthropogenic pressures (pumping, drainage, grazing, pollution and salt mining) (DE BÉLAIR, 2005).

Nevertheless, strong demographic growth, the complexity of the land structures and under-estimation of the intangible values of a wetland can constitute a threat of disproportion between the production potential of the sites and the economic needs of the local communities. Our study was conducted in the Sebkhates of Aurès wetland complex, located in North Africa where the climate is semi-arid to arid with low rainfall from year to year (WILLIAMS, 1998). Despite the water salinity, which is sometimes extremely high, the wetlands of the area offer the local population considerable economic resources and current socioeconomic issues, such as agriculture (cereal and vegetable cultivation) practiced at subsistence and industrial levels, livestock breeding, and potential for salt mining (DEMNATI ET AL., 2012).

This study was carried out in three Ramsar wetlands in North East Algeria: Garaet Timerganine (freshwater), Garaet Annk Djemel and El Merhsel (brackich water) and Sebkhet Ezzmoul (salt water). It aims to describe the profile, and the types of activities carried out by the local population. Also, this research assesses the natural and human pressure; and evaluates the threats and vulnerability levels of the three studied wetlands. The data analyses are made according to the degree of salinity of the water, which globally determines the population's activities, as well as the exploitation of the provided services. The results could provide

the state of threats weighing on these wetlands and considers conservation and management guidelines for the sustainable use of these ecosystems.

2. Materials and methods

2.1. Study area and sampling sites

The study area is located in the vast region of the eco-complex wetlands in the highlands of eastern Algeria, called "the great country of lakes" by the earliest geographers because of the presence of a large set of endorheic salt-water bodies (SI BACHIR, 1991). The study region, as well as the studied wetlands, is located in the territory of the wilaya of Oum El Bouaghi (administrative province) which covers an area of 2 492 330 ha (DGF, 2016) and provides homes for a distinct human population whose density is 120 people/km^2. The studied province harbours numerous wetlands of which 7 are classified as Ramsar sites; the total wetlands area covers 89,035 ha of the total territory of the province.

The study region is characterized by a semi-arid climate with cold winters; it suffers a long period of summer drought, which dries out streams and water bodies from June to September (average yearly precipitation is between 25 and 200 mm) (ALIAT ET AL., 2016). The region is known by a poorly supervised agricultural uses, mainly in areas where the water is fresh or slightly brackish (LARIBI ET AL., 2016).

This study focused on 3 Ramsar sites that are part of the ''Sebkhates of Aurès wetlands complex'' according to the classification established by the new national strategy of Algerian wetlands (DGF, 2016). The studied sites are: (i) Garaet Timerganine located 4 km south of Aïn Zitoune village (8 people/km^2); (ii) Garaet Annk Djemel & El Merhsel located 5 km from the village of Boughrara Saoudi (14 people/km^2); and Sebkhet Ezzmoul located 0.2 km from the village of Ouled Zouaï (36 people/km^2) (Fig. 1). The choice of sites was driven by water salinity (fresh, brackish, and salt water) which generally determines the ecosystem services provided and the human activities of the local population. The location, ground cover and general characteristics of the three study sites are provided in Table 1 and Figure 1.

2.2. Socio-economic survey

A socio-economic survey was carried out among the neighboring residents around the three wetlands (social group), as well as with people involved in the management and conservation of these sites (focus group). For the social group, 94 people were interviewed (34 in Timerganine, 19 in Ezzmoul and 17 in Annk Djemel & El Merhsel); and 24 people belonging to the focus group. We were unable to increase the size of the sample surveyed due to the constraints of accessibility to certain houses and some people categorically refused to participate in the survey.

Two types of questionnaires were used in an interview format. The first encompassed 23 questions and targeted most of the households living near the sites (riparian farmers). The questionnaire focused on two main aspects: (1) socio-economic information about the householders (age, school/ education level, main activities and incomes) and, (2) information on the wetland with the objective of identifying and evaluating the available resources and their uses: bringing out the ecosystem services provided by the wetlands, human activities/uses, and anthropogenic impact. This approach was carried out with the aim of assessing the nature of the relationship between the local communities and the wetlands as well as the impacts of their practices on biodiversity and natural habitats.

The second questionnaire survey encompassed 10 questions and targeted local administrations (focus group), where the choice was more specific and targeted people working in the environmental field (administrative directions of forest, agricultural services, and environment of Oum El Bouaghi; and the town hall of Ain Zitoune). The people surveyed were government employees who also live near the studied wetlands. The questionnaire intended for them was practically the same as that conducted with the local population and aimed to enrich the information collected, in particular, concerning the ecosystem services of wetlands and to get an idea of the skills of managers in terms of knowledge of wetland conservation and management.

The two questionnaires were written in French but the interview was done orally in local dialect Arabic or Tamazight (local languages), to simplify the understanding of all the questions by the surveyed population. The average duration of an interview was 30 to 50 minutes. Some interviews took more than an hour. All of the people interviewed during this study responded voluntarily. Some of them chose not to answer certain questions.

We also proceeded to understand the direct observations of the behavior of the users during the survey, by noting all the observations relating to the frequency of visits to the wetland and the adjacent areas as well as the anthropogenic activities carried out whilst highlighting their potential impacts and threats to the ecosystem.

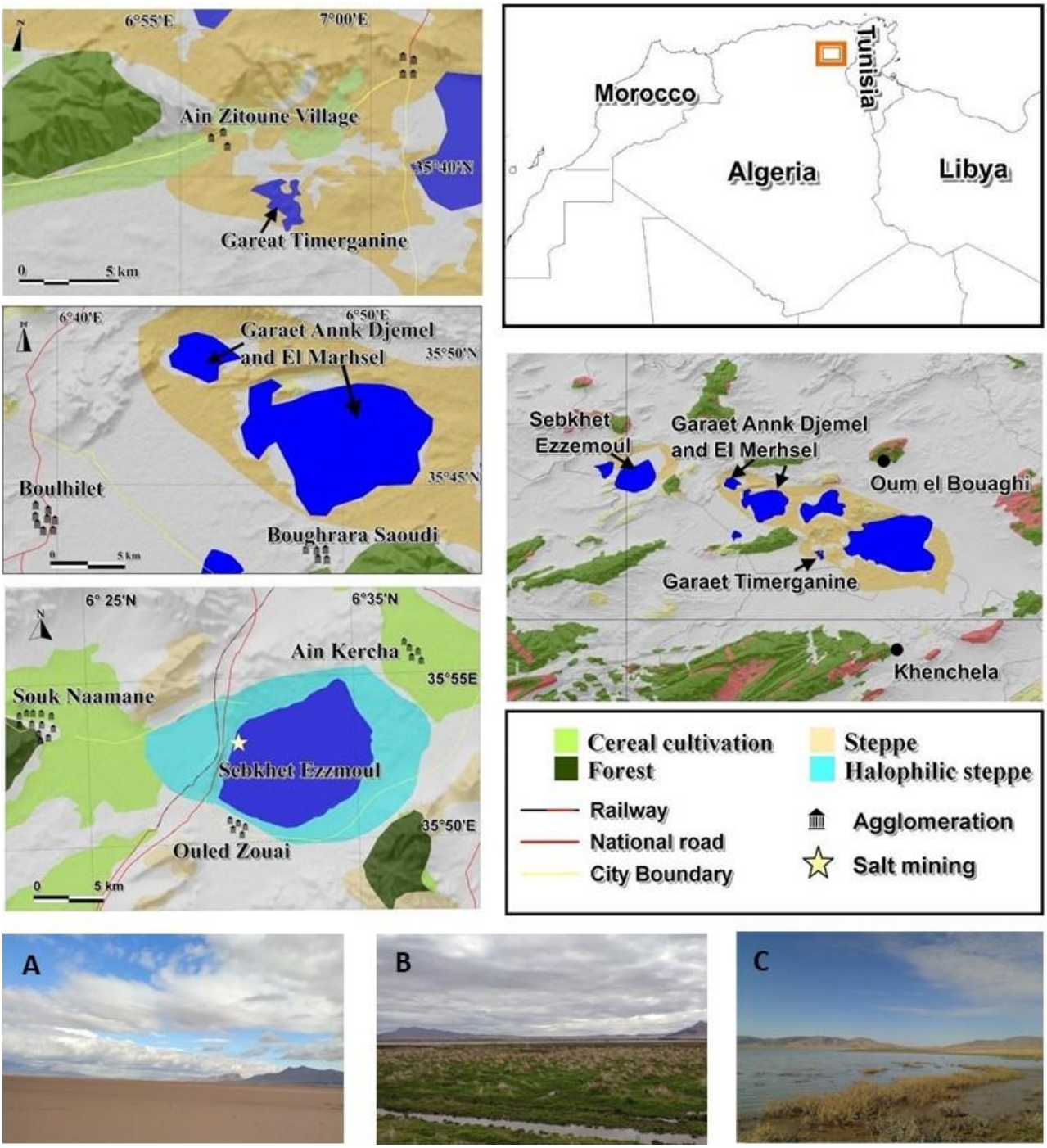


Fig. 1. Location, genaral ground cover and photos of the three studied Ramsar wetlands (North East Algeria): Sebkhet Ezzmoul (A), Gareat Annk Djemel & El Merhsel (B), and Gareat Timerganine (C)

Table 1. General characteristics of the three studied wetlands (*: see Appendix 1 for details on Ramsar classification criteria)

Ramsar Wetland	Garaet Timerganine	Garaet Annk Djemel & El Merhsel	Sebkhet Ezzmoul
Date of Ramsar designation	18/12/2009	12/12/2004	18/12/2009
Ramsar classification criteria (*)	2 - 3 - 4	2 - 6	3 - 4 - 6
Coordinates	35° 40' N - 06° 58' E	35° 47' N - 06° 51' E	35° 53' N - 06° 33' E
Water salinity (mg/l)	0.1 - 0.3 Freshwater	30 - 40 Brackish water	300 - 400 Salt water
Surface (ha)	1,460	18,140	6,765
Altitude (m)	840 - 860	830 - 844	786 - 800
Depth (m)	0.5 – 2.0	0.5 – 8.0	0.3 – 1.0

2.3. Site vulnerability assessment

Site vulnerability was evaluated using the various identified and most frequent uses of the studied sites. Vulnerability indices were assigned for each use of the sites. Indices between 0 and 3 were suggested, the value of the index increases with the impact of the use and the resilience of the wetland which is defined as the capacity of an ecosystem to resist a natural or anthropogenic disturbance (WESTMAN, 1986; BRAND, 2009). We identified and classified the specific anthropogenic uses/stressors that were used to construct this index (see Appendix 2 for more details). The depth of the sites was not taken into account in this assessment because wetland depths are not very great in the 3 studied sites (less than 1m during most of the year). The total vulnerability of each site (V_t) was calculated as the sum of the indices attributed to each use identified at the sites (V_i) by the surface area of each site (S) (MEDDEw, 2012) : $V_t = \Sigma V_i/S$.

2.4. Assessment of site pressure and threat level

Several works have dealt with the pressures and risk assessment of different environmental types (FUERTES-GUTTIÉREZ ET AL., 2016; SELMI ET AL., 2019; KUBALÍKOVÁ & BALKOVÁ, 2023). In our study, when assessing pressures, vulnerability and threats, we used the formulas established by MEDDE (2012). Thus, the ppressure is defined as the external factors that exert an influence on the natural habitats, it was calculated based on accessibility to the site, distance to the nearest road, distance to the city, the nearest house (isolated habitat), and land status. Each value representing these pressure factors (p_i) was weighted from 1 to 3 (low, medium, and high) and the final pressure index (Pt) was calculated by: Pt =Σ pi (Table 2).

The degree of threat level on each wetland (T) was calculated as the product between the total vulnerability (Vt) and the total pressure (Pt) of the site: T = Vt * Pt. It represents the risk of wetland disappearance.

2.5. Data analysis

We determined the correlation between the two pressure factors (natural and anthropogenic) and the site type using a statistical linear regression test. Odds Ratio (OR) and confidence intervals (95% CI) were performed using IBM SPSS Statistics software for Windows version 20.0 (ARMONK, NY: IBM CORP, 2019).

Table 2. Results of the association analysis of three sites studied with different threat factors (OR: odd ratio, CI: Confidence Interval; *P* is significant ≤ 0.05)

Threat factors	Garaet Timerganine		Garaet Annk Djemel & El Merhsel		Sebkhet Ezzmoul	
	OR (CI 95%)	*P*	OR (CI 95%)	*P*	OR (CI 95%)	*P*
Salt mining	-	-	1.674 (4.782-0.586)	0.336	0.55 (0.018-0.168)	**0.000**
Tourist/leisure activities	1.154 (0.493-2.702)	0.742	0.588 (0.207-1.674)	0.320	1.293 (0.530-3.154)	0.572
Eggs collecting	1.154 (0.493-2.702)	0.742	0.312 (0.096-1.012)	0.052	1.950 (0.803-4.738)	0.140
Siltation	0.703 (0.295-1.680)	0.428	1.748 (0.666-4.588)	0.257	0.909 (0.365-2.265)	0.838
Erosion	0.901 (0.372-2.181)	0.817	1.295 (0.478-3.511)	0.611	0.900 (0.352-2.301)	0.826
Drying out	2.467 (1.054 -5.218)	**0.037**	0.729 (0.266-1.988)	0.539	0.508 (1.197-1.310)	0.161
Pollution	1.481 (0.631-3.474)	0.367	0.389 (0.130-1.164)	0.091	3.103 (1.271-7.579)	**0.013**
Poaching	1.280 (0.550-2.980)	0.567	0.555 (0.195-1.576)	0.269	1.206 (0.496-2.930)	0.680
Pumping	2.750 (1.179-6.417)	**0.019**	0.412 (0.138-1.234)	0.113	0.980 (0.400-2.401)	0.966
Overgrazing/ agriculture	1.542 (0.662-3.593)	0.316	0.729 (0.266-1.998)	0.539	0.794 (0.320-1.966)	0.618
Collecting plants	3.048 (1.216-7.638)	**0.017**	0.239 (0.089-0.644)	0.050	0.695 (0.324-1.951)	0.616

3. Results

3.1. Profile of the surveyed population and wetlands ecosystem services

Almost all of the surveyed population was male, only 9.85% of women took part in the conducted surveys whose respondent ages ranged from 16 to 68 years old. At the three study sites, the illiterate people were represented by the farmer-herders, however, more than half of the herders and farmers had primary school level education. The average educational level was more represented by respondents who exercised various activities, while the focus group had secondary and university level education.

The annual declared incomes were 235,076.56 Algerian Dinars (i.e. 1,710.52 US $) for 67.6% of the surveyed households. In the three study sites, the main activity of the surveyed inhabitants was farmer-breeders who only breed animals (Timerganine: 55.54%; Annk Djemel & El Merhsel: 53.82% and Ezzmoul: 48.57%), followed by farmers (plant production), and breeders (animal production) (10 to 25%). In addition, the inhabitants practice various other activities, consisting mainly of small trades and pottery (diverse activities: less than 20%) (Fig. 2).

According to our survey, the area of the wetlands are very important for multiple uses by the local population, which represent the main ecosystem services. The collected data allowed us to identify 9 ecosystem services which are considered economic or direct services: egg collection, water uses (pumping), watering livestock and for irrigation, grazing, agriculture, recreation area, collecting plants, water treatment/flood control and salt mining. The survey also showed the importance of indirect ecosystem services rendered by the studied wetlands (water purification, flood control). Only a tiny segment of the surveyed population knew these services, which was represented mainly through the focus group (Fig. 3).

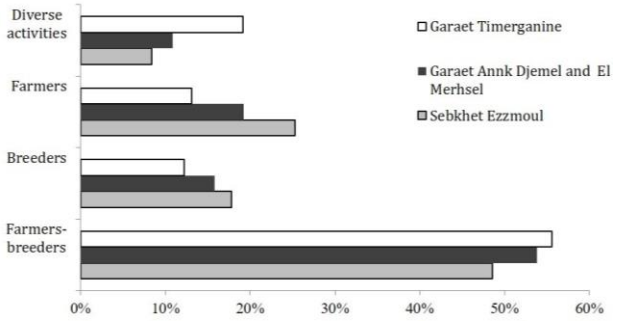


Fig. 2. Types of the uses carried out by the local population in the three studied Ramsar wetlands

The ecosystem services identified have different weights from one site to another. In Garaet Timerganine (freshwater), water pumping was the highest ecosystem service cited by people questioned with 66% wheareas, recreational area was the lowest cited with 36%. In Gareat Annk Djemel and El Merhsel (brackish water), recreational area is the highest ecosystem service cited (24%) followed by agriculture (23.52%) while watering livestock and irrigation represent only 9.33% of the responses. In Sebkhet Ezzmoul (salt water), 73% of the people surveyed recognized that salt mining was the most important ecosystem service, whereas water pumping was the lowest (20%).

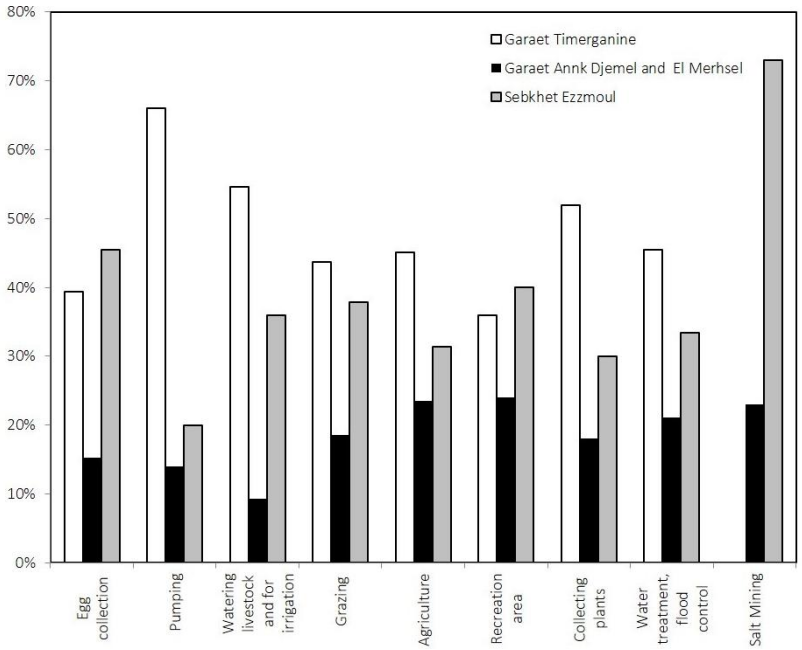


Fig. 3. Proportion of direct and indirect ecosystemic services provided by the three studied wetlands

3.2. Pressure and threat levels of the studied wetlands

For all the three studied sites, 95% of the respondents believed that these wetlands have experienced degradation in the most recent ten years and according to them, this degradation was mainly caused by natural and anthropogenic factors. The natural factors are represented by drying out (37%), siltation (31%) and erosion (36%). Anthropogenic pressure and threat levels were perceived in different ways by the population as: salt mining (26%), collecting plants (39%), pumping (43%) and pollution (33%). The studied wetlands are also affected by poaching (36%) and overgrazing/agriculture (34%), tourism and leisure activities (36%). Our survey revealed 39% of answers given regarding egg collection from birds nesting in the three studied wetlands by the residents of the sites (Fig. 4).

Our survey indicated that Garaet Timerganine was significantly correlated with drying out, pumping and collecting plants (P=0.037; P=0.019; P=0.017 respectively), although Sebkhet Ezzmoul was highly significantly correlated with salt mining (P=0.000) and pollution (P =0.013). Garaet Annk Djemel & El Merhsel showed no statistically significant correlation with any of the factors studied (Table 2).

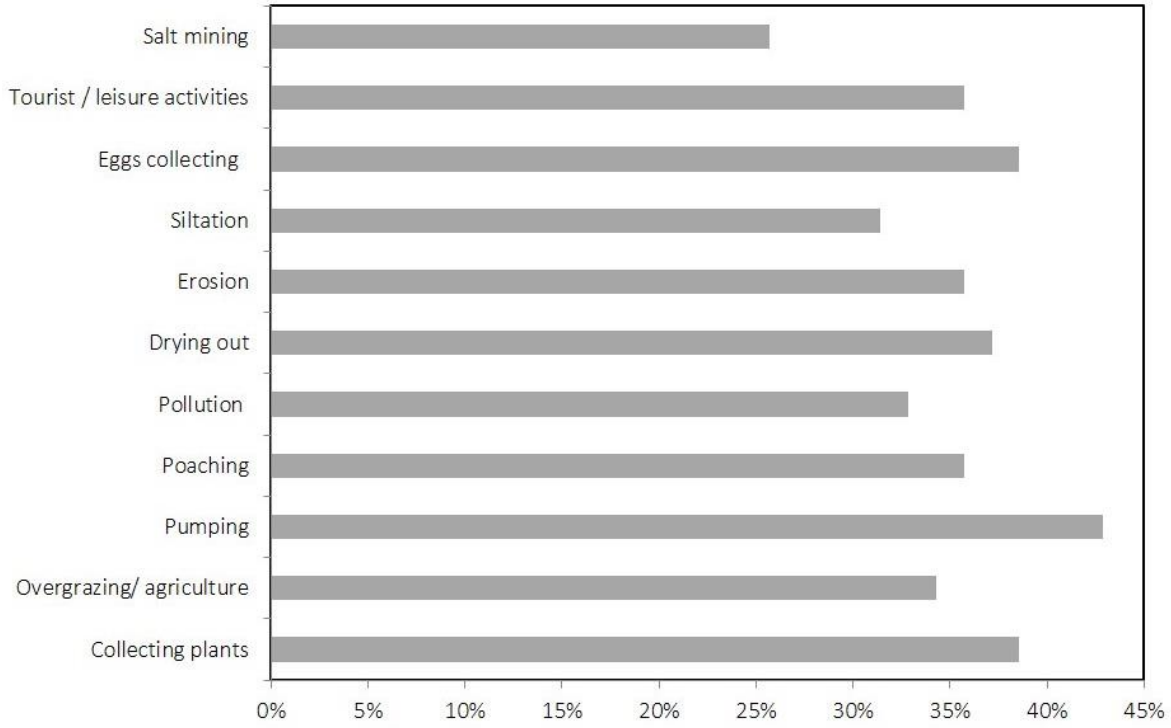


Fig. 4. Threat factors on the three studied wetlands

3.3. Pressure index, vulnerability and threat levels of the studied wetlands

We distinguished three pressure levels attributable to the study sites (Table 3). Gareat Timerganine is subject to the highest pressure (P_t = 12), followed by Sebkhet Ezzmoul with a medium pressure level (P_t = 10), while Garaet Annk Djemel & El Merhsel had the lowest pressure levels (P_t = 7).

The analysis of vulnerability indices of the studied sites revealed three levels of vulnerability distributed differently on the spatial scale of the studied perimeter. The first level, which corresponds to the weakly vulnerable site, was represented by Garaet Annk Djemel & El Merhsel (Vt = 0.08). The second level was represented by Sebkhet Ezzmoul (V_t = 0.35), which corresponds to a moderately vulnerable site. The third level was represented by Garaet Timerganine which corresponds to the very vulnerable site (V_t = 1.5) (Table 4). The threat level index is highest at Gareat Timerganine (T = 18), medium at Sebkhet Ezzmoul (T = 3.5) and lowest at Garaet Annk Djemel & El Merhsel (T = 0.56) (Table 4).

Table 3. Pressure index (P_t) attributed to the different pressure factors in the three studied wetlands (1 = low pressure, 2 = medium pressure, 3= high pressure)

Pressure factor	Effect	Garaet Timerganine (p_i)	Garaet Annk Djemel & El Merhsel (p_i)	Sebkhet Ezzmoul (p_i)
Accessibility (track or road)	Access to the wetland on foot or by car increase in attendance	1	2	3
Distance to residences	Intensification of uses	3	1	2
Distance to town	Risks of destruction by urbanization	2	1	2
Close environment	Wetlands in agricultural areas are more threatened by transformation	3	1	2
Land statuts	Public wetlands are better protected from total transformation than private ones	3	2	1
	Pressure index ($P_t = \Sigma p_i$)	12	7	10

Table 4. Vulnerability levels and index attributed to the three studied wetlands according to the identified uses and site surfaces. (Code: 0 = absent, 1 = low; 2 = medium; 3 = high)

Use	Garaet Timerganine (Vi)	Garaet Annk Djemel & El Merhsel (Vi)	Sebkhet Ezzmoul (Vi)
Salt mining	0	1	3
Tourist / leisure activities	3	1	3
Egg collecting	2	1	3
Siltation	1	1	1
Erosion	1	1	1
Drying out	3	2	2
Pollution	2	1	2
Poaching	2	3	3
Pumping	3	1	1
Overgrazing /Agriculture	3	2	2
Collecting plants	3	1	3
Total vulnerability (ΣV_i)	22	15	24
Site surface (Km^2)	14.60	181.40	67.65
Vulnerability index (V_t) $V_t = \Sigma V_i$/Site surface (Km^2)	1.50	0.08	0.35
Pressure index (P_t)	12	7	10
Threat level index (T) $T = V_t * P_t$	18	0.56	3.5

4. Discussion

4.1. Population activities and the ecosystem services of the studied wetlands

The survey seemed to be necessary in this study to highlight the relationship between the local populations and the studied wetlands, given that this is the first time that such a survey has been carried out in the region. It has therefore enabled us to provide precise, and more, or less, reliable answers to our questions. Beside their international importance, our three studied wetlands have a considerable ecological interest in the role they play as a vital migratory stage for waterbirds, a socio-economic interest, and an important source of life for the locals, supporting many production activities (farming, breeding and other small tracks). With reference to our survey, the perception of the wetlands by the local population is directly linked to the ecosystem services they provide, yet this ignores their conservation value. Also, we point out the ignorance of the local population of the indirect, or ecological services, that the wetlands of the region play. Even the focus group, representing the educated class and managers of the wetlands, only mentioned water purification, and flood control among the indirect services.

According to WOOD ET AL. (2002), wetland conservation is difficult if the local communities

do not understand the real value of the wetlands. The predominance of this practical and materialistic view in the study area may be due to the fact that these services are an integral part of the daily life of the local population, whose main activity is centered on agriculture and livestock husbandry. This practical perception is more important among men than women, whose agricultural crops are largely cereals, mainly barley, some legumes and market gardening, almost all of the production of which is intended for self-consumption. This reflects the strong attachment of the locals to these habitats to partially meet the needs of their livestock and the household, but also the distribution of roles within the household between men and women. However, it is noted that the users who are near wetlands are more aware of the services provided by these ecosystems and of their threats. Generally, there were differences in the level of knowledge and perception based on gender, age, education level and type of activities, as has been proven in previous studies (SOP & OLDELAND, 2011; ETONGO ET AL., 2017; DEMNATI ET AL., 2020). In fact, the strong demographic growth that the region has known recently, the complexity of the land structures and the underestimation of the intangible values of the wetland can constitute a threat due to the imbalance between the production potential of the site and the economic needs of the local population. A better understanding of the local population needs and perceptions are seen as key factors that affect human behavior related to ecosystems and their management (WALTERS, 2004; TIBBY ET AL., 2008).

4.2. Vulnerability and pressure levels of the studied wetlands

Water is considered to be the major economic factor of the region; the increase in the average agricultural area by farmers and livestock breeders weighed more severely on this issue. Because of its fresh waters, Garaet Timerganine suffered the most from excessive pumping of water for agricultural purposes, which limits the sustainability of the water in the wetlands. Gareat Annk Djemel & El Mekhsel and Sebkhet Ezzmoul experienced a lower pumping effect because of their brackish or salt water. ABERKANE (2014) have shown the same results in Gareat Timerganine and Sebkhet Melloul (Ramsar wetland site of the same area), indicating the effect of the excessive pumping of water, the multiple disturbances due to the dwellings and proximity of the livestock. The regression of water in the summer season, which has been observed for several years in the region, has already led to changes in the flora and fauna where several species have regressed, as is the case in the Beni-Belaid wetland, North East Algeria (BOULDJEDRI ET AL., 2011).

Soil salinity has actually increased in the studied area due to the lack of water, which pressures some farmers to reuse drainage water (ALIAT ET AL., 2016). The majority of the surveyed social group was not aware of the protected status of Sebkhet Ezzmoul and agreed that salt mining activities have opened up work opportunities for their family members, despite the threats that this anthropogenic act puts on the wetland. However, they were aware that the method used to collect the salt could have serious consequences for the wetlands and biodiversity of the region. Indeed, the intervention of trucks and engines bring unusual pollution to the wetland. Sebkhet Ezzmoul occasionally experiences periods of higher salinity under natural conditions, due to high evaporation and variability of inputs in this semi-arid region. Furthermore, harvesting salt in the same area for several years can cause pollution of the site by secondary elements mainly magnesium salt (DEMNATI ET AL., 2012). According to FINLAYSON ET AL. (2005), wetlands are now often experiencing extended periods of high salinity due to the impacts associated with changes in land cover and land use. Similar results of increasing salinity have been noted in the semi-arid Eastern Cape Karoo wetlands in South Africa (MABIDI ET AL., 2018). In addition, overgrazing salt wetlands, as is the case in Sebkhet Ezzmoul, could increase soil salinity and cause changes in the composition of the flora, as has already been observed in other saline environments in Tunisia (ZAMMOURI ET AL., 2007) and Argentina (DI BELLA ET AL., 2014).

In Garaet Timerganine, drying out was the most important phenomenon that dangerously affects the site. Indeed, drought periods are sometimes prolonged for several successive months, resulting from the increase in evapotranspiration due to the rise in temperatures by a possible decrease in precipitations and reduction of water inflows in summer from the altitudinal snowpack. The discharge of domestic and/or industrial wastewater directly into the hydrological network is the primary source of pollution in the wetlands. Since the 1970s, most of the Aurès Sebkhates ecocomplex dry out in summer and others only fill with water during years of heavy rainfall (SAHEB, 2009). Climate change, via its impact on rainfall and groundwater recharge, is an important regional driver of wetland hydrology and ecological functions (BARRON ET AL., 2013). Sebkhet Ezzmoul wetland is a wastewater receiver for the agglomerations of ''Ouled Zouai'' and ''Mechtat El Merdja''. This

increases the nutrient content in water that promotes algal growth and eutrophication, but also the disturbance of ecological functioning by damaging the biodiversity, and even the loss of rare, endangered and endemic species of the region (BENZINA ET AL., 2022).

On the other hand, our survey revealed that egg collecting is important in Sebkhet Ezzmoul and Gareat Timerganine due to the important nests that are found in these two wetlands and because of the high number of visitors and tourists.

4.3. Threat levels of the studied wetlands

This study allowed us to reveal the major short and long-term threats, which appear mainly to be linked to numerous practices that are accentuated by modification of the local hydrology by excessive pumping of water, drying out etc. These threats are even more worrying as there is currently no regular monitoring, or management of human practices in, or around, the three studied wetlands. The continued degradation of the wetlands and the decline, or loss, of ecological service functions has led to greater awareness of the importance of wetland ecosystems (XU ET AL., 2019).

Owing to the quality of its freshwater, Garaet Timerganine stands out from the other Ramsar wetlands of this complex whose waters are salty or brackish. The site is constantly subjected to quite intense and diversified uses and great pressures that threaten the site and the living species, especially birds. AOUADI ET AL. (2021) showed that birds were the most attractive wildlife component of an Algerian wetland, suggesting that birds may successfully be used as flagship species for local conservation programs.

Due to the quality of its salt water and the intensification of salt mining, Sebkhet Ezzmoul has become a beneficial site for the local population to increase their income and attract more inhabitants and more visitors. It has become one of the most polluted sites because of these practices and is therefore moderately endangered.

On the other hand, because of its brackish water, Gareat Annk Djemel & El Mekhsel was least threatened and human pressure is the lowest. The site should be the most representative of the area as it plays an important role in hosting a large migratory population of birdlife and helps to maintain their populations, which find favorable conditions for a stopover on their migration path. The anthropogenic pressures only aggravate the ecological conditions suffered by the studied sites, in particular the climate severity, which has led to drying out, which has become practically annual in recent years. Similar drying out problems were noticed in Aguelmam Afennourir, a Ramsar site in Morocco (KHAFFOU ET AL., 2022). MARAMBANYIKA ET AL. (2021) showed that provisioning, regulating and supporting services in the Driefontein Ramsar site in Zimbabwe are severely affected by a high frequency of drought, occurring at least once every two years.

5. Conclusion

In conclusion, we can say that this study has made it possible to highlight the main ecosystem services provided by the wetlands of the Aurès Sebkhates complex. We have also highlighted the vulnerability and degree of threat of the sites studied. Nevertheless, this survey deserves to be taken further for all the wetlands of the Aurès complex by trying to find common ground with the local population and to propose adequate conservation actions to ensure the continuity of these wetlands. In addition, it is necessary to identify the hotspots of these wetlands that deserve special attention in terms of efforts to conserve their biodiversity and habitats, in the context of integrated planning and management of the region using a landscape approach or watershed-based approach.

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Appendix 1. Ramsar classification criteria (Ramsar, 2013; AZHA, 2020)

Wetland	Classification criteria
Gareat Timerganine	Criteria 2. The site hosts species of high heritage value and listed vulnerable on the IUCN Red List : White-headed Duck *Oxyura leucocephala*, Marbled Teal *Marmaronetta angustirostris*, and Ferruginous Duck *Aythya nyroca*. Criteria 3. The site is characterized by lacustrine vegetation, which remain ideal shelter for a many species of Anatidae and grebes that winter there regularly. A total of 22 waterbird species have been inventoried. Criteria 4. This site is one of the few in Algeria, which serves as a refuge and contains, at the same time, the nesting of the three species (criteria 2), with high numbers in comparison with the rest of their populations present in the country.
Garaet Annk Djemel & El Merhsel	Criteria 2. The site hosts Marbled Teal *Marmaronetta angustirostris* a vulnerable species on the IUCN Red List. Criteria 6. The site hosts more than 1% of the regional population of Shelduck *Tadorna tadorna* and the Greater Flamingo *Phoenicopterus roseus*.

Sebkhet Ezzmoul	Criteria 3. The site hosts a large population of wintering and passing waterbirds (Anatidae, Greater Flamingo *Phenicopteres roseus* …). Criteria 4. Ezzmoul is one of the most important sites for Greater Flamingo wintering (10,000 individuals) and nesting in the western Mediterranean basin. Criteria 6. The site hosts a large breeding population of Greater Flamingo *Phenicopteres roseus* (15,000 individuals, 7% of Mediterranean population) and wintering population of Belon's Shelduck *Tadorna tadorna* (4,000 individuals, 6% of Mediterranean population).

Appendix 2. The different identified and most frequent uses in the three studied wetlands

Use	Effect
Salt mining	The salt extractions can be done at the expense of wetlands by modifying the flow of the water table and thus causing a risk of drying out of the surrounding wetlands. It causes a temporary change in water regime.
Tourist/leisure activities	Trampling and solid pollution, waterbirds disturbance.
Eggs collecting	This practice takes place during birds nesting period, inside either body water or the surroundings. Practiced mainly by local residents.
Siltation	May decrease wetland volume, decrease duration wetlands retain water, change plant community structure, and quality of water and soil. This natural phenomenon is accentuated by flat topography, low flows, erosion processes, as well as industrial and urban discharges.
Erosion	Damage and destroy wetland habitat, reduces wetland productivity, degrades wildlife habitat and may eventually result in wetland loss.
Drying out	Change in hydrology, loss of wetland biodiversity functions, the drying up of wetlands reduces the richness species in these environments.
Pollution	All discharges inevitably lead to disappearance of wetlands or changes in plant and animal communities, change in hydrology, loss of biodiversity functions in the wetland.
Poaching	Poaching is practiced either by local residents or by poachers who come from the surroundings. This practice covers all species, even protected ones such as Greater Flamingo (*Phoenicopterus roseus*), Greater Scaup (*Aythya marila*) and Common Crane (*Grus grus*). These practices observed throughout the year lead to the impoverishment of the wintering and nesting waterbirds.
Pumping	The farms surrounding the wetlands pump water from wetlands for irrigation and use the shores as watering points for livestock. These large extractions have an impact on hydrological functioning: upward movement of salts near the bank, change in vegetation and fauna, disappearance of many wetlands.
Overgrazing/ Agriculture	Sheep and cattle farms, land use for feeding cattle. The herds graze the vegetation around the site banks and penetrate inside the water body to graze the green shoots, causing great disturbance for waterbirds habitats. Agriculture is at the origin of illegal clearing which has fragmented the natural environments and degraded the steppes with halophytes.
Collecting plants	Humans use wetland plant species mainly for medicinal purposes (limited number of plants collected in the field).