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Characterization of Common Environmental Indicators of the Moroccan Oasean Biome, Pilot Study in the Reserve Biosphere of Oases in Southern Morocco

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Authors' contributions

This work was carried out in collaboration between all authors. Author AK designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors II, MM and MYK managed the literature searches, reviewed the first draft and provided valuable assistance. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

The major concern about the oasean biome is the fear of loss of this heritage. Hence the interest to study the main factors that affect the environment of Moroccan oases. This article focuses on the identification of Major and Common Indicators (MCI) of degradation of the Biosphere Reserve of Southern Morocco Oases (BRSMO). To address the state of the environment and natural resources, we have identified a set of the most important indicators that impact the stability of the oasean community basing on the profiles of the environmental vulnerability index already established in the three sites of this reserve. This study provide informations and an overall diagnosis to develop a real guide for future research and make recommendations to policymakers for multidisciplinary environmental management in Pre-Saharan region, and especially in the BRSMO.

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Keywords: Oasis; EVI; pilot study; Southern Morocco.

1. INTRODUCTION

The Biosphere Reserve of Southern Morocco Oases (BRSMO) is a major agro-ecological reserve in Morocco. It is constituted by the Middle Draa Valley, Upper Draa Valley and Tafilalt zone and it covers approximately 72 000 km^2. The land was declared a Biosphere Reserve by UNESCO on 2000. It contains two main parts: the cultivable part (the inside of the oases), and the part outside the oases. In fact, 5% of the area of the BRSMO is subject to agricultural activities, including hydraulic perimeters of Upper and Middle Draa Valleys and Tafilalt zone; the remaining 95% of the area of the BRSMO are for pasture use [1]. These make the economy of this oasean region closely linked with the agricultural sector. This sector is mostly for subsistence and local consumption; however marketable products play a minor role [2]. Most of the population is rural. This population is highly concentrated, where water resources are, with very high densities of up to 615 inhabitants /km^2 [1]. This region which constitutes an indicator of the major climate trends in the Mediterranean region is currently experiencing rapid climatic degradation and desertification [1]. The RBSOM is constantly threatened by drought, salinity and sand advancement [3-6]. In 2011, Bensalem et al. recorded [7] an increase in the saline groundwater in most oases of this biosphere reserve, mainly in the oases of Tafilalet. The Middle Draa Valley experiences the same phenomena especially in the downstream part [8]. In parallel with the impact of salinisation on soil quality, the dam Mansour Eddahbi (Upstream of Middle Draa Valley) is subjected to the phenomenon of siltation [9,4]. According to Diekkruger et al. [9], the capacity of the Mansour Eddahbi dam in Middle and Upper Draa was reduced by approximately 25% in 1998. In the Tafilalt zone, Hassan Edakhil Dam also suffered the same problem of siltation. Messouli et al. [10] argued that, if the siltation rate continues at its current rhythm, the dam will not be operational for irrigation in 2030. Drought and desertification have a negative impact on water availability and quality, which have damaged the agriculture economy of the region [2]. Drought, dam siltation, soil and water salinisation are therefore the general aspects of degradation in this region.

Several methods (indices and conceptual frameworks) have been developed to determine indicators of degradation like DPSIR proposed by the European Environment Agency (EEA), which distinguished driving forces, pressures, states, impacts and responses [11]. Its main purpose is giving a structure in which to present system indicators to policy makers on environmental impacts and on impacts of political actions [12]. Fundamental research initiative created which the Integrative Science for Society and the Environment (ISSE) applied in Iriki Lake (Downstream of Middle Draa Valley) and in the whole upper Draa Valley. This model allows determining the short-term and long-term stresses in a socio-ecological dimension under climate change context. Another recent approach called the Water-Energy-Food Nexus is a new approach in support of food security and sustainable agriculture. Otherwise, there are many examples of the use of indicators to assess vulnerability to various hazards and threats to the environment such as:

1. Environmental Sustainability Index (ESI);
2. Flood Vulnerability Index (FVI);
3. Water Poverty Index (WPI);
4. Climate Change Vulnerability Index (CCVI);
5. Social Vulnerability Index (SoVI);
6. Climate and Disaster Resilience Index (CDRI);
7. Environmental Vulnerability Index (EVI)

In this paper, we have identified in a multidisciplinary way, the main indicators that can affect the environment of the all oases of the BRSMO. In fact, three studies were performed on case studies: in Tafilalt by Ben Salem, (2014) [3], in Middle Draa Valley by Karmaoui et al. [4] and in Upper Draa Valley by Karmaoui et al. [5]. However, this study of the common indicators in all the BRSMO was synthesized. The findings of our investigations to disseminate relevant informations, and engage with other components to fully exploit the opportunities that may arise. The main objectives are as follow:

1. Identify the major indicators of common degradation of the Biosphere Reserve of Oases in Southern Morocco;
2. Synthesize informations on the degradation of this reserve plan and;
3. Present the need to influence the reform of laws and processes that have an impact on the ecosystems of the reserve basing on the established indicators.

2. METHODOLOGY

2.1 Study Area

The study area is located in southeastern part in the pre-Sahara of Morocco, where, the climate varies with altitude and latitude with an almost common aridity characteristic of the whole area [13]. In terms of ecological importance, this region includes several sites of ecological interests like Ramsar sites (4), National Parks (2), Observatories of Sahara and Sahel (3), and the famous solar complex of Ouarzazate (500MW). The researchers worked on the majority of Moroccans oases sites (Fig. 1). These sites were selected because it represent the different types of landscapes across the pre-Sahara of Morocco.

The topography passes from 4068 m of altitude in M'goun (High Atlas) to 450 m in the Iriki Lake (Sahara) (Fig. 2). The spread of the territory in latitude covers 500 km.

The region is characterized by low and irregular rainfall in time and space (Fig. 3). The rainfall varies from an annual maximum of about 800 mm to less than 50 mm from north to south.

With additional challenge of climate change, oasean region may face in future major constraints particularly in terms of water availability, and increases in extreme weather events [13]. Dryer conditions in the future, however, are a highly probable scenario and might substantially affect livelihood options within the socio-ecological system [5].

2.2 Methodology

The data of three environmental vulnerability profiles of the three sites of the Biosphere Reserve of Southern Morocco Oases BRSMO was used. Basing on these profiles, we have identified indicators having a score equal or higher than 4 (vulnerable to extremely vulnerable) that we called Major and Common Indicators (MCI) of BRSMO environmental vulnerability. Analyzes of the vulnerability of the environment of the oasean system was performed using the results collected from the profiles of the 3 oasean sites of the BRSMO (Middle Draa Valley, Upper Draa Valley, and Tafilalt). The Environmental Vulnerability Index (EVI) using 50 indicators for estimating the vulnerability of the environment of a delimited area was utilized (Table 1). Data for each indicator is located within an EVI scale which ranges between 1-7, where the value EVI=1 indicates low, while, EVI=7 indicates extreme vulnerability. The environmental vulnerability index (EVI) was designed to summarize a wide range of environmental vulnerability informations.

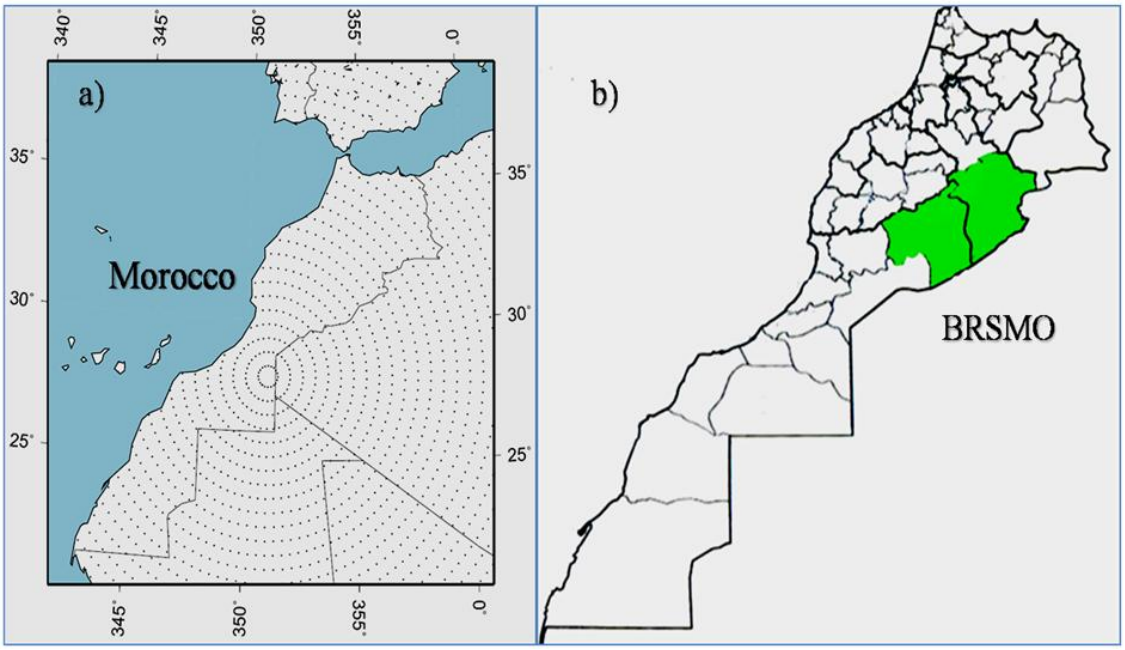

Fig. 1. a, Morocco (Grid ARPEGE-climate model [12]. b, Map of the geographic situation of the Biosphere Reserve of Southern Morocco Oases (BRSMO)

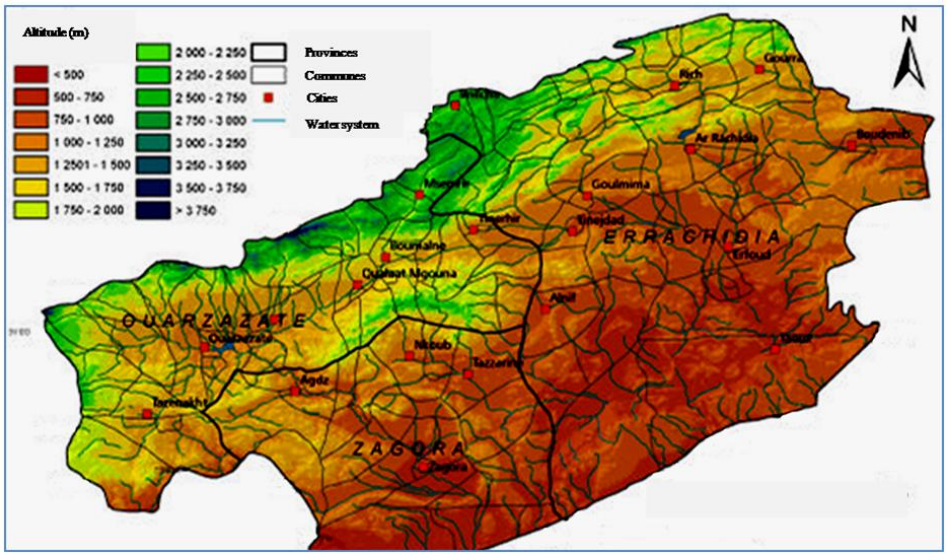

Fig. 2. Topography of the RBOSM

Data: DEM, administrative network: Statistical Service; Census 1998; Cartography: M. Finckh, J. Oldeland. GCS_WGS_1984; Date: D_WGS_1984 [1]

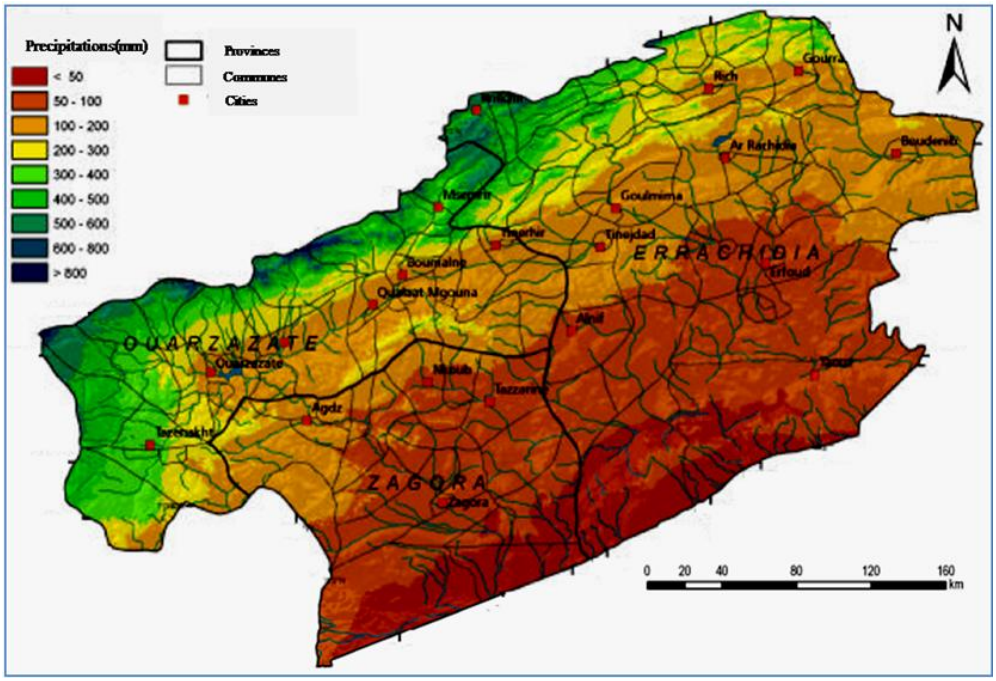

Fig. 3. Average annual rainfall BRSOM (Errachidia, Ouarzazate and Zagora)

Data: DEM, administrative network: Statistical Service; Census 1998; Cartography: M. Finckh, J. Oldeland. GCS_WGS_1984; Date: D_WGS_1984 [1]

After the EVI Calculator (www.vulnerabilityindex.net/), the 50 indicators are grouped into seven sub-indices. The climate change indicators (CC) include 13 indicators, the Biodiversity (CBD) 19, the Water (W) 12, the Agriculture/Fisheries (AF) 20, Human Health Aspects (HH) 6, Desertification indicators (CCD) 11 and Exposure to Natural Disasters (D) scores of 11.

Table 1. Indicators of Environmental Vulnerability Index (EVI) of the Biosphere reserve of southern Morocco Oases

No	Type	Description	UDV	MDV	TAF
1	Wind	Average annual excess wind over the last five years (summing speeds on days during which the maximum recorded wind speed is greater than 20% higher than the 30 year average maximum wind speed for that month) averaged over all reference climate stations (days/yr)	1	1	1
2	Dry	Average annual rainfall deficit (mm) over the past 5 years for all months with >20% lower rainfall than the 30 year monthly average, averaged over all reference climate stations (mm/station/yr)	2	2	2
3	Wet	Average annual excess rainfall (mm) over the past 5 years for all months with >20% higher rainfall than the 30 year monthly average, averaged over all reference climate stations (mm/station/year)	1	1	1
4	Hot	Average annual excess heat (degrees Fahrenheit) over the past 5 years for all days more than 9F (5°C) hotter than the 30 year mean monthly maximum, averaged over all reference climate stations (degrees/yr)	4	4	4
5	Cold	Average annual heat deficit (degrees) over the past 5 years for all days more than 5°C cooler than the 30 year mean monthly minimum, averaged over all reference climate stations (degrees / yr)	3	3	3
6	SST	Average annual deviation in Sea Surface Temperatures (SST) in the last 5 years in relation to the 30 year monthly means (degrees/yr)	0	0	0
7	Volcano	Cumulative volcano risk as the weighted number of volcanoes with the potential for eruption greater than or equal to a Volcanic Explosively Index of 2 (VEI 2) within 100km of the country land boundary (divided by the area of land) (VEI Units / million sq km)	1	1	1
8	Earthquake	Cumulative earthquake energy within 100km of country land boundaries measured as Local Magnitude (ML) ≥ 6.0 and occurring at a depth of less than or equal to fifteen km (≤15km depth) over 5 years (divided by land area) (Number ML >= 6, Depth <= 15km)	1	1	1
9	Tsunami	Number of tsunamis or storms surges with run-up greater than 2 meters above Mean High Water Spring tide (MHWS) per 1000km coastline since 1900 (Number since 1900 >2m run-up)	1	1	0
10	Slides	Number of slides recorded in the last 5 years (EMDAT definitions), divided by land area (Slides/million sq km land)	1	1	1
11	Land	Total land area (km^2) (sq km)	4	4	5
12	Dispersion	Ratio of length of borders (land and maritime) to total land area (km/ 1000 sq km)	4	4	2
13	Isolation	Distance to nearest continent (km)	6	6	1
14	Relief	Altitude range (highest point subtracted from the lowest point in country) (m)	3	1	3
15	Lowlands	Percentage of land area less than or equal to 50m above sea level (%)	1	1	1
16	Borders	Number of land and sea borders (including EEZ)	1	2	2

No	Type	Description	UDV	MDV	TAF
		shared with other countries			
17	Imbalance	Ecological Imbalance as weighted average change in trophic level since fisheries began (for trophic level slice ≤3.35).	0	0	0
18	Openness	Average annual USD freight imports over the past 5 years by any means per km^2 land area (USD Thousands / sq km land).	1	1	0
19	Migratory	Number of known species that migrate outside the territorial area at any time during their life spans (including land and all aquatic species) / area of land (Spp / 1000 sq km land).	2	3	1
20	Endemics	Number of known endemic species per million square km land area (Spp / 1,000,000 sq km land)	6	6	5
21	Introductions	Number of introduced species per 1000 square km of land area (Spp / 1,000 sq km land).	2	2	2
22	Endangered	Number of endangered and vulnerable species per 1000 sq km land area (IUCN definitions) (Spp / 1,000 sq km land).	3	4	2
23	Extinctions	Number of species known to have become extinct since 1900 per 1000 sq km land area (IUCN definitions) (Spp / 1,000 sq km land).	4	4	3
24	Vegetation	Percentage of natural and regrowth vegetation cover remaining (include forests, wetlands, prairies, tundra, desert and alpine associations) (% of original cover).	0	0	6
25	Loss Veg	Net percentage change in natural vegetation cover over the last five years (% change (-ve = loss).	5	5	0
26	Fragment	Total length of all roads in a country divided by land area (km/ sq km)	1	1	1
27	Degradation	Percent of land area that is either severely or very severely degraded (FAO/AGL Terrastat definitions) (%).	7	7	1
28	Reserves	Percent of terrestrial land area legally set aside as no take reserves (% of land area).	1	1	1
29	MPAs	Percentage of continental shelf legally designated as marine protected areas (MPAs) (%).	0	0	0
30	Farming	Annual tonnage of intensively farmed animal products (includes aquaculture, pigs, poultry) produced over the last five years per square km land area (t / sq km / yr).	5	5	0
31	Fertilizers	Average annual intensity of fertilizer use over the total land area over the last 5 years (kg / sq km / yr).	2	2	1
32	Pesticides	Average annual pesticides used as kg/km^2/year over total land area over last 5 years (kg / sq km / yr).	2	2	0
33	Biotech	Cumulative number of deliberate field trials of genetically modified organisms conducted in the country since 1986. (Total number trials).	1	1	1
34	Fisheries	Average ratio of productivity : fisheries catch over the last 5 years (tC / sq km / yr : t fish / sq km / yr).	5	0	0
35	Fish Effort	Average annual number of fishers per kilometer of coastline over the last 5 years. (fishers / yr / km coast).	1	0	0
36	Water	Average annual water usage as percentage of renewable water resources over the last 5 years (%).	7	7	5
37	Air	Average annual SO2 emissions over the last 5 years (t / sq km / yr).	1	1	1
38	Waste	Average annual net amount of generated and imported toxic, hazardous and municipal wastes per square km land area over the last 5 years (t/km^2/yr).	1	1	0

No	Type	Description	UDV	MDV	TAF
39	Treatment	Mean annual percent of hazardous, toxic and municipal waste effectively managed and treated over the past 5 years (%).	7	7	7
40	Industry	Average annual use of electricity for industry over the last 5 years per square km of land (toe / km^2).	1	1	0
41	Spills	Total number of spills of oil and hazardous substances greater than 1000 litres on land, in rivers or within territorial waters per million km coast during the last five years (Number of spills / million km coasts).	1	1	1
42	Mining	Average annual mining production (include all surface and subsurface mining and quarrying) per km2 of land area over the past 5 years (t / km^2 / yr).	4	7	2
43	Sanitation	Density of population without access to safe sanitation (WHO definitions)	5	4	3
44	Vehicles	Number of vehicles per square km of land area (most recent data).	1	1	1
45	Density	Total human population density (number per km^2 land area) (people / km^2)	1	1	5
46	Growth	Annual human population growth rate over the last 5 years (%)	6	6	7
47	Tourists	Average annual number of international tourists per km^2 land over the past 5 years (people/km^2/yr).	7	7	2
48	Coastal	Density of people living in coastal settlements (i.e. with a city centre within 100 km of any maritime or lake* coast) (people/km^2).	0	0	1
49	Agreements	Number of environmental treaties in force in a country (treaties).	2	2	1
50	Conflicts	Average number of conflict years per decade within the country over the past 50 years (Average conflict years / decade).	1	1	1

Source: Types of indicators and their description was extracted from the EVI calculator (www.vulnerabilityindex.net/). Scores of UDV, MDV and Tafilalt was extracted and compiled from the profiles realized individually by Karmaoui et al. [5] in UDM, Karmaoui et al. [4] in MDV and Ben-Salem, [3] in Tafilalt; Indicators scoring 0: Not applicable or not data

3. RESULTS AND DISCUSSION

In this article, we extracted and compiled the score of each indicator for the 3 individual sites and rank them in sub-indices (Table 2).

After this table, the sub-indices of climate change for UDV was to be 2.8, 2.6 in MDV and 3 in Tafilalt. The 'Biodiversity' sub-indices were 2.9 for UDV, 3 for MDV and 2.5 for Tafilalt. The 'Exposure to Natural Disaster' index was 1.6 for both UDV and MDV and 2 for Tafilalt. Regarding the 'Desertification' sub-indices, the scores are 3.4 for UDV, 3.2 for MDV and 2.7 in Tafilalt. The score of the 'Agriculture/Fisheries' category is 3 for both UDV and MDV and 2.10 for Tafilalt site.

Table 2. Environmental vulnerability index (EVI); category scores

	Upper Draa Valley	Middle Draa Valley	Tafilalt
Climate change	2.8	2.6	3
Exposure to natural disasters	1.6	1.6	2
Biodiversity	2.9	3	2.5
Desertification	3.4	3.2	2.7
Water	3.8	3.75	3.55
Agriculture / Fisheries	3.0	3.0	2.10
Human health aspects	4.0	3.83	3.4

(Source: Authors' compilation from environmental vulnerability profiles developed independently by Karmaoui et al. [5], in UDV, Karmaoui et al. [4] in Middle Draa valley and Ben-Salem [3] in Tafilalt

However the 'Human Health Aspects' was scored 4 for UDV, 3.83 (MDV) and 3.4 for Tafilalt, and finally, the score of the 'Water' sub-indices is 3.8 (UDV), 3.75 for MDV and 3.55 for Tafilalt. After these values**,** the indicators with the highest scores were mostly anthropogenic followed by water and desertification. The anthropogenic pressure is especially because the intensive agriculture, the main economic sector that has a great pressure on water resources and subsequently soil quality.

The individual scores for each site used to determine the overall index are illustrated in Table 1. Because of the dynamic nature of the environment, this EVI is not a fixed value, and it can change in the future to reflect changes in the environmental. After the EVI calculator, the total scores are classified in five classes (Resilient, at risk, Vulnerable, Highly Vulnerable and Extremely Vulnerable) as showed in Table 3.

Table 3. EVI scores (from the EVI calculator: www.vulnerabilityindex.net/)

1	Extremely vulnerable	365+
2	Highly vulnerable	315+
3	Vulnerable	265+
4	At risk	215+
5	Resilient	<215

The three zones were classified basing on the data from Table 3. Based on the analysis of the data collected, the overall environmental vulnerability index (EVI) for the Moroccan oasean system was determined to be 278 in Upper Draa Valley, 288 in Middle Draa Valley and 234 in Tafilalt (Table 4). After this table, the MDV is the most vulnerable followed by UDV and Tafilalt; we signal that the low vulnerability of Tafilalt is due probably to the low percent of the data used that is under the minimum requirement of 80% [14] fixed by the South Pacific Commission for Applied Sciences (SOPAC).

The Hazards index for this region (Table 5) was determined to be 2.67 in UDV, 2.75 in MDV and 2.24 in Tafilalt. The resistance index is 3.38 both in UDV**,** and MDV and 2.50 in Tafilalt, and the damage index was found to be 2.57 in UDV, 2.86 in MDV and 2.44 in Tafilalt. UDV and MDV are resistant, and more exposed to Hazards and Damage.

3.1 Major and Common Vulnerability Indicators of the BRSMO

For each site (Middle and Upper Draa Valley, and Tafilalt zone), individual scores compiled in Table 1 constitute a large amount of informations that assess what has priority for the oasean community. Identifying indicators with a score equal or greater than 4 (vulnerable to extremely vulnerable) (Table 6), allow us therefore to identify the key questions on the environmental vulnerability of the oasean system.

The indicators scores of the three sites of the biosphere reserve (BRSMO) lead to select indicators having a score equal or higher than 4 (Vulnerable to extremely vulnerable) that have called Major Indicators (MI) as showed in the Table 6.

Regarding the average values between the three sites together, the Table 7 gathers a selection of indicators having a score equal or higher than 4 of vulnerability called Major and Common Indicators (MCI) for the all study area. After this table, 11 of 50 indicators are common in this biosphere reserve.

In order to give a comparative environmental vulnerability in the BRSMO, we described and analyzed each category of vulnerability between the three sites in the following sections.

3.2 Climatic Indicators

Several studies put forward the high evapotranspiration, the very hot and very dry air and the high thermal amplitude of pre-Saharan oases [15,16]. The environmental vulnerability Index showed also that he Moroccan oasean system is characterized by 'Hot Periods'.

Table 4. EVI Classification

	Upper Draa Valley (UDV)	Middle Draa Valley (MDV)	Tafilalt
Data entry (%)	90	86	76
Total scores	278	288	234
Classifications	3 Vulnerable	3 Vulnerable	4 At risk

Data extracted and compiled from Karmaoui et al. [5], in UDV, Karmaoui et al. [4] in Middle Draa Valley and Ben-Salem [3] in Tafilalt

That is to means that this region knows a high vulnerability to heat waves, desertification, water resources, and temperature stress. After the EVI technical report [14], this indicator is designed to captures stress on land surfaces that can affect productivity and accelerate fire risks. The three zones have the same climatic vulnerablility (Fig. 4a). The total study area is vulnerable on 'Hot' Indicator as shown in Fig. 4b.

3.3 Geological Indicators

The geological indicators capture the risk of damage associated with volcanic eruptions, slides, earthquakes and Tsunami to ecosystems. After the results in Fig. 5, the oases of this study area are stable toward geological events.

3.4 Geography

Draa region (UDV & MDV) is more vulnerable to geographical risk ('Land', 'Dispersion' and 'Isolation' Indicators) and Tafilalt is especially vulnerable to 'Land' indicator (Fig. 6a). The average graphic (Fig. 6b) shows that the study area is vulnerable to 'Land' and 'Isolation' indicators. The 'Land' and 'Isolation' vulnerability makes the whole oasean system often at the periphery of society, politically and economically.

Table 5. Aspects of environmental vulnerability of the biosphere reserve of oases in southern Morocco BRSMO

	UDV	MDV	Tafilalt
Hazards	2.67	2.75	2.24
Resistance	3.38	3.38	2.50
Damage	2.57	2.86	2.44

Data was extracted and compiled from Karmaoui et al. [5], for UDV, Karmaoui et al. [4] in Middle Draa Valley and Ben-Salem [3] in Tafilalt

Table 6. Major indicators (environmental vulnerability indicators of the Moroccan oasean system scored 4 or plus)

Indicators	Climate	Geography	Ecosystem and services	Anthropogenic
Upper Draa Valley	Hot	Land dispersion isolation	Endemics, Extinctions, Los Veg., Degradation, Farming, Fisheries, Water, Treatment, Mining and Sanitation	Growth tourists
Middle Draa Valley	Hot	Land dispersion Isolation	Endemics, Endangered, Extinctions, Los Veg., Degradation, Farming, Water, Treatment, Mining and Sanitation	Growth tourists
Tafilalt	Hot	Land	Endemic, Vegetation, Water and Treatment	Density growth

Table 7. Major common indicators (MCI) of the Moroccan oasean system

	Climate	Geology	Geography	Ecosystem and services	Anthropogenic
Oasean region	Hot	0	Land Isolation	Endemics and Degradation Water and Treatment Mining and Sanitation	Growth Tourists

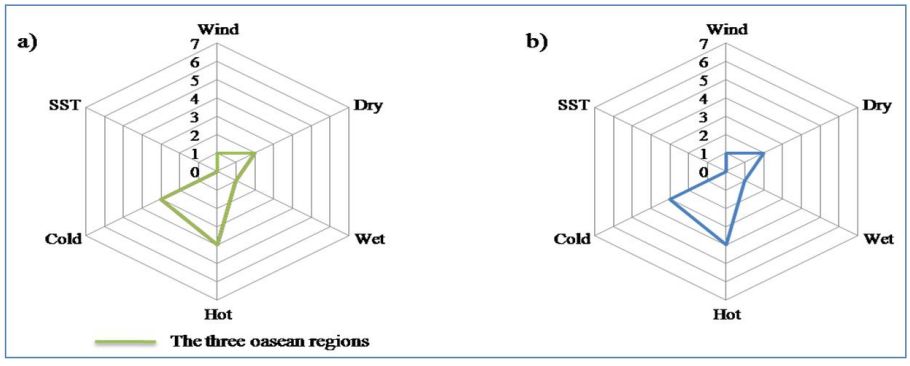

Fig. 4a. Climatic indicators of the three sites and b. The average value of climatic vulnerability of oasean zone (common indicators)

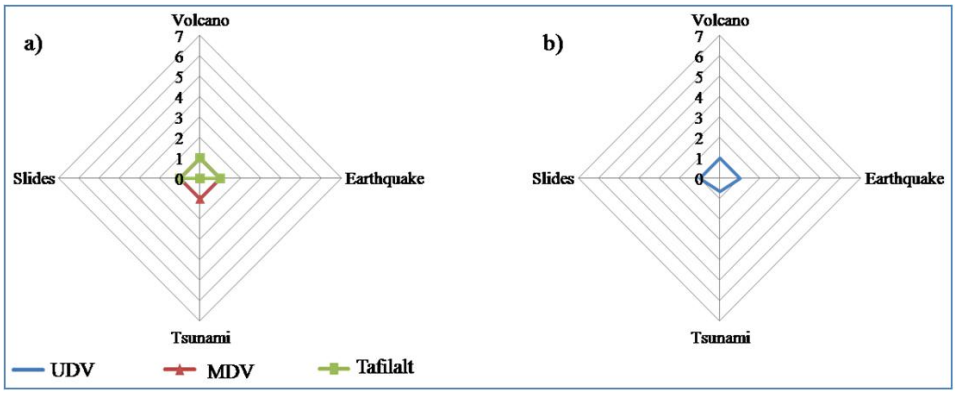

Fig. 5a. Geology vulnerability of the three Oasean regions; b. Average geology of Oasean zone

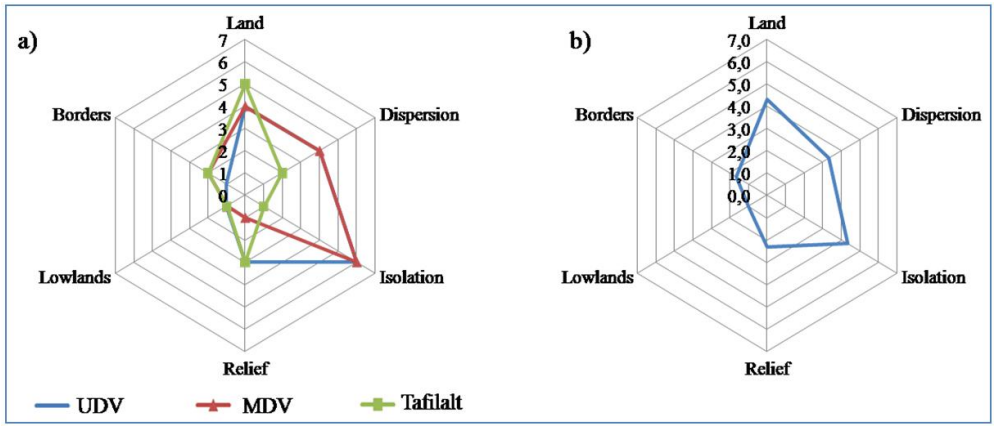

Fig. 6a. Geography indicators of the three sites and b. The average value of Geography vulnerability of oasean zone (common indicators)

3.5 Ecosystems and Services

Regarding the 'Ecosystem and services' category, the study area is marked mainly by the following indicators: 'Endemics', 'Degradation', 'Water', 'Treatment', 'Mining' and 'Sanitation'. All these indicators are a result of a purely human pressure.

The 'Endemic' indicator is common for the entire oasean region; it is the risk of losing unique species. Losses of species can affect ecosystems for sustainable activities for foreign exchange.

The "Degradation" indicator is the second common indicator of this region. It is capturing the loss of ecosystems including water and wind erosion, chemical and physical deterioration, agriculture, deforestation and grazing. These can be associated with salinisation and desertification which leads to decreasing biodiversity and soil quality. The soil salinity is particularly acute in the lower valleys and plains [1,8]. Degradation of ecosystem structure will certainly cause ecosystem services of the oasean system. Reduction of the oases ecosystem services includes the loss of biodiversity and reduced agricultural productivity that result in poor harvest and food shortages [4]. After [3], biodiversity and ecosystem services are profoundly altered due to overexploitation of resources and the introduction of invasive species. The genetic outstanding, which is an unrecognized wealth may eventually diminish, regress and even disappear [17,18]. Regarding the "Water" indicator or renewable water is in turn common for this region; it indicates the risk to terrestrial and aquatic ecosystems. It focuses on sustainable use of surface free water and groundwater and damage through salinisation, and extraction. In fact, the quantity and quality of domestic water has decreased [2].

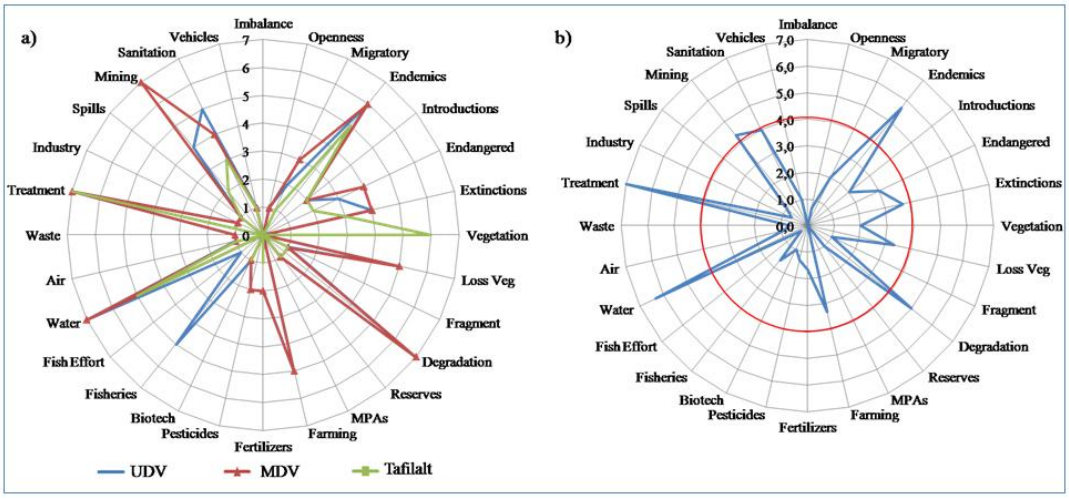

Fig. 7. a, Ecosystems and services vulnerability of the three Oasean regions; b, average ecosystems and services of Oasean zone

'Treatment' or waste treatment refers to the risk to terrestrial, aquatic ecosystems from municipal, agricultural or industrial wastes. The treatment leads to reducing the overall waste load in an area. High waste loads present risks to all aspects of the human and environment health. The 'Sanitation' it deals with hygiene, disease control. If sanitation is of a low standard, ecosystems downstream have a higher risk to be polluted. Wastewater in oasean system is a threat to the water. Their management is poorly developed or non-existent in the oasean environment which generates a health risk in addition to the pollution of groundwater [16]. The latest common indicator is 'Mining' which captures the risk to terrestrial, aquatic ecosystems from the effects of ecosystem disturbance from mining of all kinds. High levels of mining activity present risks to all aspects of the environment. Regarding the impact of mining in the Middle Draa Valley, Zainabi (2003) [8] reported that:

> *« … a first study by the Regional Directorate of Water (DRH) in 1997 stated that "the activity of Bleida copper mine (Omnium North Africa group) generates significant metal pollution that has an impact on the quality of water resources in the area". The study of the Department of the Environment confirmed the study of DRH, stating that pollution from the mine is characterized by high levels of copper, arsenic, lead and chromium.. Large amounts of solid waste was also deposited as dykes ... The study also confirmed that the mine has produced since its entry into service, more than 280 000 tons / year of solid waste, consisting mainly of sulfides and oxides copper and quantities stored currently amount to more than 4 million tons. Moreover, the wastewater from the mine is estimated at 400,000 m^3 / year. This wastewater transported about 85,000 tons / year of suspended solids, 260 tons / year of oxidizable materials and 14 000 tons / year of high heavy metal mainly iron, aluminum, copper and manganese… Omnium North Africa group (ONA) has developed a adversarial study (ONA-Reminex 2000) disclaims any responsibility; firstly of mining on the pollution of groundwater and also empowers both the local geology including the strong presence of sulfates in the area and the local population for his inappropriate use of water points. These justifications was considered by all the concerned in this region as an escape ahead of the ONA group»* [8].

3.6 Anthropogenic Indicators

'Density' indicator or population density is a measure for pressure on the environment resulting from the number of humans being supported per unit of land and the production of wastes and physical disturbance of the environment [14]. This indicator characterizes mainly the Tafilalt zone. In this later, the anthropogenic activities have a greater impact than that induced by climate; it accelerates the process of vulnerability [3]. However the common

vulnerability indicators are firstly the 'Human Population Growth' that is the damage caused by all human activities relating to the increasing rates of habitat damage, and the exploitation of natural resources; and secondly the 'Tourists' indicator which is associated with international visitors. Tourists place additional pressure on the environment through increasing demands on local resources and through chemical and physical disturbances of the environment.

The results of above qualitative traits analysis show that according to the informations from the EVI synthesis, factors influencing the destruction of natural resources are divided into four main categories(climate change, Geography, Resources and services, and anthropogenic). Other factors were significantly effective in the destruction of natural resources related to the social vulnerability like the illiteracy rate which is about 48.9% in Draa oases (Upper and Middle Draa sites), and 42% in Tafilalet and the average poverty rate in the Draa is 30% and 50% in Tafilalet [19,20]. These high rates accelerate the dependence and subsequently pressure on ecosystem services.

3.7 General Scheme of Oasean Vulnerability Basing on the Major Common Indicators

Climate change causes many environmental impacts, which disrupts the well being of man. Moroccan oasean has always been an area of anthropogenic activity. Incomes in the region are largely from the agricultural sector. This region knows a wide variety of sensitive ecosystems. Basing on the outputs of the EVI tool in context of the three delimited oasean sites of the biosphere reserve of Morocco developed by Karmaoui et al. [5], for UDV, Karmaoui et al. [4] in Middle Draa Valley and by Ben-Salem [3] in Tafilalt, we develop a scheme (Fig. 9) gathering the principal indicators influencing environmental vulnerability (Major Common Indicators) and tracing also the interactions between the different components regarding the oasean vulnerability.

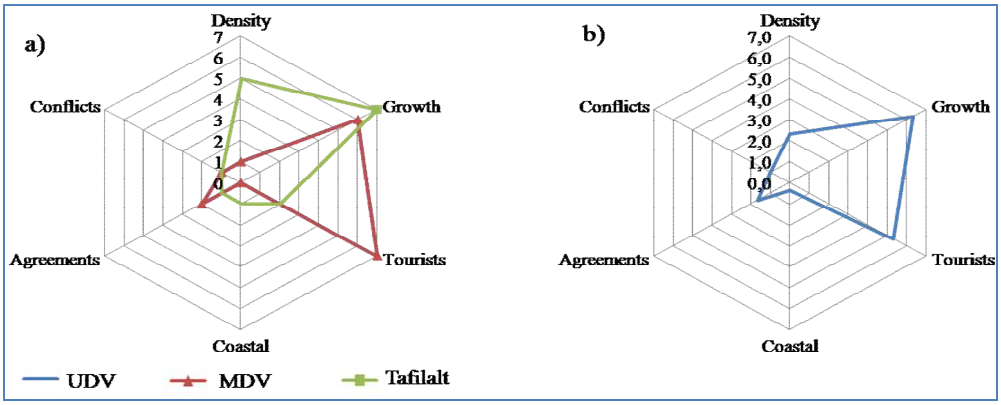

Fig. 8a. Anthropogenic vulnerability of the three Oasean regions UDV and MDV have the same scores; b. Average anthropogenic vulnerability of the Oasean zone

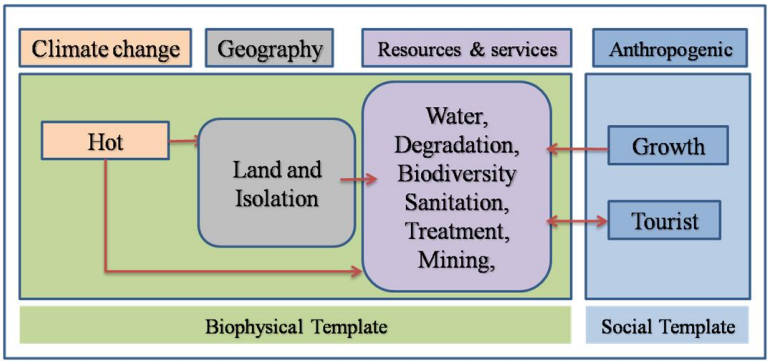

Fig. 9. Scheme of the principal factors, influencing environmental vulnerability and interactions of the different components of Mediterranean vulnerability

As the EVI is a multidisciplinary approach for overall evaluations. The impacts of climate events that occurred in the oasean region, such as heat waves and floods, highlight the significant vulnerability and exposure of certain ecosystems and human systems. The impacts of these climatic events include the alteration of ecosystems and impact on human well-being. Climate exacerbates other stressors. In addition, growth and tourist pressure especially accelerate vulnerability of natural resources. Use these informations lead to better understand the overall state and the trends of the oasean ecosystems.

The biosphere reserve oases extend from High Atlas mountains to the Sahara region offering a high diversity of substrates. This wealth creates extremely varied ecological systems that make the High Atlas a center of diversity and endemism at the continental level [1]. The results can be used by decision makers. Our approach seeks to determine what could be the types of informations needed to make better decisions on the conservation of oases. From profiles already made in these three sites, we took into account the main indicators**,** and then search the major indicators having values indicating a high vulnerability and are common in the study area**,** in order to assist in decision making. The existence of specific informations to these sites could guide the local development of oases policy. The results show for example that population is worried about the reduction of some valuable resources, especially plants. An understanding of the major and common indicators of degradation allows finding suitable solutions. If we know what are the sites and the most affected sectors, we bring attention to management that could be carried out in a targeted manner. The palm groves are often damaged by overexploitation, which deteriorate the socio-economic vulnerability. This vulnerability is justified in part by the low activity rate that is about 28.4% in the BRSMO compared to the national rate of 35.9%, which underline the precarious economic conditions that characterize the oasean region [1]. We could avoid these problems if we agree to consider the sites and the most vulnerable sectors that require priority and urgent intervention.

Many future activities will be based on the data of this study. Checks the list of major and common indicators of degradation by using a sufficiently like EVI is valid and useful in the field of environmental research. Satellite imagery and GIS tools can also be used to extrapolate these indicators spatially explicit. This list of indicators can be used as a reference against which future trends can be evaluated. Agricultural activity is the essential source of life for the majority of the population and the date palm is confirmed as a fitting quality of the oasean system. The rehabilitation of the palm through a number of crucial actions [2].

- Solve the problem of soil salinization**,**
- Improve drip irrigation,
- Use cultural practices that consume less water**,**
- Improving the management of natural resources**,**
- Improving the living conditions of the populations.

The use of indicators with scores equal or higher than 3 gives additional and detailed informations on oasean state (or indicators having a higher accumulative score equal or higher than 9). The Fig. 10 shows the scheduling indicators priority in the studied areas based on the EVI of the three sites of the biosphere reserve.

In addition of the above selected indicators, we can adding the indicators (Cold, Dispersion, Endangered, Extinctions, Farming, and Loss Veg.) showed in Table 9.

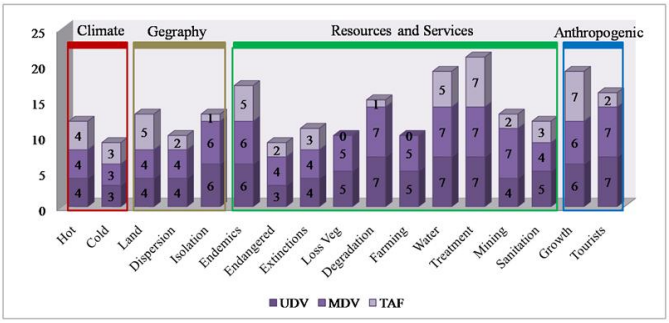

Fig. 10. Indicators having a higher accumulative score (equal or higher than 9)

Table 9. Additional common vulnerability indicators of the whole BRSMO

	Climate	Geology	Geography	Ecosystem and services	Anthropogenic
Oasean region	Cold	0	Dispersion	Endangered, Extinctions Farming and Los Veg.	0

4. CONCLUSION

This paper presents a synthesis of the environmental vulnerability indicators of the RBOSM. We gathered and compiled values of 50 indicators of the three sites of this reserve biosphere. These data are processed in large part to review current scientific knowledge on Moroccan oasis system. The informations define priorities for intervention in the management of resources, local decision-making regarding the use of these resources. The environmental vulnerability of the biosphere reserve includes water stress, soil degradation, and vegetation loss. The impact of climate change is seen in these areas especially on water resources and on agriculture; the main economic resource in the oasean region, which makes the region very vulnerable, and adaptation is related to water management [2]. Degradation of natural resources is induced by both climatic factors and especially by human activities, exacerbated by socio-economic context marked (especially extreme poverty). Successive droughts in recent years have also severely limited the production of environment. The rapid population growth in recent years and the radical change that has occurred in lifestyle have led to strong pressure on natural resources. The intensification of agriculture in this area illustrates the pressures that the oasean system is exposed. For the purposes of this activity, excessive water from shallow groundwater pumping is made. Waste of this valuable resource in the area is much more serious than it is often used to irrigate agricultural production speculative very low economic productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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