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Research Article

Potential and perspectives for establishing protected areas in El-Jabal El-Akhdar region, northeast Libya; an overview and example from 'El-Abyar area'

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Abstract

This study was conducted in El-Abyar area in El-Jabal El-Akhdar region, northeast Libya. The aim was to study the environmental settings and the potential and possibility of establishing a protected area in this important region from a historical, biological, social, and economic point of view. The methodology included an intensive literature review, distribution of 300 questionnaires, soil and water analysis, fauna and flora survey, in addition to extensive field observation during the period from 2011 to 2021. The study highlighted the significant representative state of the study area for the whole El-Jabal El-Akhdar region in terms of environmental conditions and inappropriate anthropogenic pressure. Although the area has been severely degraded due to the arid climate coupled with decades of mismanagement, it still has remarkable ecological and environmental features and there is a feasible possibility of being converted into an effective protected area for biodiversity conservation with sustainable use of its natural resources by the local population (Category VI on the International Union for Conservation of Nature Classification for protected areas). The remaining barriers for which drastic solutions need to be implemented are a lack of awareness, a lack of protected areas guidelines and national perspectives, interest conflict with local people, a lack of constant funding, and failure of legislation enforcement.

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Introduction

Global terrestrial biodiversity is currently undergoing an unprecedented deterioration in terms of massive habitat destruction, populations decline, and loss of ecosystems, species, and genes. The degradation of ecosystems and, consequently, the loss of biodiversity are mainly linked to climate change and increased anthropogenic disturbances (Xu et al., 2012). The latter include over-exploitation, pollution, urbanization, agricultural activities, introduction of alien and invasive species, ecosystem fragmentation, and habitat destruction (Stolton et al., 2010; Dähler et al., 2019). In the past 300-years alone, more than half of the earth's land surface has been altered by human activity, which has driven widespread habitat destruction and ecosystem changes (Wilson et al., 2014), and over 83% of the Earth's land surface have been modified as a result of the expansion of various human land-uses (Hamilton et al., 2013). In the arid regions, land degradation, also known as desertification, has influenced many areas in Africa,

Asia and the Mediterranean region for centuries, even thousands of years (Dregne, 2002). In the Libyan context, the increasing intensity of unsustainable anthropogenic activities and the failure to protect ecosystem integrity are deemed to present a greater threat to biodiversity than climate change. Libya is still lagging behind when it comes to protecting biodiversity and wildlife.

The designation of specific areas for conserving natural systems and their biota, abating negative human impacts, and halting the rapid loss of biodiversity has become now a common practice and a vital legislative component of most national and regional strategies to combat biodiversity loss and remains the most widely deployed and best-known strategy at local, regional, and global scales (Redford et al., 2015; Negret et al., 2020). It is a cornerstone of the strategies to protect nature and human well-being. Hence, it has been studied well over the past few decades from a variety of social, economic, and environmental perspectives. The current expansion of protected areas (PAs) and their total share in the entire national or regional areas are now amongst the few indicators of positive environmental performance (Lopoukhine et al., 2019). In addition, the establishment of new PAs is a prerequisite for many international environmental conventions and agreements, including the Convention on Biological Diversity (CBD) (Possingham et al., 2006).

More than 80% of the world's PAs have been declared since the First World Parks Congress, which was held in 1962 in Seattle, USA (Possingham et al., 2006); the various designation categories range from strict protection, e.g., the International Union for Conservation of Nature (IUCN) protected area categories I–IV, to sustainable uses, e.g., the IUCN protected area categories V–VI (Wu et al., 2020). As of 2016, PAs covered 14.7% of the world's terrestrial and inland waters, 10.2% of the coastal and marine areas, and 4.12% of the world's ocean (UNEP-WCMC and IUCN, 2016; Shwartz et al., 2017). This is still below the current CBD target of 17%, of terrestrial and 10% of marine areas under the so-called Aichi Biodiversity Target 11 by 2020 (Muñoz Brenes et al., 2018; Lopoukhine et al., 2019). A number that has increased from 10% since the 2000–2010 Strategic Plan, but is still a political compromise that many conservation scientists believe it is still too low (Watson et al., 2014).

The PAs could be clearly defined as geographical areas aimed at the long-term to conserve biodiversity, natural and related cultural resources, and to be managed in a legal or any other efficient ways (IUCN 1994; Rodríguez-Rodríguez and López, 2018). They act as shelters for both ecological processes and species that normally cannot survive in disturbed areas and as a species-rich source for the colonization of other seascapes and landscapes (Stolton et al., 2010). PAs work by prohibiting or restricting some human activities that are harmful to the environment, such as construction, mining, or resources overutilization (Rodríguez-Rodríguez and López, 2018). Historically, most PAs were originally established to protect landscape features and/or wildlife and, more recently, to protect biodiversity, including genetic, species, and ecosystem diversity levels.

Today, many PAs also conserve diverse ecosystem services and other social, economic, and cultural benefits in the long term, e.g., protecting and enhancing water flows, helping buffer society from the effects of climate change, and maintaining the critical ecosystem services on which all societies depend (Lopoukhine et al., 2019), and can also create investment opportunities and employment (CBD, 2010). In addition, PAs contribute to the livelihood of local communities, supporting human life (e.g., providing drinking water and clean air), support national economies through tourism revenues, replenish fisheries and forestry, and play a key role in the mitigation or adaptation to climate change, among many other functions (Watson et al., 2014). PAs also have cultural significance and offer recreational opportunities (e.g., sacred sites and hiking trails) (Stolton et al., 2010). Indeed, many PAs could be justified with just one of these terms (Stolton et al., 2010).

Up to 2004, 188 countries were signatory states to the CBD, which committed themselves to expand the global network of PAs to develop and maintain a "comprehensive, effectively managed, and ecologically representative system of PAs" (Stolton et al., 2010). Libya signed the CBD on June 29, 1992, and ratified it on July 12, 2001. The CBD calls on the countries to establish a system of PAs to conserve biodiversity, develop guidelines for the selection, establishment, and management of PAs; and promote the protection of ecosystems, natural habitats, and the maintenance of viable species populations.

Compared to many other countries in the Middle East and Africa, the conservation of natural wilderness in Libya is still very limited. Officially there are nine PAs cover an area of about 2,355 km^2, protecting only 0.14% of the country's territory (El Barrasi and Saaed, 2015), far from the 17% of the Aichi target by 2020 (CBD, 2010; Sayre et al., 2020). Most of these PAs are poorly managed and face significant threats and challenges, such as lack of adequate government support, serious encroachments, failure of legislation enforcement, insufficient resources, administrative instability, lack of awareness of the importance of PAs, and inappropriate development inside and outside their boundaries. Added to these is the lack of a clear vision and perception of the future of the required protected areas and domains, along with the lack of strategies, methods, the required types of PAs, and the appropriate management processes.

El-Jabal El-Akhdar Region (JAR) is one of the most important wildlife areas in Libya and an area of exceptionally high priority for biodiversity conservation. In relative terms, the JAR is distinguished for its wide range of biodiversity and habitats variation and is recognized as part of the 36

global biodiversity hotspots (de Araujo and Moura 2011; Kothari et al. 2011). Land degradation in the JAR has received a lot of attention, long ago and recently, because it is deemed to be the most endangered vegetated region in Libya. However, fewer and inconsistent efforts were put to control inappropriate management practices such as urban development, overgrazing, agrarian expansion, firewood collection, charcoal production, over-collection of medicinal and aromatic species, bush fires, mining, extinction of many wildlife species (flora and fauna), and uncontrolled camping and leisure trips particularly in spring and summer (El-Barasi and Saaed, 2013). As a result, the JAR suffers from extreme biodiversity loss and habitat degradation. There is a growing understanding that the degree of fragmentation of natural habitats in large parts of the JAR is now so extreme to the degree that it could be irreversible. It is very important to start extensive environmental studies and conservation programs now, and to declare new PAs that not only include soil and biodiversity protection, but also landscape beauty protection and direct more concern for the local population, as they play an important role in the ecological processes and habitat changes throughout the area (El-Barasi and Saaed, 2013).

Although the data available about the conservation programmes in Libya is still sparse, there are no national guidelines for the establishment and management of the PAs to assist government agencies, non-governmental organizations, and the local community in developing a National Reserve System (NRS), and to assist interested individuals and parties to understand these processes. This general under-representation of ecosystems in the Libyan PAs, particularly in the JAR is a major concern and adds to the growing body of evidence that national biodiversity is inadequately conserved. With this publication, we aimed to emphasize the importance of the JAR as a significant area from the point of view of biodiversity worth conserving and to demonstrate the role of the PAs as the last defence line for wildlife habitat and biodiversity conservation, using an example from El Abyar area in the western part of the JAR.

Materials and methods

Study zone

El-Jabal El-Akhdar Region (JAR), also known as the Green Mountain, is an Afro-Mediterranean region in northeast Libya south of the Mediterranean Sea. It covers an area of approximately 8,000 km^2 and relatively is rich in wildlife and biodiversity. The region has a unique and high natural, cultural, and agricultural values. The study area (the proposed selected PA; El-Abyar area) is located in the western part of the JAR on the first trace, approximately 50 km northeast of Benghazi and 10 km southwest of El-Marj cities. Extending between latitudes 32° 21’ to 32° 52 north and longitudes 20° 38’ to 20° 79’ east, and covers an area of about 622 km^2 (Figure 1). The earth’s surface elevation ranges between 110 and 420 m above sea level. The eastern part of the study area comprises an open undulating plain that is used for crop production and communal pastoralism. The western part consists of a large network of valleys (dry rivers) that flow with the water towards Benghazi Big Plain in the rainy seasons and finally end at sea in the west.

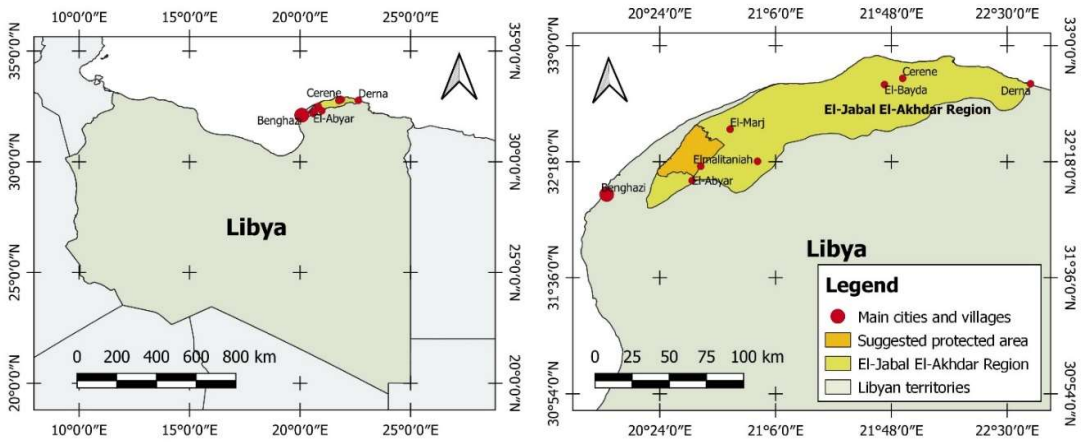


Figure1. The geographical location of the study area (the proposed protected area north of the El-Abyar city), northeast of Libya.

The drainage network and hydrological system of the area modify and redistribute the surface water after rainfall. Hence, it has a huge impact on the spread of wildlife biota; the lowlands and valley beds receive more moisture from runoff and have more protection against wind and human activities therefore they have more vegetation cover and higher biodiversity. Many of these valleys harbour various wildlife species that have been disappeared from other parts of the region (El-Barasi and Saaed, 2013).

The JAR records the highest amount of rainfall in all of Libya. It has a monomodal rainfall regime with a mean annual rainfall of about 400 mm/year, in Cyrene city, it is up to 600 mm/year; the rainfall decreases as we move south away from the seacoast. In El-Abyar area, the mean rainfall is 350-400 mm/year (El-Barasi and Saaed, 2013). About 75% of the precipitation falls during the winter season from November to February. The annual mean of the maximum temperature is around 31 °C in July, and the annual mean of the minimum temperature is 8 °C in January, while the rate of evaporation exceeds 2,000 mm/year (El-Barasi and Saaed, 2013). Based on the arid categories of the United Nations Convention to Combat Desertification (Hoffman and Ashwell, 2001), the area could be classified as an arid Mediterranean climate; the MAP:PET ratio = 0.18-0.20. And according to the World Temperature and Moisture Domains, the JAR is classified as a warm temperate dry area (Sayre et al., 2020). The region is rich in many medicinal and aromatic plant species such as *Pistacia lentiscus* L., *Ceratonia siliqua* L., *Thymbra capitata* (L.) Cav., *Juniperus phoenicea* L., *Rosmarinus officinalis* L., *Deverra tortuosa* (Desf.) DC., and *Olea europaea* L. There are also many wild animals in the area such as *Lepus capensis* L., *Canis aureus* L., *Vulpes vulpes* L., *Hyaena hyaena* L., *Hystrix cristata* L., *Testudo kleinmanni* Lortet, and *Aquila chrysaetos* L. The JAR's vegetation and flora belong more to the eastern Mediterranean than to the adjacent parts of North Africa and are considered to be an important centre for plant diversity and endemism (Hegazy et al., 2011).

Data collection

Socio-economic-ecological survey

Since the collaboration and involvement of local people in the planning and management of the PAs are crucial, their ideas and opinions have been extrapolated in this study. By interviewing the locals and decision-makers in the region and distributing 300 questioners, we collected a huge amount of data on the vegetation, animals and birds, current human activities and main land-use, the available resources, the local and cultural interest, the opinion of the local people about the challenges of the establishment of a PA in the vicinity, and the expected outcomes of the land protection and resources management on both the surrounding environment and financial situation of the locals themselves. Many photos of the historical sites and ruins, land-uses, landscape features, and any other special and distinctive natural scenery were captured and documented.

Vegetation and fauna survey

In order to investigate the current state of the biota (fauna and flora), extensive field trips were carried out in the area during the period from 2011 to 2021. Plant specimens were collected and identified, and the main perennial species and vegetation distribution were noted and recorded. Plant species identification has been verified and nomenclatures have been updated according to the Flora of Libya (Ali and Jafri, 1976−1977; Jafri and El-Gadi, 1977−1988; El-Gadi, 1988−1992). The currently accepted scientific names at the specific, generic, and familial levels were updated according to the latest checklist from the Plant of the World Online database and the Global Biodiversity Information Facility (POWO, 2021; GBIF Secretariat 2021). The frequent fauna and its distribution were also recorded and the nomenclatures were updated according to Al-Awami (1997) and GBIF Secretariat (2021).

Soil and water resources survey

Eight soil samples were collected at random from different locations to cover most of the study area using a 10 cm diameter auger and from the topsoil layer; 0-20 cm. Six soil cores (replications) were collected at each location and combined to form one sample. The samples were filled in sealable plastic bags and transferred to the laboratory. The soil samples were first air-dried for 72 hours, then sieved through a 2 mm sieve, and all subsequent analyzes were carried out with the fraction < 2 mm. A soil water suspension (1:5 soil to water ratio) was used to measure soil pH and electrical conductivity (EC), according to Rayment and Higginson (1992). The organic matter content was determined by the method of Walkley and Black (1934) and Magdoff et al. (1996). The $CaCO_3$ percentage was determined using the method of Black et al. (1965). Particle-size analysis of the soil was performed using the hydrometer method as described by Bashour and Sayegh (2007).

Five water samples were also collected at random from various water sources used by the locals in the area, including artesian wells, old Romanian cisterns, and modern concrete water cisterns. Water samples were transferred to the laboratory in sealed plastic bottles and water turbidity, colour, pH, and EC were determined according to Black et al. (1965).

Based on the data collected from the climate records, the questionnaire, the field observation, vegetation and fauna survey, and soil and water study, the main challenges to biodiversity were determined and the natural resources and area potential were defined. In addition, several previous publications about the land degradation and anthropogenic activities in the region were consulted (e.g., El-Barasi et al., 2013; El-Barasi and Saaed 2013, 2015).

Results and Discussion

Over the past ten decades, anthropogenic pressures have altered natural ecosystems faster and more significantly than any similar era in human history, as 60% or more of the earth's ecosystems have been damaged. These changes have brought many economic benefits, but with increasing environmental costs, including a decline in biodiversity and land degradation. Which in turn has resulted in many economic, social, and cultural losses. In the Libyan

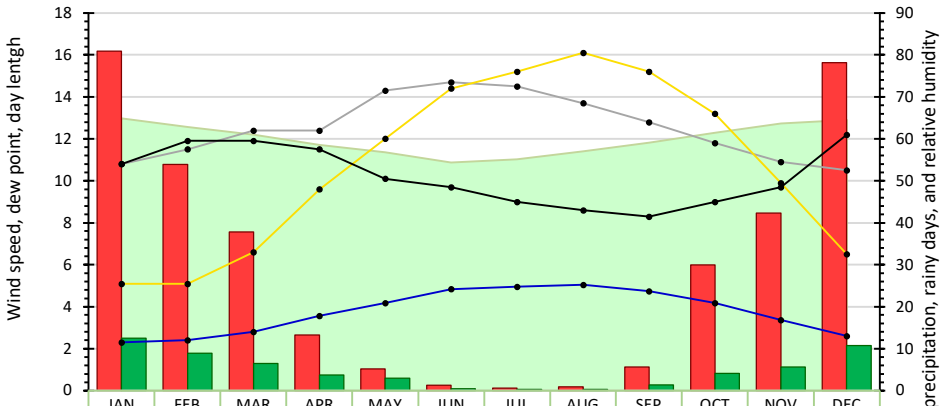
case, ecological degradation was not widespread until the beginning of the 20th century. Perhaps the greatest negative ecological impacts have come from urbanization, expansion of dryland grain cropping, and livestock overgrazing. Extremely large swaths have either been permanently eliminated from perennial vegetation or natural habitats and ecosystems have been fragmented. Little was the landscape protected in the entire Libyan protectorate, mainly through land-uses restrictions. Indeed, while frustratingly difficult to pinpoint the number of such areas (especially given temporal changes), the number is actually modest. These PAs have been established for a wide variety of reasons, including the representation and/or protection of landscapes, habitats, species, and populations. From an ecological point of view, however, it makes sense to ascribe to the PAs as a whole the potential to offer a mechanism for the preservation of the greatest possible biodiversity in the future. This is still missing from the management of the Libyan PAs. In many PAs, the current focus is on the conservation of habitats and rare or localized species that are threatened (El Barrasi and Saaed, 2015). The PAs in Libya still lack adequate attention and continuous follow-up and suffer from mismanagement and serious encroachment.

The natural potential

The area of interest is characterized by a Mediterranean climate, which is reflected in a relatively higher biodiversity value compared to other areas in Libya. The climate is hot and dry in summer and warm rainy in winter (Figure 2). Indeed, the climatic aridity and variability added to anthropogenic pressures lead to landscape fragmentation, habitat degradation, biodiversity decline, and gradual loss of natural resources, e.g., soil, vegetation cover, wildlife, and landscape beauty in the area.

Although the proposed area in this study is not very large (around 622 km^2), it is relatively rich in terms of biodiversity and habitat heterogeneity. The setting aside of PAs large enough to function as full ecosystems is no longer an option in most cases (Stolton et al., 2010). In addition to the historical sites and ruins found in many locations in the area, the diverse topographical features, landscape heterogeneity, and wilderness of the area create astonishing natural beauty scenes that attract tourists and residents alike for human pleasure, enjoyment, recreation, or discovery of attracted wildlife. This is another issue of further priority for the conservation program. The remains of ancient temples and churches from the Roman and Byzantine eras could be a destination for those looking for meditation, contemplation, and worship.

In the study area, there is no perennial water resource; therefore, precipitation in autumn and winter is the most important available surface water resource. The technique of harvesting runoff water after rainfall has been used since ancient times (Figure 3). The old underground cisterns, rocky dams, and man-made terraces could be found in various places. In addition to deep boreholes that use the groundwater, many new concrete cisterns have been built recently. While these are limited water resources, they could sustain normal wildlife and part of the local population supply. The chemical and physical analysis of the water from the various sources showed an acceptable quality in terms of pH (ranging between 6.9-7.1), EC (between 365-1459 µS/cm), colour (between 0-100 units), and the turbidity (between 0.68-4.69 units) (Table 1).



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Relative Humidity (%)	64.9	62.8	61	58.5	56.8	54.4	55.1	57	59.1	61.5	63.7	64.5
Precipitation (mm)	80.9	53.9	37.8	13.2	5.2	1.3	0.6	0.9	5.6	29.9	42.3	78.2
Number of rainy Days	12.5	8.9	6.5	3.8	3	0.5	0.3	0.3	1.4	4.1	5.6	10.7
Length of Day (Hours)	10.8	11.5	12.4	12.4	14.3	14.7	14.5	13.7	12.8	11.8	10.9	10.5
Dew Point (°C)	5.1	5.1	6.6	9.6	12	14.4	15.2	16.1	15.2	13.2	9.9	6.5
Wind Speed (km/h)	10.8	11.9	11.9	11.5	10.1	9.7	9	8.6	8.3	9	9.7	12.2
Temperature (°C)	11.5	12	14	17.8	20.9	24.2	24.8	25.2	23.7	20.9	16.8	13

Figure 2. The climatic data of El-Abyar meteorological station (after Weatherbase, 2021).

As expected, the Roman cisterns have the lowest EC values because they harvest runoff water after the rainfall, but its turbidity is high due to the contamination with soil particles and organic matter during runoff.

The groundwater has the highest EC values and the lowest turbidity and colour. The harvested water by the cisterns is mainly used to drink livestock, and the community's main supply comes from the groundwater deep wells. The soil in the study area is typical of the soils of the arid Mediterranean zone, consisting mainly of a shallow layer of red soil over the mother limestone rocks. The organic matter content is low (mean = 2.1%) (Table2), which reflects the low vegetation cover. The soil reaction is neutral to slightly alkaline (mean = 7.1), and the salinity is low (mean = 225.4 µS/cm). The calcium carbonate content is high (mean = 19.5%) due to the calcareous nature of the bedrocks. The soil texture is represented by three different types; Loam (consists 37.5%), Clay loam (37.5%), and Silt loam (25%). Due to the undulating nature of the earth's surface, the sheet and gully erosion of soil is widespread in the area and the bedrocks could be seen in many places (Figure 3).

Figure 3. Many Roman cisterns are still in use in the study area (El-Abyar vicinity), also the bed roks could be seen due to soil erosion over centuries.

Table 1. Water quality of the various resources within the study area.

Sample	Sample type	Coordinate	Turbidity (Unit)	Colour (Unit)	pH	EC (µS/cm)
1	Roman cistern	32.1596 N & 020.3656 E	4.54	30	7.0	275.5
2	Roman cistern	32.1615 N & 020.3657 E	2.48	20	7.1	258.5
3	Artesian well	32.1549 N & 020.4177 E	0.68	0	7.0	1281
4	Concrete cistern	32.1550 N & 020.4911 E	4.69	100	6.9	365
5	Artesian well	32.1185 N & 020.4079 E	2.74	0	6.9	1459

Table 2. The chemical and physical analysis of the soil samples collected from different locations within the study area.

Sample	Organic matter (%)	pH	EC (µS/cm)	$CaCO_3$ (%)	Clay (%)	Silt (%)	Sand (%)
1	2.48	6.7	331	18.35	20	48	32
2	1.61	6.8	271.2	19.09	20	50	30
3	1.34	6.5	237.5	0.30	22	50	28
4	1.61	7.1	502	15.41	28	50	22
5	1.74	7.5	113.7	40.11	32	40	28
6	3.82	7.3	115.2	38.48	22	44	34
7	2.35	7.4	118.5	15.40	24	40	36
8	1.68	7.5	114.2	8.61	36	42	22

In general, the flora of Libya is not rich in the number of species; however, the JAR has the richest vegetation and the highest number of species known from this country (Boulos, 1997). The vegetation of the JAR represents in most of its aspects a pronounced autonomy; it is the only remaining forest found along the southern Mediterranean coast from Tunisia in the west to Israel in the east. The flora of the JAR accounts for 65% (1,350/2,082) of the total national flora at the specific level and about 61% (59/97) of the endemic and near-endemic species in Libya (Saaed et al., 2019). According to Le Houerou (1995), this zone

(surrounded by the Sahara Desert) is considered to be one of the most important centres rich in endemic species in Libya. Areas like the JAR, with species concentrations of endemism and unique habitats, that are exposed to risks, are deemed to be biodiversity hotspots. Endemics are usually rare and restricted to rather small geographical areas or even in small pockets, so they deserve special attention for their conservation. They are an important part of our heritage and can provide us with essential food, medical, or other resources in the future (El-Barasi and Saaed, 2013). To escape the drought and survive, most of the vegetation in the area exists where the prerequisite of life, e.g., moisture and fertile soil, is more available in wadis (valleys), so they harbour many wild species, especially endemic and rare species (El-Barasi and Saaed, 2013).

Although the area has not been sustainably managed for a long time, it still contains relatively rich wildlife, particularly in the valleys, which have been long disappeared from other adjacent areas such as the coastal plains, e.g., Big Benghazi Plain, and southern areas of the JAR. The study area harbours more than 31 wild animal species, and 297 wild and naturalized plant species belong to 200 plant genera in 53 families (Table 3). Three species belong to the gymnosperms, 51 to monocots, and 242 to dicots. Many of the animals are endangered by overhunting and habitat destruction. And many of the plants are endemics or near-endemics such as *Arum cyrenaicum* Hruby, *Leopoldia comosa* (L.) Parl., *Romulea cyrenaica* Bég., *Daucus syrticus* Murb., *Carlina sicula* Ten., *Crepis libyca* (Pamp.) Babc., *Echinops cyrenaicus* E.A. Durand & Barratte, *Echinops galalensis* Schweinf., *Onopordum espinae* Coss., *Onopordum cyrenaicum* Maire & Weiller, *Nonea vivianii* DC., *Hippocrepis cyclocarpa* Murb., *Nepeta scordotis* L., *Phlomis floccosa* D.Don, *Linaria virgata* (Poir.) Desf., *Linaria tarhunensis* Pamp., *Plantago cyrenaica* E.A.Durand & Barratte, *Bellis sylvestris* var. *cyrenaica* Beguinot, and *Arbutus pavarii* Pamp. Other plants are rare such as *Barlia robertiana* (Lois.) W., *Neotinea maculata* (Desf.) Stearn, *Artemisia herba-alba* Asso., and *Salvia spinosa* L. The high anthropogenic pressures associated with climate change pose a high threat to the biota in the area, particularly large mammals and rare and endemic plant species, and have resulted in accelerated biodiversity loss. This requires urgent and effective interventions to save the remaining habitats and biota species.

Table 3. Different taxonomic plant groups present in the study area.

Plant groups		No. of the species	No. of the genera	No. of the families
Gymnosperms		3	3	2
Angiosperms	Monocots	51	35	9
	Dicots	243	162	42
Total		297	200	53

Local culture and interest

The historical background of the area shows that it has been inhabited since ancient times, and overages it was short of any important natural resource, except vegetation and wild and domestic animals. The mainland-uses throughout history have been grazing, grain farming, gathering firewood, producing bee's honey, and collecting medical and economic species. Many plant species were edible for the population; at the same time, the vegetation, especially in the valleys and mountains, offers shelter for many kinds of birds and wild animals. Some of these animals and birds also served as sources of food and medicine (Saaed et al., 2019). The historical land-uses have left their imprint on the environmental conditions in the area. The population is now about 200,000 people (Department of Vital Statistics, 2011) who live in and around the study area in several small towns and villages such as El-Marj, El-Abyar, El-Rajmah, El-Hamadah, Bu-Mariam, and El-Malaytaniyah. About 223 farms grow rain-fed crops and raise domestic animals. The grazing animals are estimated at 123,977 animals (116,754 sheep, 4,886 cattle, and 2,357 camels). The results obtained from the questionnaire showed that rain farming, overgrazing, land pollution from liquid and solid wastes, firewood gathering, medical and aromatic plants collection, and over-hunting of birds and mammals are still prevalent in the area. About 88% of the population practice rain farming, 72% collect firewood, 71% produce charcoal from forest wood for their use and marketing. About 92% of the population believe that the natural habitats and wildlife (fauna and flora) in the area are deteriorating. About 93% think that the soil erosion rate is higher today than in the past. However, only 52% support the idea of banning animal and bird hunting. On the other hand, 82% do not support the establishment of any private houses or constructing new buildings in the natural areas due to the negative impact on the wildlife and the environment. 83% support the idea that the state or investors should buy the land from local owners and convert it into a PA, and 78% expect that the PA will offer new job opportunities and increase their incomes. 94% support the idea that the establishment of a program to improve the honey bee industry in this area will be very successful.

In addition, the questionnaire showed that the local population is aware of the land degradation taking place in their lands and that their answers clearly showed a general acceptance of a declaration of PA in the study area. However, they are concerned

about the conflicts of interest with the management program and are afraid of losing their lands and reducing their incomes due to the expected restrictions. Also, despite the conviction of the locals that the lands in their areas are deteriorating and wildlife is decreasing, a large percentage of them do not have any intention to change their behaviours that are harmful to the surrounding environment. To achieve the potential in conserving biodiversity and assisting in reducing poverty, PAs should be integrated into a comprehensive planning agenda for sustainable development (SCBD, 2008). The relationships between comprehensive, resilient, effectively managed, and economically safe PAs on the one hand, and the economic and social well-being of the country, community, and individuals, on the other hand, are undisputed (Ervin et al., 2010).

Worldwide, there is no doubt that there is a growing awareness of the importance of conservation and PAs' establishment for poverty reduction and sustainable development (SCBD, 2008). This should be a cornerstone of any conservation effort in the region; this message should be clearly communicated to the local community. It is possible to use the remaining natural habitats in the study area to restore these valuable ecosystem services for both rural and urban residents on a broad basis. A comprehensive, well-managed, and equitable national system of PAs can not only support biodiversity but is also critical to human well-being at multiple levels. Through governance issues, PAs play an important role in empowering people and in influencing decision-making processes (SCBD, 2008). The proposed protected area can provide numerous socio-economic benefits to the locals that could contribute to their well-being, such as providing clean drinking water, contributing to soil stabilization, improving the rangelands and natural vegetation condition, creating new jobs and work opportunities, and providing an opportunity for education and environmental awareness. PAs are also central cornerstones of various cultural, spiritual, and religious practices. This applies in addition to the numerous environmental benefits at local and regional levels. The study area showed remarkable potential to provide many of these services to the local population. However, managing PAs in developing countries such as Libya, poses profound challenges in the view of widespread poverty, rapid population and economic growth, and political and administrative instability.

Gradually, the need is becoming very critical to ensure that nature conservation interventions are pro-poor in their approach and effects, and in particular to design economic and financial instruments for the management of PAs that incorporate poverty reduction and economic development goals, and to ensure that there is a fair distribution of costs and benefits at all levels (SCBD, 2008). There would be little point in generating revenue from PAs if they create great inequality at the local level, undermine social cohesion, and destroy cultural and customary traditions. In many cases around the world, it can be difficult to obtain tangible economic benefits from PAs (SCBD, 2008). This should be taken into account when planning and managing PAs at the regional or national levels.

Undoubtedly, with their habits, traditional farming methods, and grazing animals, inhabitants of this area have been a part of the ecosystem for hundreds of years. Therefore, special attention must be paid to the local population; their activities should not be banned but adapted to the potential of the study area. Awareness must focus on changing the behaviour of the local population to generate a large economic income through the maximum possible use of the available resources with minimal extinction and environmental costs (El-Barasi and Saaed, 2013). To make any conservation program successful, the diverse need of the population should be balanced with the potential of the area's resources. Local people's awareness of environmental degradation, the decline in biodiversity, and the consequential negative impacts not only on the surrounding and nearby areas but also on themselves is central to any conservation program.

Challenges to biodiversity

Threats to PAs must be eliminated if PAs are to achieve their goals and contribute to the conservation of biodiversity. The IUCN has established a framework for measuring management effectiveness that takes into account: (1) issues related to the design; (2) adequacy of the management; and (3) whether the goals of the PAs are being achieved (Possingham et al., 2006).

Although the predicted climate change and prolonged drought periods are suspected of influencing the biota of natural areas in different and significant ways (Rutherford et al., 1999), the greatest threat in the study area comes from anthropogenic activities. Land-use changes have a long history in the region and pose significant threats to biodiversity, especially to rare and endemic species. For example, deforestation in the area seems to have started 27 centuries ago when the Greeks and Romans occupied the region. Trees were felled for firewood and charcoal, but also for civilization, shipbuilding, and furniture, as in the earlier times in the eastern Mediterranean. Population growth, deforestation, overgrazing, and the expansion of rainfed farming to include catchment areas and ever-steeper slopes are the main reasons for the increasing soil erosion. After the Greeks and Romans, the Arab conquest of Libya and other parts of North Africa resulted in a deluge of tree felling for the construction of new cities and other uses. A rapid increase in the numbers of livestock was responsible for further deterioration in vegetation cover and more erosion. Hunting birds and wild animals has continued over the ages, but the great tragedy began about ten decades ago when modern firearms and SUV cars were introduced in Libya. Unfortunately, the transformation of natural and semi-natural habitats into artificial land is the dominant

change in land-use and land cover change in the region, which has been accelerated since the beginning of the past century. It is noteworthy that the large collection of plant species and overhunting of birds and mammals (Figure 4) led many species to permanently local extinction and brought many others to the brink of extinction. Continuous loss of biodiversity and severe degradation force the ecosystem into 'dynamic inertia', and if restoration action is not taken to overcome the thresholds exceeded by degradation, ecosystems can become stuck in one of the severely degraded and unproductive states (Carrick et al., 2015). Another challenge for the establishment and active management of the PAs in Libya is the lack of sufficient and continuous funding, be it from the government or the private sector, as yet no awareness of donations to such institutions by public and civil society organizations.

Figure 4. Poaching of wild animals and birds in the study area as *Alectoris Barbara* Bonn.

PAs need financing like any other element of basic infrastructure, which require funding to maintain the equipment and facilities (e.g., roads, health clinics, schools, sanitation, and water supplies) necessary for the functioning of the community and economy (SCBD, 2008). Financially weak PAs are often improperly managed and, therefore, rarely meet the conservation objectives for which they were created (Possingham et al., 2006). In addition, the lack of guidelines for establishing and managing PAs and the inadequate application of relevant laws pose extra significant challenges. Although the Libyan legislation is, to some extent, sufficient to curb the widespread wildlife exploitation and habitat destruction, there is no strict enforcement or follow-up by the relevant official authorities or even the public or civil organizations.

Conservation focus

Restoration in arid and semi-arid areas is not an easy process due to the often-unique biota diversity, very little rainfall, and complex spatial and biological dynamics that are driven by stochastic events (Carrick et al., 2015). Also, due to the scarcity of natural resources, these areas are often exposed to strong anthropogenic pressures. Over the past ten decades, many intact ecosystems in Libya, especially in the northern parts, have been rapidly converted into human-dominated uses, making the need to declare new PAs more urgent. However, the distribution of scarce nature conservation resources must be given priority over the expansion of the existing or planned PAs. So that efforts to protect biodiversity can be broadly organized and their impact amplified. Even in cases of little or no management or infrastructure, species abundance and diversity are usually higher within PAs than in the surrounding landscapes, and many species eliminations have been avoided by being set aside within PAs. In regions with high anthropogenic pressure, such as the study area, PAs are often the only remaining patches of native biota (Possingham et al., 2006).

It must also be emphasized that the conservation of all parts of the wildlife in the region is very important. Each one has a fundamental role in the ecosystem cycle and all components are highly interdependent. The life and persistence of a plant or animal species are linked to the existence of the other types of organisms and even to the existence of other environmental components (such as location, climate, soil, topography, etc.) (El-Barasi and Saaed, 2013). Another important aspect to consider is that land-use changes around PAs can reduce their effective size and limit their ability to conserve biodiversity, as land-use changes alter ecological processes and the ability of organisms to move freely between PAs (Hamilton et al., 2013).

Supporting both the increased effectiveness of the current PAs and the establishment of new ones, as called for in the Aichi Target 11 of the Convention on Biological Diversity, requires significantly greater support from the local community; Supporting that is likely to come only through demonstrating strong relationships between biodiversity conservation and human well-being (Redford et al., 2015). Even as the effectiveness of existing PAs is increased and new

ones are established, there will always be a critical need to work outside the boundaries of PAs, as much the Earth's biodiversity is to be found in such settings (Redford et al., 2015). Politicians, conservation planners, decision-makers, and other stakeholders are responsible for developing and applying the plans that aim to strengthen the design, representativeness, and management effectiveness inside and outside the PAs (Schmitz et al., 2012).

The first step in any conservation program is to prevent the harmful effects of human activity. Another crucial point is the choice of conservation priority, i.e., rare, medicinal, endemic species, special geological or landscape features, or aesthetic views. Full protection may be imperative if the goal is to preserve the entire ecosystem in the area, there is more room for manoeuvre, but in the end, we have to save both species and ecosystems (El-Barasi and Saaed, 2013). This option may not be appropriate or realistic in the case of the study area. PAs must primarily protect biodiversity and the natural environments, but they must do so without disproportionately affecting local society (Mammides, 2020). However, the management of the proposed PA could be conceptualized in three spatial categories: (1) management within the boundaries, (2) cross-border or landscape-level ecosystem management, and (3) Global to regional management of the establishing, officially authorized state, and allocation of the PAs (Baldwin and Beazley, 2019). The proposed PA should work in an integrated web with the other national and international PAs.

In the case of the proposed El-Abyar protected area, the most important step in conservation should be a general plan for all the regions and all their components, focusing in particular on soil, biodiversity (fauna and flora), beauty, and local population and ending with the declaration of the JAR as a protected area with all necessary legal regulations (El-Barasi and Saaed, 2013). One of the ongoing concerns of conservation scientists is to ensure that PAs are not only effective now, but persist so in the future in the face of changes in the environment and land-uses by humans (Gaston et al., 2006). In order to assess the effectiveness of PAs, it is of the utmost importance to collect data regularly and systematically (Gaston et al., 2006). The fundamental obstacle in the Libyan PAs is the paucity of available data. Much of the problem is a lack of systematically collected data. Legally protected sites in Libya were hardly assessed, if not at all. As a result, the available data on the PAs and other areas of importance to biodiversity are very little and the ecological and biodiversity states are not yet fully understood.

What the local population would like to conserve is always a question of personal preference and perspective, as quality is often overlooked in favour of gloss or numbers (Cowling and Wilhelm-Rechmann, 2007). Conservation of species and ecological processes within any PAs requires that the entire landscape settings must be considered in the management and monitoring plans (Belote and Wilson, 2020). The landscape studies in JAR, though not across the country, are still very few and shallow. Without monitoring and evaluation programs, the success of the management activities in the PAs can hardly be assessed objectively (Gaston et al., 2006). Better monitoring of larger PA ecosystems will help quantify and identify the causes of any decline in biodiversity and mitigate the resulting adverse effects (Belote and Wilson, 2020).

Conclusion

The current situation of the biodiversity in the JAR is very critical; it is reflected in the disappearance or accelerated degradation of natural ecosystems, habitats fragmentation, and the rarefaction of certain wild biota. Of all the factors threatening biodiversity in this area, climate and land-use changes remain the greatest. As noted above, PAs, established and managed primarily to protect biodiversity, can offer a variety of other values, including resources with direct economic returns, means of subsistence, and less tangible values such as spiritual peace or mental well-being. This should be communicated clearly to the decision-makers and local communities to ensure a successful conservation programme.

Overall, our study highlights the need to better understand the ecosystems in the region and to put more effort and resources into establishing new PAs and to be managed more properly and effectively based on a scientific basis and appropriate conservation programs. The study area with its geographical location, landscape features, biodiversity, environmental characteristics as well as historical sites worth conservation and could be a good example of the JAR conservation. The current study suggested the category (VI) of the IUCN classification of PAs management; PAs with sustainable use of natural resources. This category conserves both habitats and ecosystems with the local cultural values and traditional systems of natural resource management. The PAs in this category are usually large, with most of the area in a natural condition, in which a certain proportion is seen as under the sustainable management and environmentally friendly, non-industrial use of natural resources at a low level, one of the main goals of the region. However, what is currently missing is that there are no guidelines for establishing or managing PAs in Libya, this gap should be filled without any further delay. Also, the awareness of the importance of PAs at the local, national, and governmental levels is still quite modest, disrupting any conservation efforts. Also, the legislation should be updated and strictly enforced.

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