A LAS regional rangeland situation analysis, including an overview of the state of rangeland health and estimated cost benefit of restoration and protection

Final Report

Executive summary:

Rangelands contribute to the national income of many of these countries, and rangelands have a vital role in protecting the environment and providing ecosystem services. Rangelands livestock production is one of the pillars of food security in the Arab countries. For example, in Syria rangelands used to provide more than 30 percent of the total value of agricultural production. Rangelands support the livestock sector, which one of the pillars of the national economy in Sudan, and rangelands represent a source of livelihood and national food security. Due to free access to grazing lands, and lack of sustainable rangeland management and policies significant degradation of rangelands has been occurred in most of the Arab Countries. The pastoral livestock sector relies on healthy rangelands, which also deliver valuable ecosystem services in terms of climate change mitigation and adaptation, purification and infiltration of ground water, medicinal herbs, and storage of genetic diversity of flora and fauna. These ecosystem services have been in decline over the past five decades in the Arab rangelands.

This study was prepared based on ACSAD experts' long-term experiences in rangelands rehabilitation and management in the LAS region, the available secondary rangelands data, remote sensing data, technical reports, studies, and scientific articles and policy papers. Rangeland production in Al-Hamad ecosystem in four different Arab countries from 1980 to 2019, the data presented were based of rangeland field survey and only 2019 data was based in analyses of remote sensing data combined with rapid field measurements. Productivity trend in general showed high downward and reduction in rangeland productivity particularly from perennial shrubs. The highest reduction in rangeland productivity was noticed in Jordan whereas rangeland plant production decreased from 590.5 kg/ha in spring season of 1982 to 95 kg/ha in the spring season of 2019. It could be projected that about 25 % of the LAS rangeland areas could have fit for application of the Hima restoration approach. Total rangelands area in the Arab countries estimated by 375 million ha in 2017; 25 % of these area could have the potential to be managed under the Hima with 25 % open access approach. We used the Jordan case study results to estimate the costs and benefits of restoration and protection at the regional scale of LAS region and we roughly estimated the value at the LAS countries.

ACRONYMS

ACSAD Arab Center for the Studies Arid Lands and Dry Zones

AOAD Arab Organization of Agriculture Development

FAO Food and Agriculture Organization

IUCN International Union for Conservation of Nature

LAS League of Arab State

LDN Land Degradation Neutrality

NDVI Normalized Difference Vegetation Index

SDGs Sustainable Development Goals

SRM Sustainable Rangeland Management

Table of Contents

Lists of Tables

Lists of Figures

1 Introduction

1.1. Background

Arabian rangelands are important source of income for large portion of the Arab countries populations. Rangelands represent major part of food security and ecosystem services in several countries of the region. Rangelands in the LAS region are highly deteriorated and making living in them has always been a challenge (ACSAD, 2015). Landscapes characteristics have important impact on climate, hydrology, biodiversity, and soils, hence, land cover changes have been indicated as one of the high priority concerns for research and development of sustainable management strategies. Rangelands are globally the most abundant land cover type that sustains critical social and economic systems. Excluding the deserts on most of the Arab countries, the Arabian rangelands cover about 33 % of the region (ACSAD, 2015), and are important for food production and ecosystem services in most of the Arab countries. The LAS region has been facing tremendous changes in the last 50 years including high urban development rates, rapid population growth, rangeland overgrazing, land degradation, drought, and agriculture lands expansions.

Most of rangeland areas in the LAS region occur in arid lands with average rainfall from range 50 or less to 200 mm (ACSAD, 2015). The climate, topography and level of development are far from uniform and this has given rise to a variety of livestock production systems. Continued heavy grazing resulted in great degradation of soil and vegetation, and it led to tremendous reduction on the pastoral grazing lands in the past 50 years due to increasing livestock numbers. Mismanagement and lack of integrated strategies and adaptive rangeland plans have been the most basic problem confronting rangeland livestock production in the region. People have been taking rangelands as granted resources for many years without implementing development and improvement programmes, this make it more complicated to apply any management and restoration plans. The way rangelands have been used and the weak participation of local communities and government agencies constrain the achievement of the sustainable development of rangelands.

Although rangelands in the LAS region are widely considered to have deteriorated, they provide around 39 % of livestock feed (ACSAD, 2015), which support mainly livestock herders, livestock owners, and small farmers in the Arab region. Sheep and goats are by far the most numerous livestock species in the LAS region, with sheep generally exceeding goats' numbers; sheep exceeded 183 million heads in 2016, followed by goats with 91.7 million heads, in addition to about 16.6 million heads of camels (AOAD, 2017). Sheep numbers exceed goat and camels most properly as sheep considered the main source in supplying rangelands local communities with milk, red meat, as well as wool and leather for making clothes, and the basis, it covers all the needs of living.

1.2. The importance of the rangelands and its linkage with the SDGs

The SDGs aim to improve the quality of people's lives in number of ways: eradicating poverty and hunger; promoting health and education; reducing inequality and gender disparities; building sustainable infrastructure and making cities more sustainable; combating climate change; protecting oceans, forests and biodiversity. The financial gap to achieve the sustainable development goals in the Arab countries is estimated at 230 billion US dollars annually (The Arab Forum for Environment and Development, 2018). Moreover, the Arab region is highly vulnerable to climate change. There are urgent needs for mitigation and adaptation related to issues such as water scarcity, sea level rise, drought, land degradation and desertification. Large portion of the LAS population are vulnerable and live in rural areas and depend on agriculture and rangelands for their livelihood.

There is a global concern that rangelands shouldn't be allowed to be degraded through overgrazing, drought, and human activities. There are several drivers to achieve SRM including, low rangeland productivity and livestock production depends on concentrate feed, and hence improving rangeland productivity could increase the carrying capacity; desertification and land degradation that seriously impact food security and social and economic life of many people living in the rangelands; overgrazing and mismanagement practices; sand encroachment and sand and dust storms as a results of plant cover degradation.

1.3. Methodology

This study was prepared based on ACSAD experts' long-term experiences in rangelands rehabilitation and management in the LAS region, the available secondary rangelands data, remote sensing data, technical reports, studies, and scientific articles and policy papers. The secondary data sources used in this study included technical reports of projects, programs, studies, scientific articles, policy papers, and maps which were conducted in the LAS and available. Some of the available secondary data sources at ACSAD include, 1) rangelands survey data and final technical reports of Al-Hamad Basin studies project conducted by ACSAD in Jordan, Iraq, Syria, and Saudi Arabia in the period from 1979 to 1983; 2) final technical report and rangeland survey data of the development of Al-Hamad basin in Iraq: rehabilitation and improvement of rangelands project implemented by ACSAD, 2015; 3) final technical report and rangelands survey data of the survey of natural resources in the Syrian Badia project implemented by ACSAD, 2004, 4) rangeland survey data and maps of the establishment of data base for rangelands sites in Oman project, implemented by ACSAD, 2010; 5) rangeland survey and final technical report of the potential GIS maps of land cover/ land use in the state of Sudan, ACSAD, 2009 and 2019; 6) final technical report of the survey of rangelands in the central, northern, and eastern zones of Kingdom of Saudi Arabia project, KSA Ministry of Agriculture, 2007; 7) Final Technical Report of the Evaluation of Rangelands in the Kingdom of Saudi Arabia: the south-west region project, KSA Ministry of Agriculture, 2015; and 8) The study of current rangelands condition and their development methods in the Arab countries, ACSAD, 2015.

The assessments of ecosystems and land degradation, good restoration efforts, ecosystems services valuation, and current land management and rangelands practices in the LAS were reviewed to response to the publication on the LAS regional rangeland situation analysis objectives and outlines, and to deliver a comprehensive report on the state of rangelands in the LAS region, a DPSIR analysis of change in rangeland health, a high level estimates of potential cost of rangeland degradation and rangeland restoration, and recommendations for rangeland restoration.

2

Spatial analysis of the rangelands area in the LAS region

2.1 Rangelands definition:

Rangelands are places of important biodiversity and ecosystem services that occupy up to half of all land and up to three quarters of the world's drylands, providing benefits to local communities, to economies and to global society (Davies et al., 2015). Rangeland are lands on which the indigenous vegetation (climax or sub-climax) is predominantly grasses, grass-like plants, forbs or shrubs that are grazed or have the potential to be grazed, and which is used as a natural ecosystem for the production of grazing livestock and wildlife (Allen et al., 2011).

Recently, Rangelands were defined as areas of grasses, grass-like plants, forbs, shrubs and sometimes trees that are grazed or have the potential to be grazed by livestock and wildlife. They are diverse in their vegetation highly influenced by rainfall, temperature and other climate phenomena, and habitat for a wide range of wildlife, many species of which are found nowhere else (ILRI, IUCN, FAO, WWF, UNEP and ILC, 2021). Rangelands may include natural grasslands, savannas, shrublands, many deserts, steppes, tundra, alpine communities and marshes.

According to the Society for Range Management world map of rangelands (Figure, 1), mostly the following rangeland types are occurring in the LAS countries:

Savannas: Grassland characterized by precipitation between 375 and 1500 mm year), variable proportions of trees or large shrubs, especially in tropical and sub-tropical regions. It is often a transitional vegetation type between grassland and forestland

Steppe: Semi-arid, sparse to rolling grassland characterized by short to medium-height grasses occurring with other herbaceous vegetation and occasional shrubs.

Shrubland are lands on which the vegetation is dominated by low-growing woody plants.

Desertland are lands on which vegetation is sparse or absent and is characterized by an arid climate. Deserts may be classified as hot or cold deserts depending on latitude and elevation.

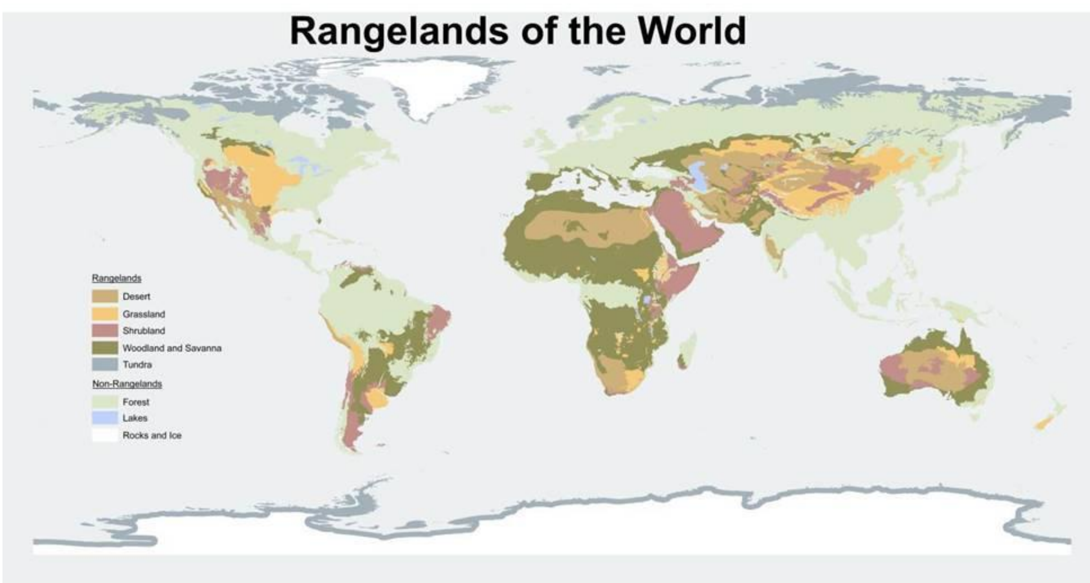

Figure (1) Map of the world's rangelands, (Source; Society for Range Management)

2.2 Spatial analysis of the physical area of rangelands in the LAS region

Even though rangelands are one of the earth's major ecosystems, estimating of the amount of the earth's land surface covered by rangelands vary from 18% to 80% (Figure, 2) according to Lund, (2007). The primary cause of the variation in the rangeland area in the world is the different criteria which used for classification of rangelands and land cover. These criteria include the differences in bases used for estimation the area i.e. earth surface, land surface, ice-free land surface, etc.), the information sources of distinguish rangeland area (ground surveys and inventories, remote sensing, climatic or soils maps, etc.), and the definitions used to identify rangelands (Lund, 2007). This variation in estimating rangelands area could be also true in the LAS region. Table (1) shows the changes in rangelands area in the Arab countries from 2010 to 2017, however, it is clear that there were no changes in the rangelands area in the LAS region, but in Sudan at 2012 due to the separation of South Sudan.

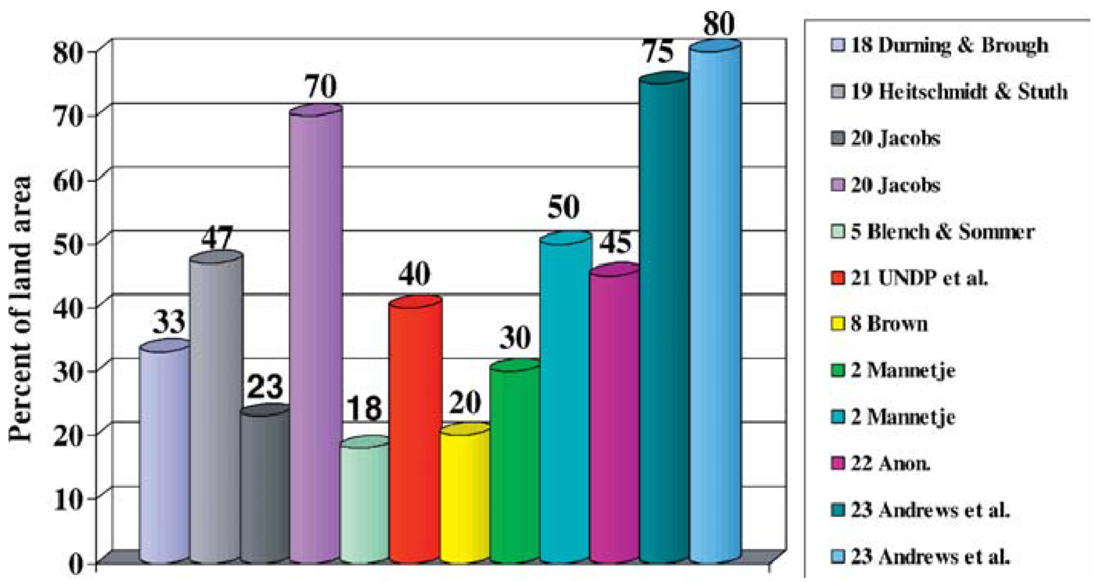

Figure (2) Recent estimates of world's rangeland (the numbers on the columns represent the percent of rangelands from the total land area on the earth as reported by different sources), (Source; Lund (2007)

The League of Arab State is a union of Arab-speaking African and Asian countries. It was formed in Cairo in 1945 to promote the independence, sovereignty, affairs and interests of its 22member countries. The 22 members of the Arab League are Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, the United Arab Emirates and Yemen. Figure

(3) shows an illustrated map of LAS members' countries. The LAS countries have a total land area of about 13.3 million km^2. Rangelands cover about 33 % of LAS region area.

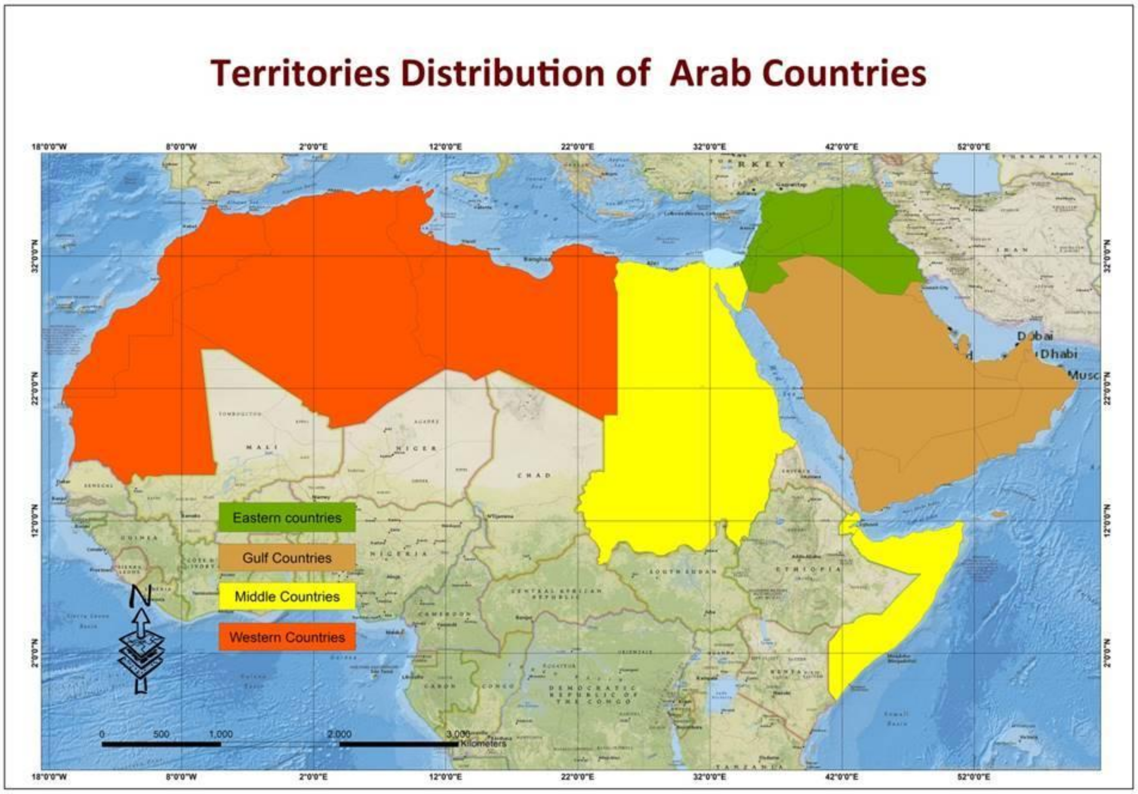

Figure (3) LAS members' countries map, Eastern countries include Iraq, Syria, Lebanon, Palestine, and Jordan; Gulf countries include Oman, Qatar, Bahrain, Kuwait, United Arab Emirates, Saudi Arabia, and Yemen; Middle countries include, Egypt, Sudan, Somalia, Djibouti, and Comoros; Western countries include, Libya, Tunisia, Algeria, Morocco, and Mauritania.

Data in Table (1) show the rangeland area in the Arab Countries (AOAD, 2018). The Arab Organization for Agriculture Development (AOAD) works with agriculture ministries in the Arab countries to collect and analyses statistics data regarding agriculture and natural resources. Some Arab countries have accurate estimation of rangeland areas, however other don't; each country provide AOAD yearly with the statistics data including areas of cultivated lands, rainfed, rangelands, forest, .etc. In Syria for example, rangeland area is estimated by all the land occurred under 200 mm rainfall line and represent about 55% of the total land area of the country. Some countries such Oman had changed their rangeland area by adding more of the desert rangelands type to the total rangeland area (Table, 1). Moreover, data presented in the same Table show that Mauritania had reviewed the rangeland area in the country by decreasing the area in 2014 to 13.8 million ha. Sudan also show changes in the rangeland area after the separation of south Sudan that happened in 2011, where the total land area of the country had reduced by 700,000 km^2 (ACSAD, 2019c). That is the probably the main reason there are variation in the rangeland areas in those countries. However, the variation in estimating rangelands areas in the LAS countries in general could be due there is no adopted common definition of rangelands or certified criteria and methods to estimate the area of rangelands in the Arab countries.

Table 1. Rangeland area in the Arab Countries

Country	**Rangeland Area in 1000 ha**							
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Algeria	32938.3	32942.08	32943.69	32969.44	32965.97	32968.51	32910.65	32500
Bahrain	0	0	0	0	0	0	0	0
Comoros	10	10	10	10	10	10	10	10
Djibouti	200	200	200	200	200	200	200	200
Egypt	4000	4000	4000	4000	4000	4000	4000	4000
Iraq	32634.5	32634.5	32634.5	32634.5	3384.5	3384.5	3384.5	3384.5
Jordan	800	800	800	800	800	800	800	800
Kuwait	136.22	136.22	136.22	136.22	136.22	136.22	136.22	136.22
Lebanon	16	16	16	16	16	16	16	16
Libya	13300	13300	13300	13300	13300	13300	13300	13300
Morocco	24850	24850	24850	24850	24850	24850	24850	24850
Mauritania	39340	39340	39340	39340	13800	13800	13800	13800
Oman	354	354	354	354	1350	1350	1350	1350
Palestine	161	161	161	161	161	161	161	161
Qatar	50	50	50	50	50	50	50	50
Saudi Arabia	170000	170000	170000	170000	170000	170000	170000	170000
Somalia	42000	42000	42000	42000	42000	42000	42000	42000
Sudan	117180	117180	48194.76	48194.76	48194.76	48194.76	48194.76	48194.76

Syria	8212.2	8199.01	8189.67	8189.67	8189.67	8185.67	8185.53	8185.38
Tunisia	4839.5	4839.5	4839.5	4839.5	4839.5	4819.97	4767.56	4715.15
UAE	305	305	305	305	305	305	305	305
Yemen	7000	7000	7000	7000	7000	7000	7000	7000

Source; AOAD (the Arab Organization for Agriculture Development), 2018

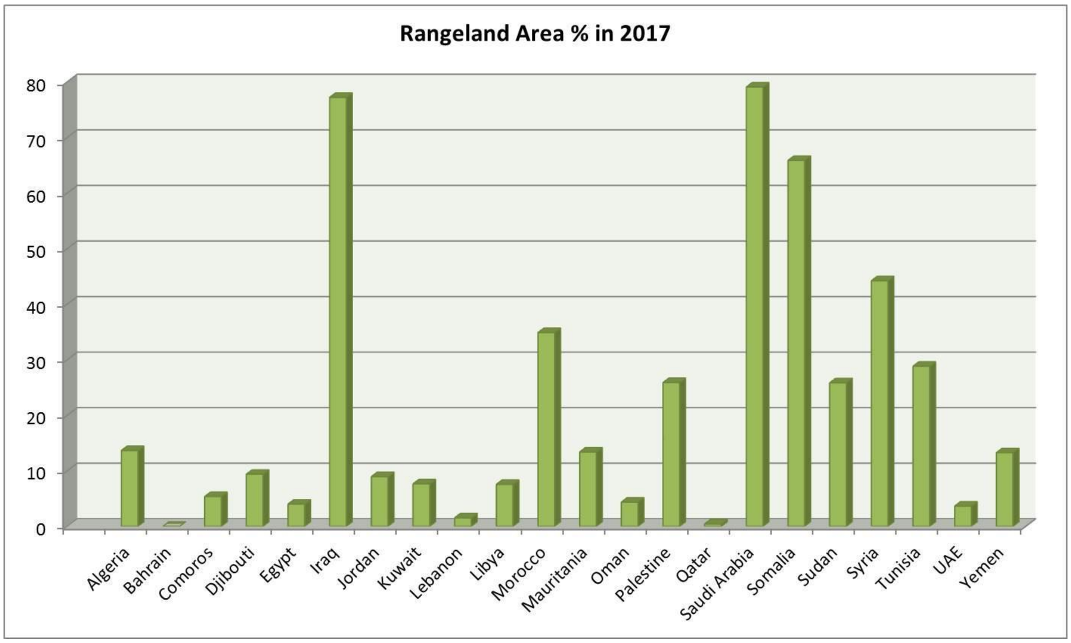

Figure (4) Rangeland area percent in 2017 from the total areas of LAS members' countries, (Source; AOAD, 2018)

2.3 Rangelands terminologies and classification in the LAS countries

The phytogeographical subdivisions of the LAS countries as described by Zohary (1973) include:

1. The Mediterranean region, which occupies a narrow belt along the Mediterranean Sea, with a gap between Palestine and Libya where the desert closely approaches the Mediterranean.
2. The Irano-Turanian region, which occupies about half of the Middle East, mainly Centeral and East Turkey, Iran, Iraq, Syria and Palestine; it is floristically rich, high in endemism and a centre of radiation of several genera.

3. The Saharo-Sindian region, which occupies most of the Arabian Peninsula, southern Palestine and SE Iraq.
4. The Sudanian region, which occupies SW Arabia, Gulfs of Suez and Aqaba, Gulf of Oman and the Arabian Sea.
5. Tropical savanna region, This region covers vast parts of Sudan, Somalia and Mauritania, and some southern parts of the Arabian Peninsula (parts of Yemen, Oman and Saudi Arabia).

Camels grazing severe degraded desert rangelands in Middle Sinai Peninsula, Egypt, Fall 2016, photo by the Consultant

Camels grazing steppes at Southern Tunisia, Spring 2019; photo by the Consultant

Steppes, Jordan at Spring, 2019; photo by the Consultant

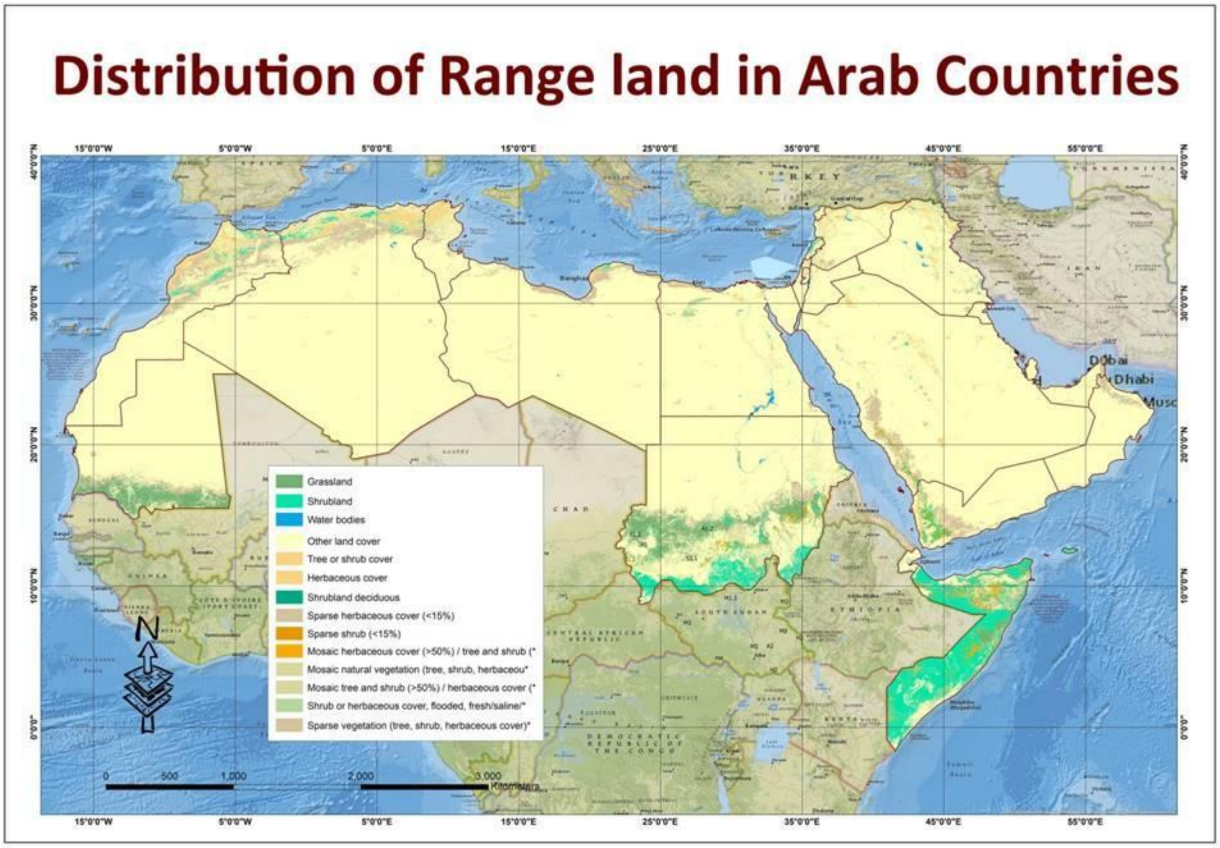

Figure (5) Rangelands types in the LAS countries, it can be noted that the largest land cover type is other land cover, which represent large land areas including deserts classified as rangelands in the LAS countries, (Source, ACSAD GIS Unit using Global Land Cover data, ACSAD, 2019a).

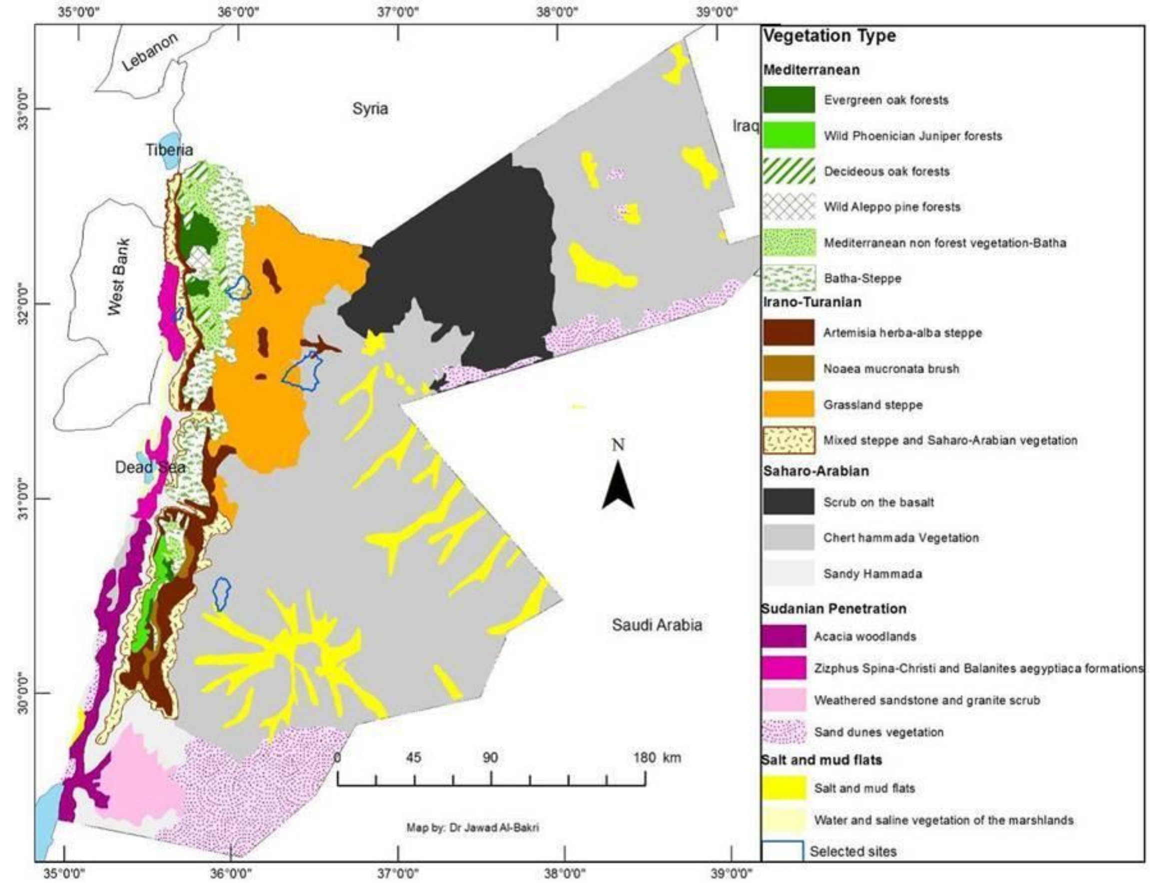

Figure (6) Jordan Rangelands vegetation types, (Source; IUCN, Mapping Rangeland in Jordan 2015).

Classification of rangelands and naming rangelands types in LAS region are slightly different among the Arab countries. For example in the Mashriq (east) Arab countries including Jordan, Iraq, Syria rangelands usually classified into two types i.e Badia (desert shrublands) and steppe. In the central Arab countries such as Sudan rangelands mainly classified into Desert, Semi-Desert and Low Rainfall Woodland and Savanna based on the variations in climates, soils, and topography. Also rangelands can be classified based on the season of grazing to Makharf (grazing during the fall season) and Massaief (grazing during the summer season) like the case of Sudan. In the Maghreb (west) Arab countries rangelands are usually classified into desert rangelands, steppe, mountain rangelands, and forest rangelands.

3

Spatial analysis of rangeland productivity trends

3.1 Spatial analysis of rangeland productivity trends

A simple spatial analysis of rangeland productivity trends using earth observation data and secondary data sources, preferably using the approved LDN indicators such NDVI, GPP, NPP, and land cover where possible provided in this study. Earth observation data such as MODIS Vegetation Index Products (NDVI), MODIS Gross Primary Production (GPP)/Net Primary Production (NPP), and MODIS Land Cover Type/Dynamics were acquired and analyzed for the LAS region. Also output maps and results of ACSAD monitoring and evaluation of changes in vegetation cover and land degradation of the LAS region using remote sensing technology will be provided. Figure (7) shows map of vegetation cover changes in the Arab region produced by remote sensing and GIS unit at ACSAD.

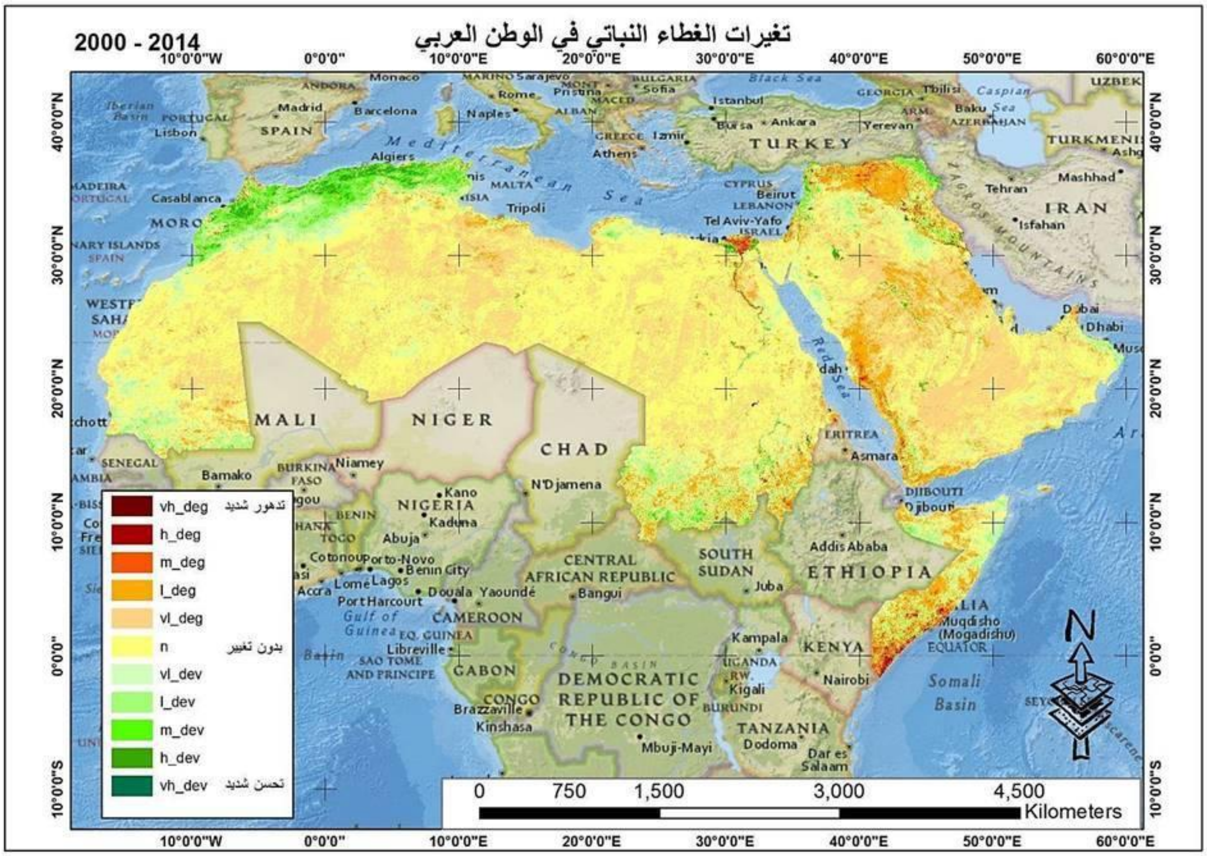

Figure (7) Map of vegetation cover changes in the Arab region produced by remote sensing and GIS unit at ACSAD, 2016. Note: the map legend include, vh_deg means very high degradation, h_deg means high degradation, m_deg means moderate degradation, l_deg means low degradation, vl_deg means very low degradation, n means no changes, vl_dev means very low development, l_dev means low development, m_dev means moderate development, h_dev means high development, and vh_dev means very high development.

3.2 Evaluation of vegetation changes in LAS countries:

To evaluate vegetation changes in the LAS region, MODIS Vegetation Index Products (NDVI) were used in the period from 2000 to 2018. MODIS vegetation indices produced on 16-day intervals and at multiple spatial resolutions, provide consistent spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure. The vegetation indices are retrieved from daily, atmosphere-corrected, bidirectional surface reflectance. The VI's use a MODIS-specific compositing method based on product quality assurance metrics to remove low quality pixels. From the remaining good quality VI values, a constrained view angle approach then selects a pixel to represent the compositing period (from the two highest NDVI values it selects the pixel that is closest-to-nadir). Because the MODIS sensors aboard Terra and Aqua satellites are identical, the VI algorithm generates each 16-day composite (phased products) to permit a higher temporal resolution product by combining both data records. The MODIS VI product suite is now used successfully in all ecosystem, climate, and natural resources management studies and operational research as demonstrated by the ever increasing body of peer publications.

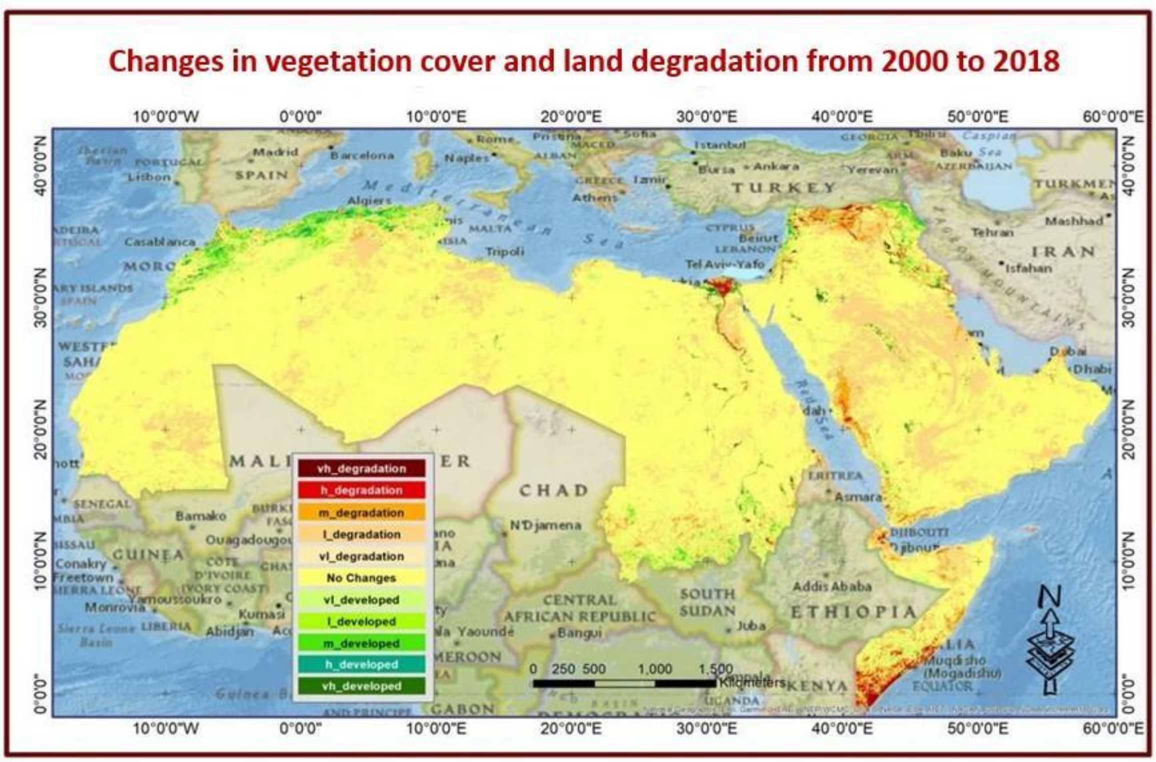

Figure (8) Map of vegetation cover changes in the Arab region, (produced by remote sensing and GIS unit at ACSAD, 2019a).

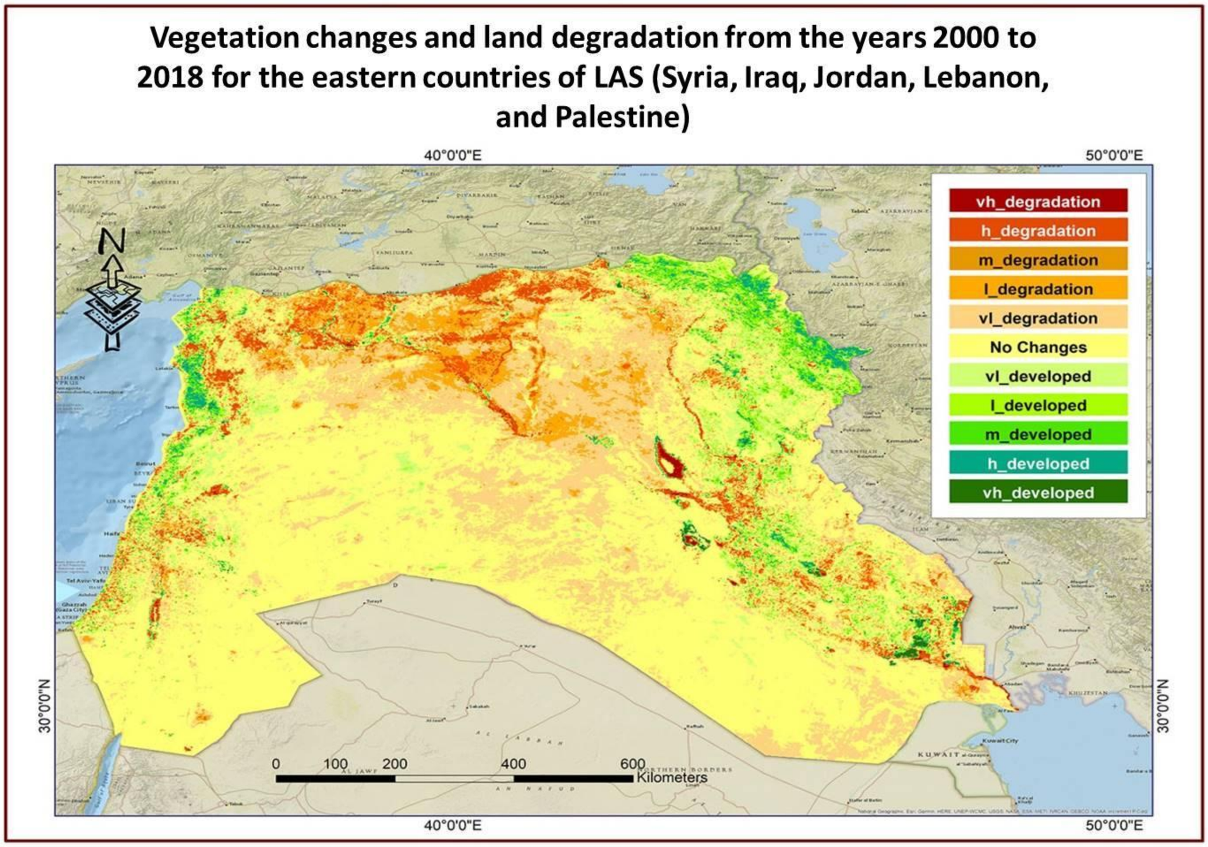

Figure (9) Map of vegetation cover changes in the Eastern Countries of the Arab region, (produced by remote sensing and GIS unit at ACSAD, 2019a).

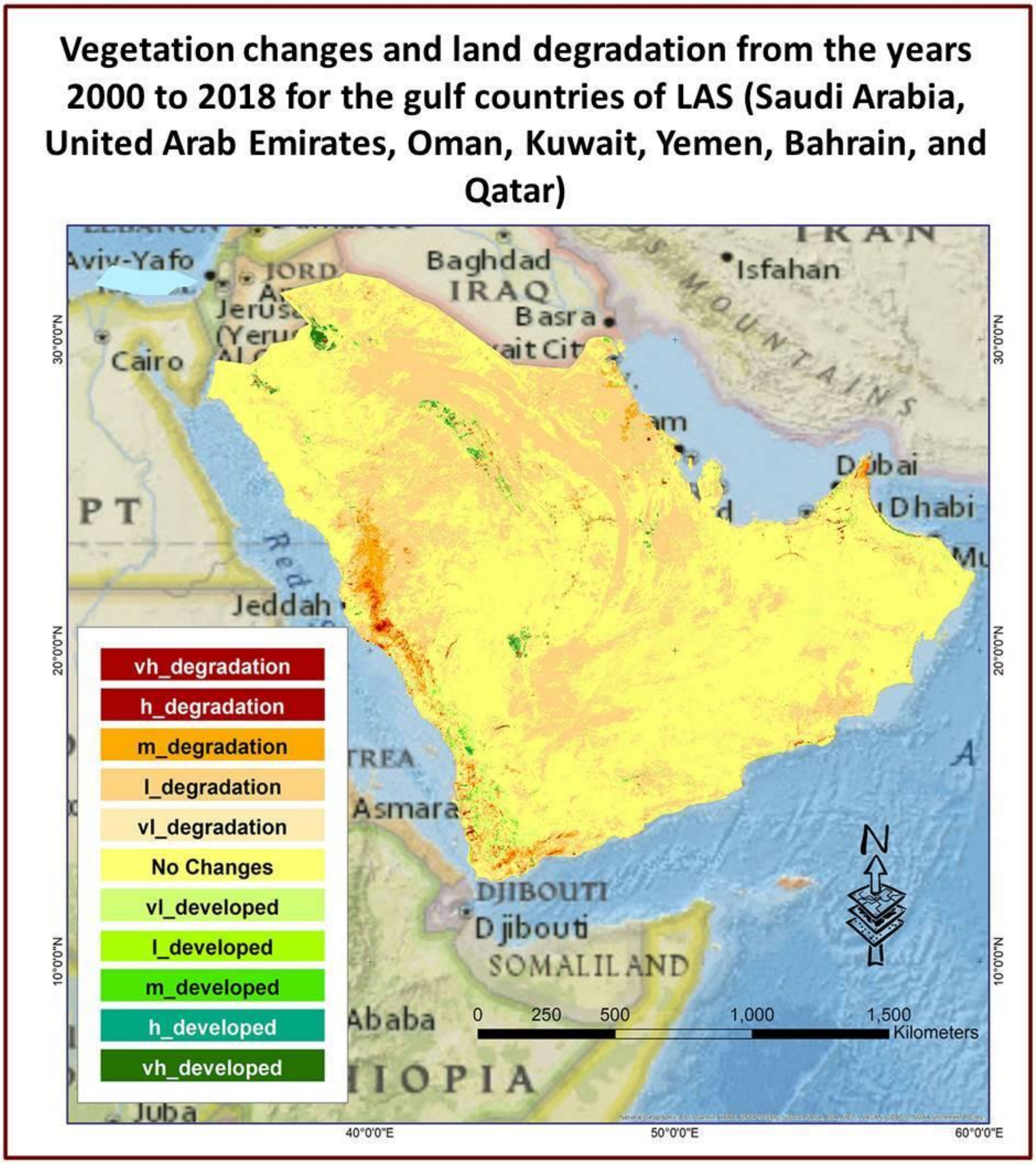

Figure (10) Map of vegetation cover changes in the Gulf Countries of the Arab region, (produced by remote sensing and GIS unit at ACSAD, 2019a).

Vegetation changes and land degradation from the years 2000 to 2018 for the Middle Countries of LAS (Egypt, Sudan, Somalia, and Djibouti)

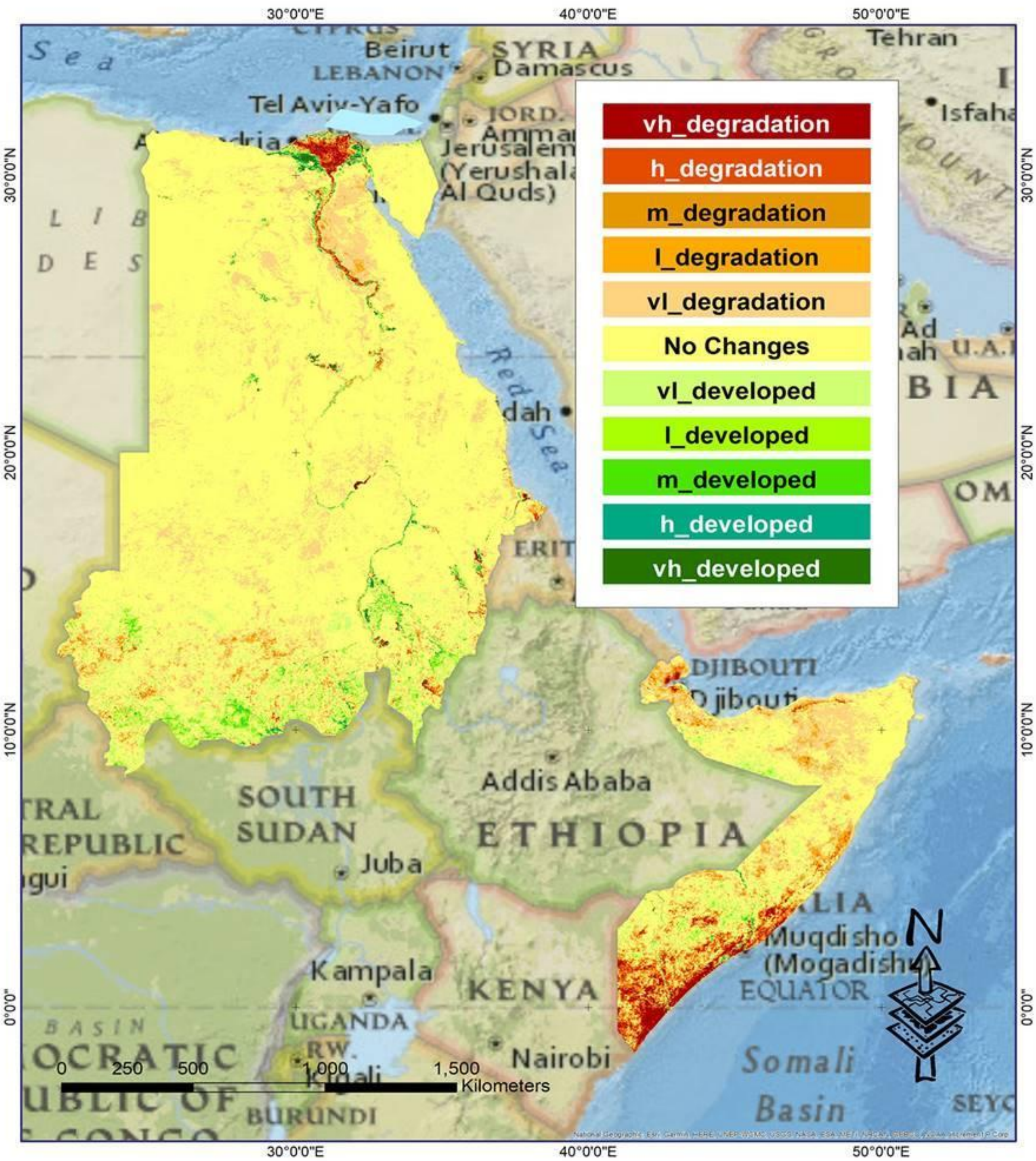

Figure (11) Map of vegetation cover changes in the Middle Countries of the Arab region, (produced by remote sensing and GIS unit at ACSAD, 2019a).

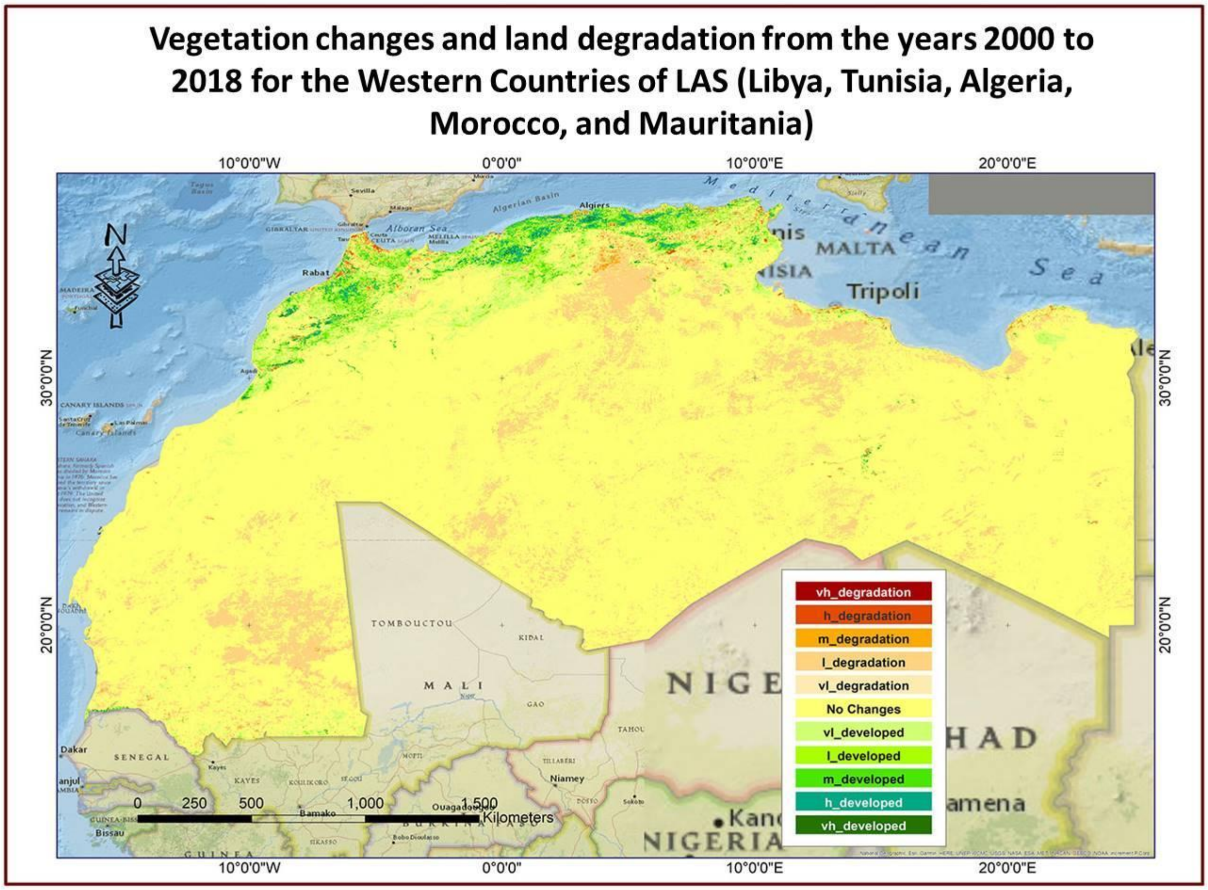

Figure (12) Map of vegetation cover changes in the Western Countries of the Arab region, (produced by remote sensing and GIS unit at ACSAD, 2019a).

Table 2. Vegetation cover changes and estimation land degradation in the Arab region from 2000 to 2018, (produced by remote sensing and GIS unit at ACSAD, 2019a).

Country	Area (ha)	High Deg.	%	Moderate Deg.	%	Light Deg.	%	No Change	%	Improve	%
Kuwait	1781800	1629.5	0.1	5986.8	0.3	957577.8	53.7	757583.7	42.5	59022.1	3.3
Oman	30950000	63601.8	0.2	86829.3	0.3	4895596.0	15.8	25450032.0	82.2	453940.6	1.5
Saudi Arabia	214969000	841338.0	0.4	1601243.9	0.7	98581983.1	45.9	110666524.2	51.5	3277910.8	1.5
U A E	8360000	72368.9	0.9	67790.7	0.8	1282369.0	15.3	6745382.0	80.7	192089.4	2.3
Yemen	52800000	161092.4	0.3	404174.0	0.8	11013963.0	20.9	39027318.0	73.9	2193452.0	4.2
Qatar	11437000	10082.0	0.1	9985.1	0.1	2480602.0	21.7	8644152.0	75.6	292178.9	2.6
Bahrain	66500	899.6	1.4	1268.0	1.9	11458.7	17.2	48092.0	72.3	4781.7	7.2
Iraq	4383700	68740.8	1.6	59822.1	1.4	1231510.0	28.1	2333998.0	53.2	689629.2	15.7
Syria	18518000	995307.3	5.4	966364.7	5.2	6943842.0	37.5	7814353.0	42.2	1798133.0	9.7
Palestine	622000	17087.3	2.8	18745.0	3.0	108678.8	17.5	386386.2	62.1	91102.8	14.7
Lebanon	1040000	21588.1	2.1	24425.6	2.4	111574.6	10.7	411795.1	39.6	470616.8	45.3
Jordan	8934200	44669.9	0.5	45754.4	0.5	957618.3	10.7	7627565.0	85.4	253279.4	2.8
Egypt	99545000	1149510.5	1.2	795646.5	0.8	13888976.0	14.0	81144236.1	81.5	2566630.9	2.6

Somalia	63765700	3624475.8	5.7	3506599.8	5.5	21870289.8	34.3	30124427.2	47.2	4639907.4	7.3
Sudan	186581300	470986.0	0.3	735706.6	0.4	24966031.6	13.4	140918624.3	75.5	19489951.5	10.5
Djibouti	2132270.2	113080.2	4.9	170889.4	7.4	1527170.9	66.4	285430.0	12.4	35699.7	1.6
Morocco	71255000	239088.8	0.3	208268.3	0.3	2367668.0	3.3	53281297.0	74.8	15158678.0	21.3
Tunisia	16361000	81680.3	0.5	81655.6	0.5	2213940.0	13.5	10429926.0	63.8	3553798.0	21.7
Algeria	238174100	178140.9	0.1	207436.6	0.1	25585664.7	10.7	196324195.9	82.4	15878662.0	6.7
Libya	175954000	72350.4	0.0	95139.6	0.1	18683556.5	10.6	155628676.7	88.5	1474277.0	0.8
Mauritania	103070000	15501.5	0.0	20585.4	0.0	17640415.6	17.1	83277177.0	80.8	2116320.5	2.1
Total	1310700570	8243220.0	0.6	9114317.3	0.7	257320486.4	19.6	961327171.4	73.3	74690061.5	5.7

MODIS Gross Primary Production (GPP)/Net Primary Production (NPP)

The Primary Production products are designed to provide an accurate regular measure of the growth of the terrestrial vegetation. Production is determined by first computing a daily net photosynthesis value which is then composited over an 8-day interval of observations for a year. The product is a cumulative composite of GPP values based on the radiation use efficiency concept that may be used as inputs to data models for calculating terrestrial energy, carbon, water cycle processes, and biogeochemistry of vegetation.

The rainfall in the Arab region is divided into winter rains and summer rains. As for the winter rains, they fall on countries on the coasts of the Mediterranean, such as Palestine, Syria, Lebanon, the Arab Mashreq countries, the northern Maghreb countries, the Arabian Gulf, and the north and center of the Arabian Peninsula. As for the Monsoon rainfall, they fall on the south and central Sudan, Yemen, Somalia, Mauritania and the Asir Highlands in the Kingdom of Saudi Arabia. Net Primary Production during March of 2003 presented in Figure (13) is showing that there is increasing the rangelands areas that receive winter precipitation comparing with Figure (14) that shows the Net Primary Production derived from MODIS imagery, which show improvement in the productivity of rangelands areas that receive summer precipitation. A clear downward trend can be observed when we compare the Net Primary Production in winter 2003 with Net Primary Production in winter 2008 (Figures 13 and 17). Also a downward trend can be observed when comparing the Net Primary Production in summer 2003 with the Net Primary Production in summer 2008 (Figures 14 and 18).

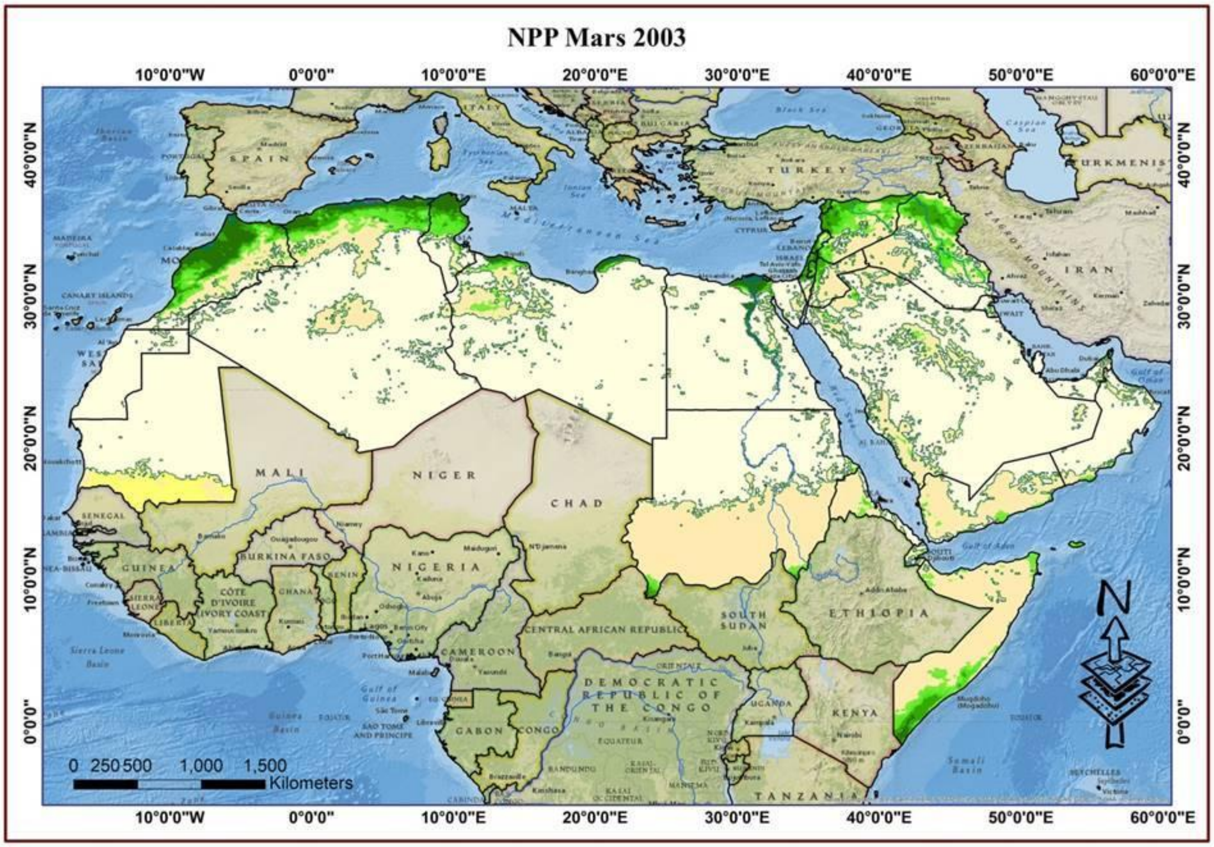

Figure (13) MODIS Gross Primary Production (GPP)/Net Primary Production (NPP) map of LAS region at March, 2003.

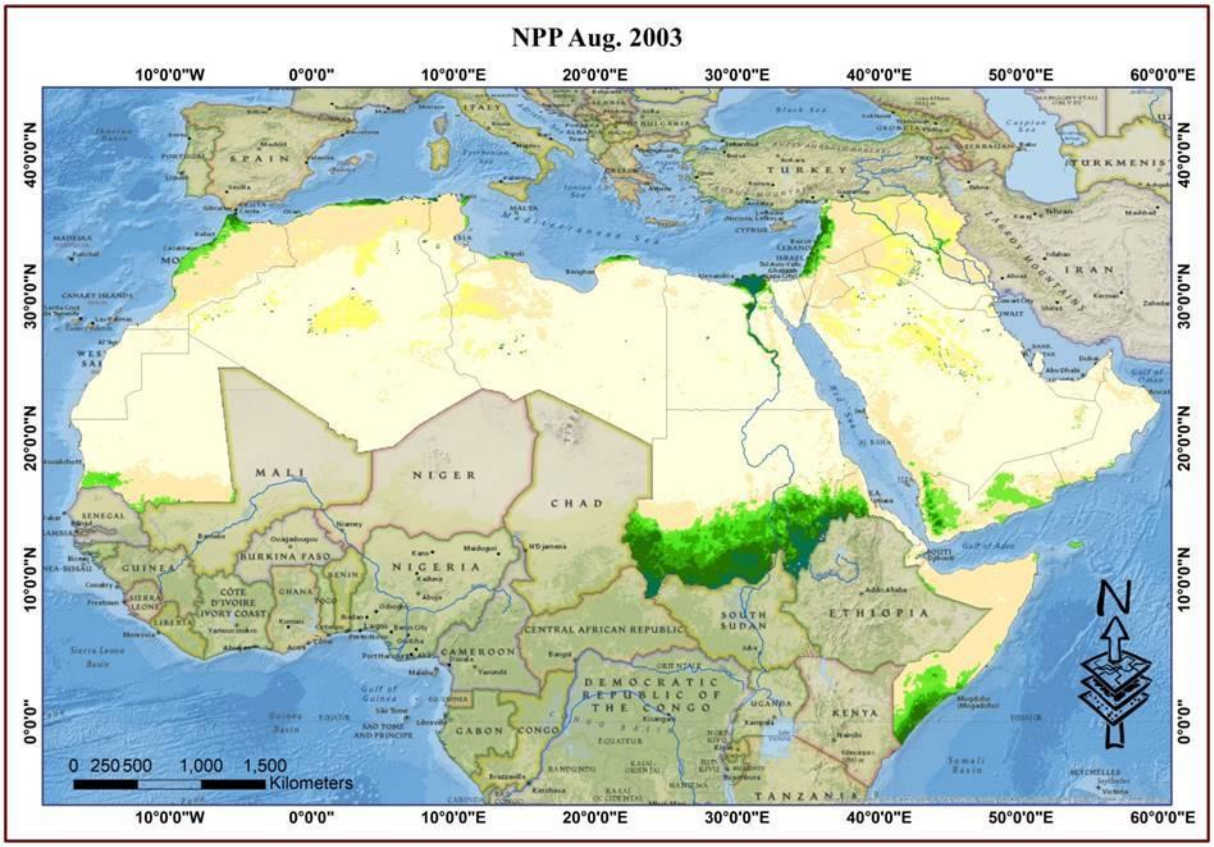

Figure (14) MODIS Gross Primary Production (GPP)/Net Primary Production (NPP) map of LAS region at August, 2003.

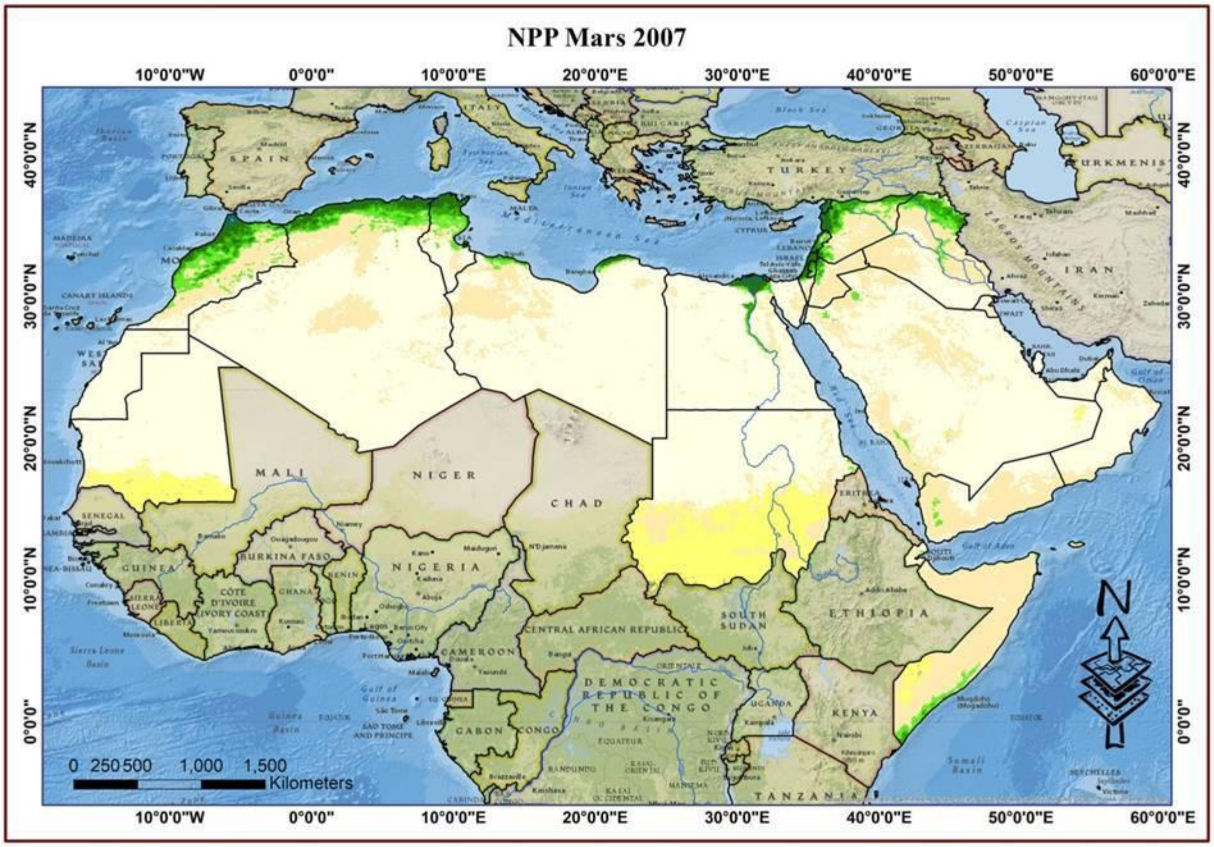

Figure (15) MODIS Gross Primary Production (GPP)/Net Primary Production (NPP) map of LAS region at March, 2007.

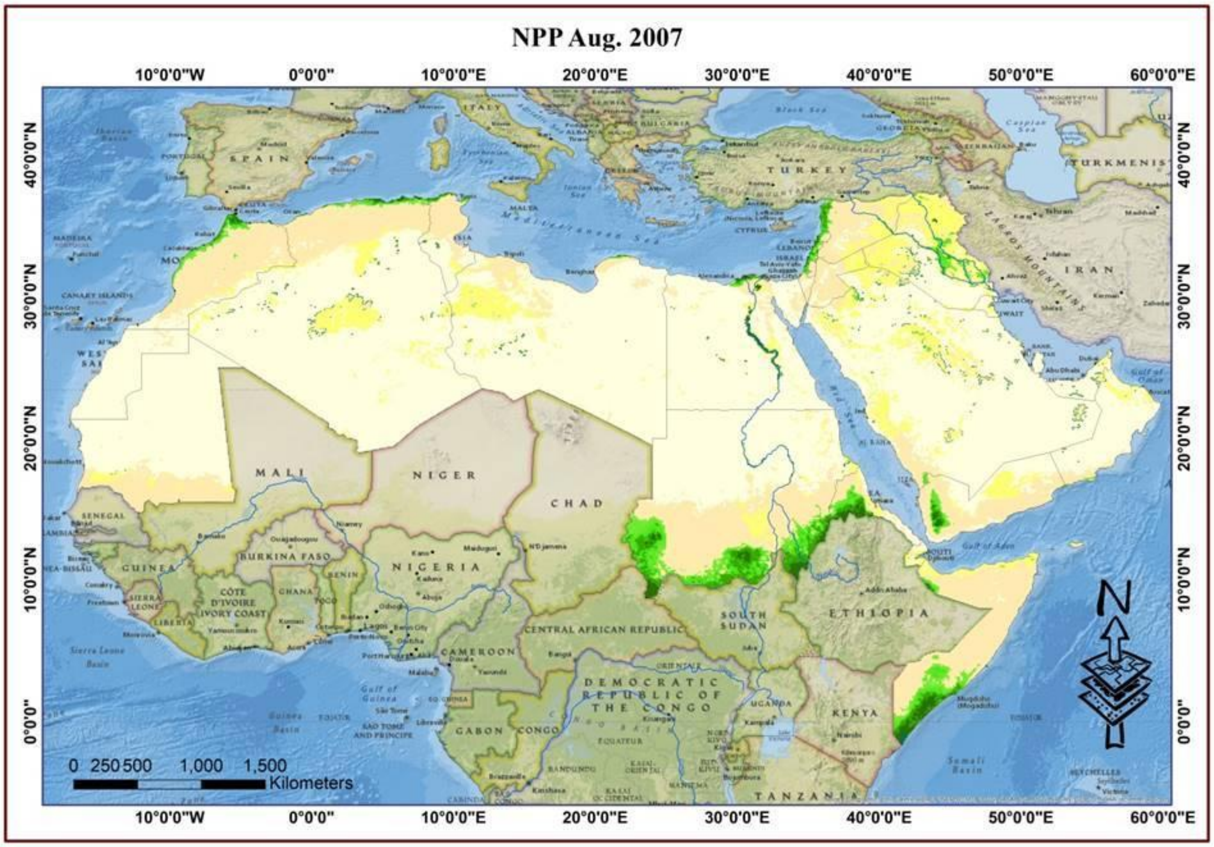

Figure (16) MODIS Gross Primary Production (GPP)/Net Primary Production (NPP) map of LAS region at August, 2007.

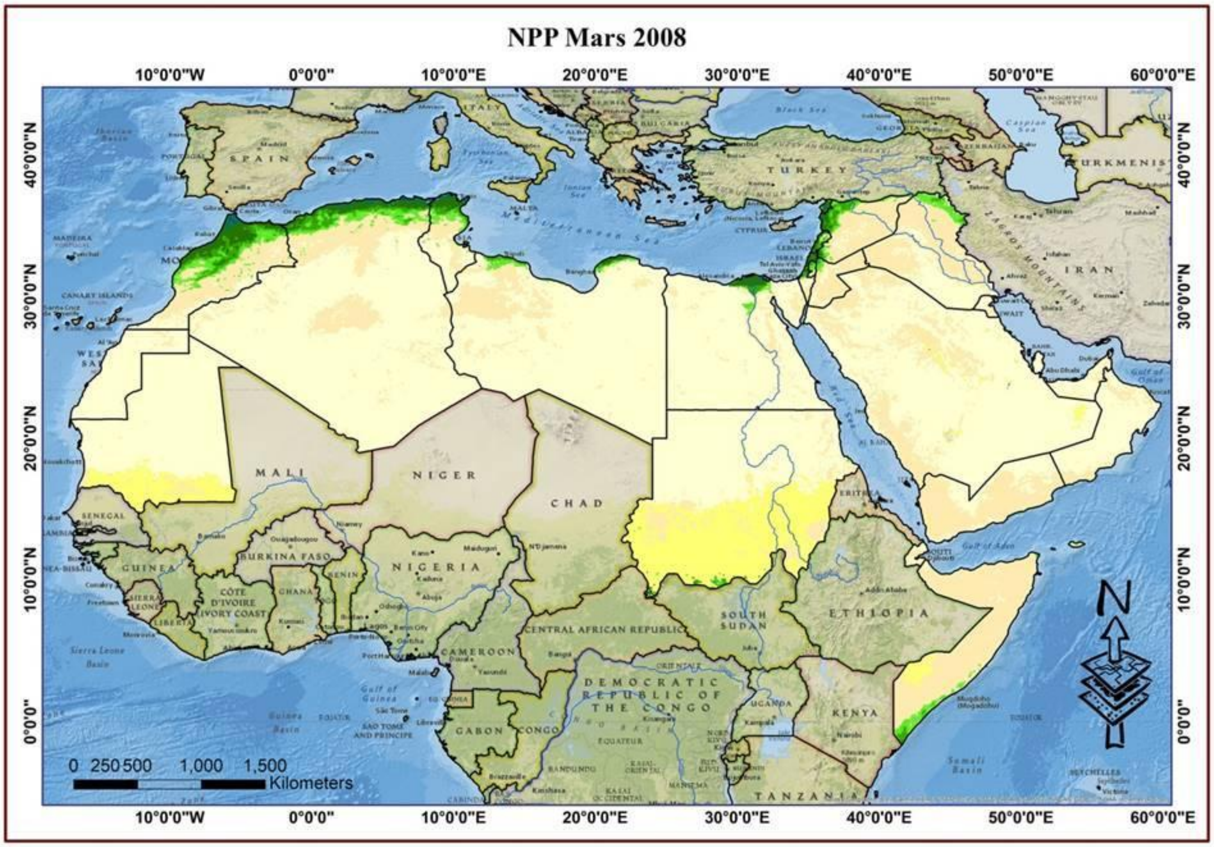

Figure (17) MODIS Gross Primary Production (GPP)/Net Primary Production (NPP) map of LAS region at March, 2008.

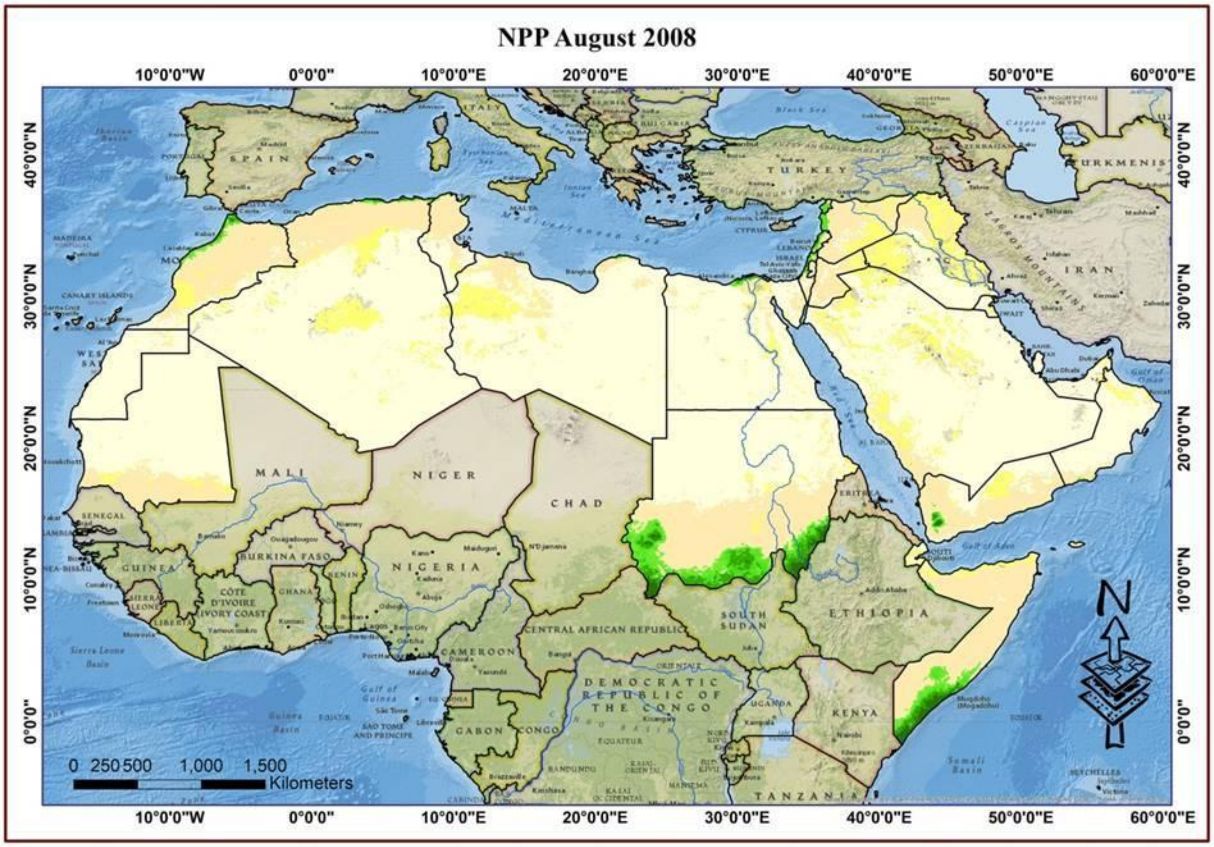

Figure (18) MODIS Gross Primary Production (GPP)/Net Primary Production (NPP) map of LAS region at August, 2008.

3.3 Rangelands productivity and condition in the LAS Countries:

Data presented in Table (3) are derived from ACSAD, (1983); ACSAD, (2012), ACSAD, (2015); ACSAD, (2019b) and show changes in rangeland production in Al-Hamad ecosystem in four different Arab countries from 1980 to 2019, the data presented were based of rangeland field survey and only 2019 data was based in analyses of remote sensing data combined with rapid field measurements. Productivity trend in general showed high downward and reduction in rangeland productivity particularly from perennial shrubs. The highest reduction in rangeland productivity was noticed in Jordan whereas rangeland plant production decreased from 590.5 kg/ha in spring season of 1982 to 95 kg/ha in the spring season of 2019.

Plant cover, plant density, and rangeland condition in general also experienced high levels of deterioration; figures (19 & 20) show that 80 % of Al-Hamad ecosystem northern in Saudi Arabia was in deteriorated rangeland condition.

Table 3 . Changes in rangeland plant productivity (kg/ha) in the spring season from 1981 to 2019 in Hamad ecosystem at four Arab countries (Source: ACSAD, (1983); ACSAD, (2012), ACSAD, (2015); ACSAD, (2019b).*

Country	1980	1981	1982	2004	2011	2014	2019
Syria	-	508	793.5	442.8	-	-	180
Saudi Arabia	396	-	-	-	130	-	80
Jordan	-	470.4	590.5	-	-	-	95
Iraq	-	-	648.7	-	118.6	84.6	-

* Missing data are due unavailability of field survey or satellite driven data regarding rangeland productivity.

Key data regarding rangeland types, rangeland vegetation type, and rangeland productivity in Jordan is shown in Table (4). It is clear that rangeland production in steppe and Badia ecosystems faced decline downward trend as it decreased from 200 kg/ha in 1990 to 80 kg/ha in 2013, and from 100 kg/ha in 1990 to 40 kg/ha in 2013, for both ecosystems respectively.

Table 4. Rangeland productivity and key rangeland data for Jordan (from, Laban, 2020).

Ecozone	Area km^2	% of country	Rainfall (mm/year)	Vegetation type	Biomass productivity	Land use

Steppe	10,000	10 %	200 – 350	Shrubs and herbaceous (40-60% ground coverage)	1990: 200kg/ha 2013: 80kg/ha	Bedouin pastoralism + barley
Badia (desert)	70,000	80 %	> 200	Shrubs and herbaceous (20-40% ground coverage)	1990: 100 kg/ha 2013: 40kg/ha	Bedouin pastoralism

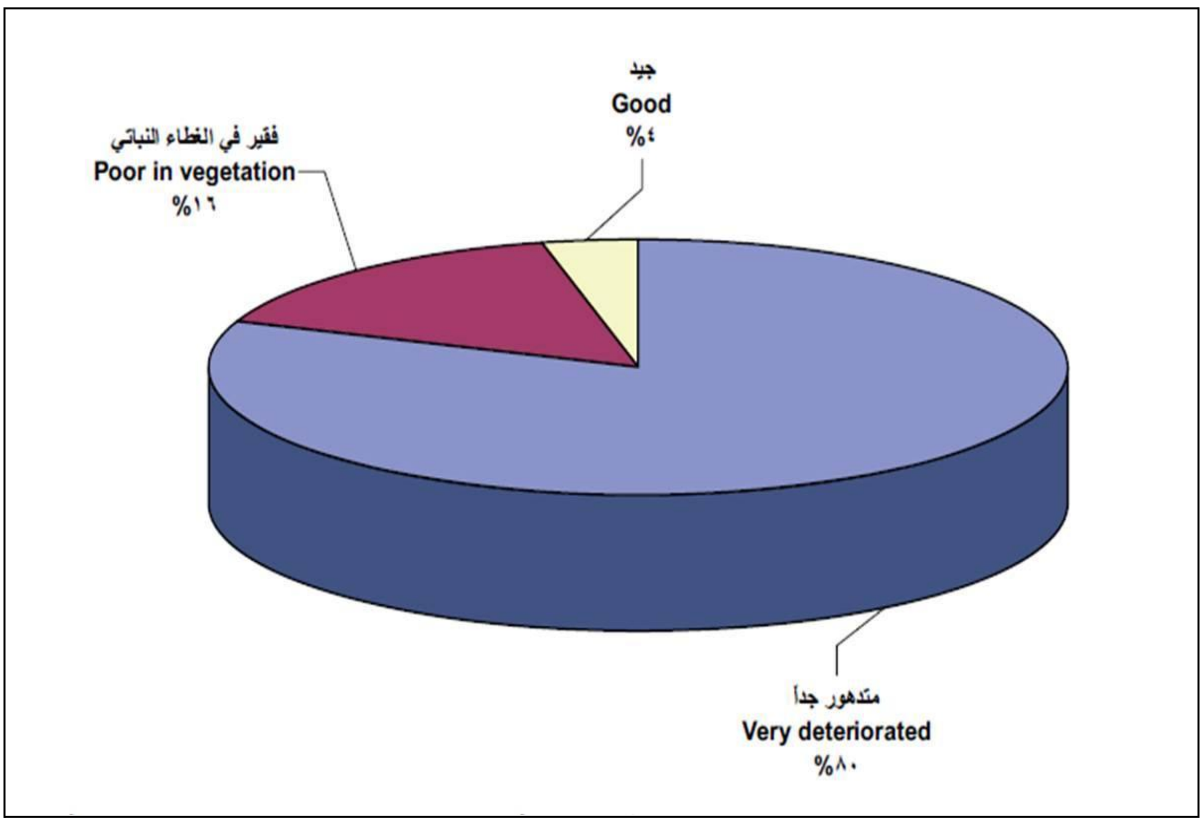

Figure (19) Rangeland condition percentage in Al-Hamad and Wadi El Serhan, northern Saudi Arabia, (Source, Ministry of Agriculture, KSA, 2007.

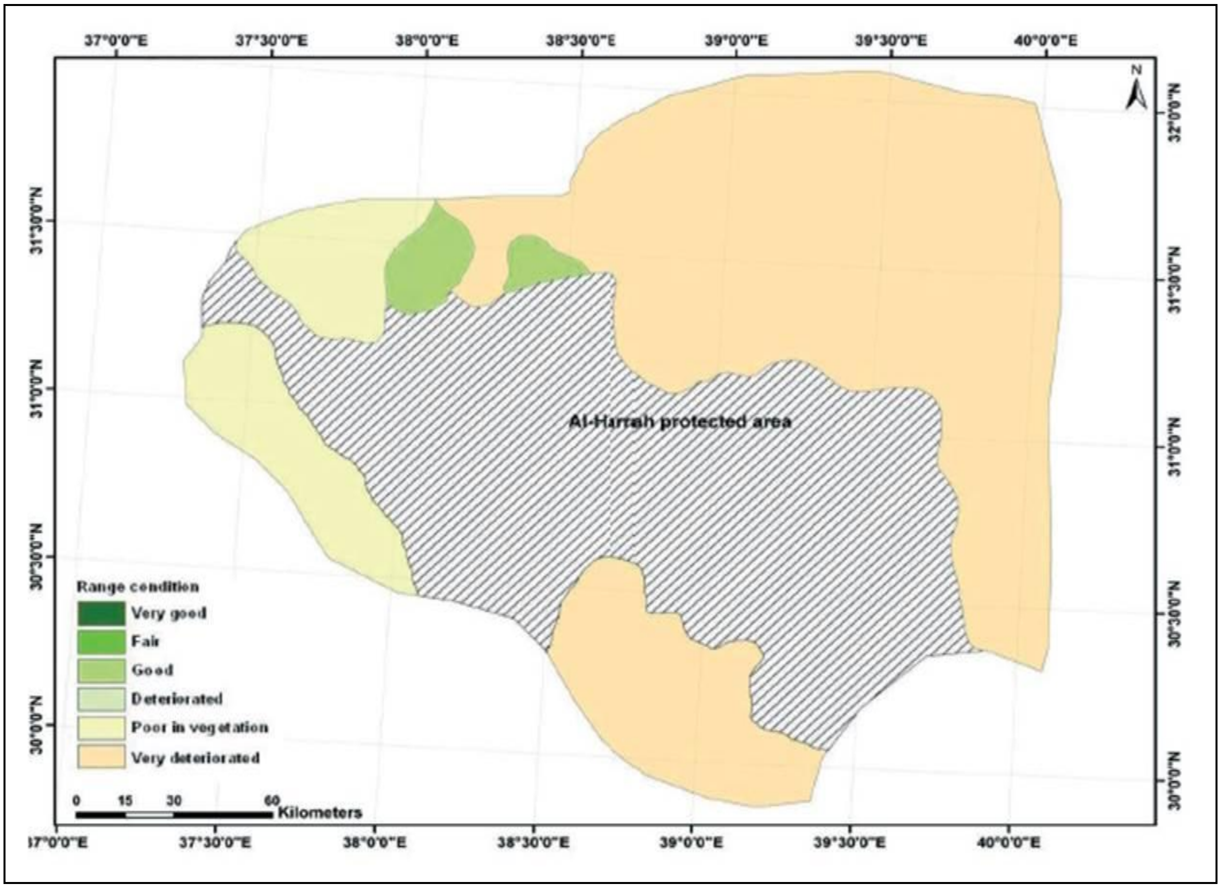

Figure (20) Rangeland condition map in Al-Hamad and Wadi El Serhan, northern Saudi Arabia, (Source; Ministry of Agriculture, KSA, 2007).

4

LAS Countries Case Studies

According to the current availability of secondary rangelands data sources in the LAS countries more detailed country analyses were provided in this study. These countries are Oman, Saudi Arabia, Syria, Jordan, Sudan, and Egypt.

4.1 Sultanate of Oman

Rangelands are considered important natural resources and cover about 55 % of the country (ACSAD, 2010). Rangelands are utilized by wild and domesticated animals, and the pastoral plant communities vary from north to south of Oman due to the different climate and terrain, and the plant diversity includes trees, shrubs and forbs.

Rangelands in Sultanate of Oman can be classified into two types:

1.4. Rangelands of northern Oman: It is one of the dry rangelands, and its area is estimated at about 850 thousand hectares (ACSAD, 2010). It is characterized by the presence of open spaces covered by annual and perennial herbs, most of which are grasses, in addition to trees and shrubs. There are also areas of forest and open trees areas in this type.

1.5. Rangelands of southern Oman: The area of rangelands and forests in Dhofar Governorate is estimated at about 500,000 hectares (ACSAD, 2010), as forest rangelands in southern Oman are distinguished by the diversity of pastoral environments and various terrain that consist mainly of deserts, mountains and coastal plains. It is characterized by a variety of unique and biological properties not only at the level of the Sultanate of Oman, but also in the Arabian Peninsula.

The frequent use of rangelands and the lack of awareness of the risks of land and rangeland degradation in the country make them threatened by degradation and increasing desertification rate, mainly due to several reasons that could be summarized as follows: overgrazing, drought, tourism, urban encroachments, off roads driving, and degreasing the role of government agencies in controlling rangeland use. There are indicators that about one quarter of the rangeland in the country is degraded (ACSAD, 2010).

To evaluate rangeland condition and productivity analysis was done using satellite data over an area of 6.7 million ha at southern Oman (Figure, 22 and Table, 5). Results indicated that about 67 % of the area is in a degraded rangeland condition that had a total plant productivity ranged from 20 to 200 kg/ha. The second land cover type was fair rangeland with an area of 26.5 % of the total area. Good rangeland condition land cover type occupied 4 % of the area. Water and clouds represented about 0.1 % from the study area (ACSAD, 2019b).

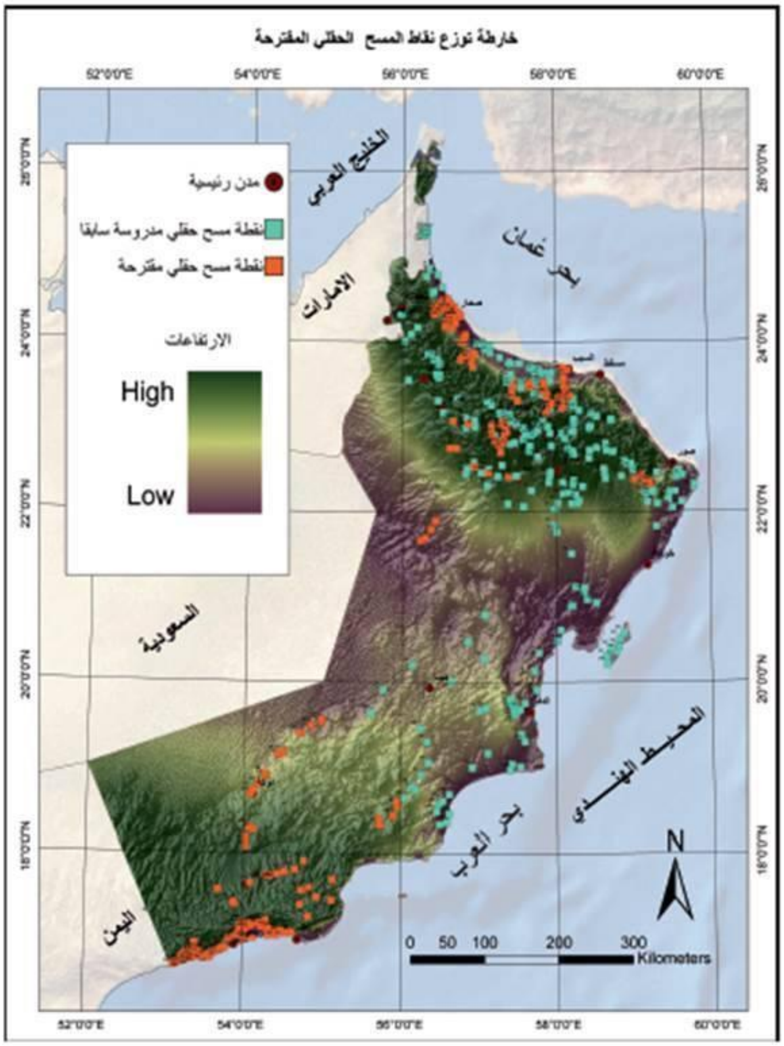

Figure 21. Location rangeland survey points implemented, (Source; ACSAD, 2010)

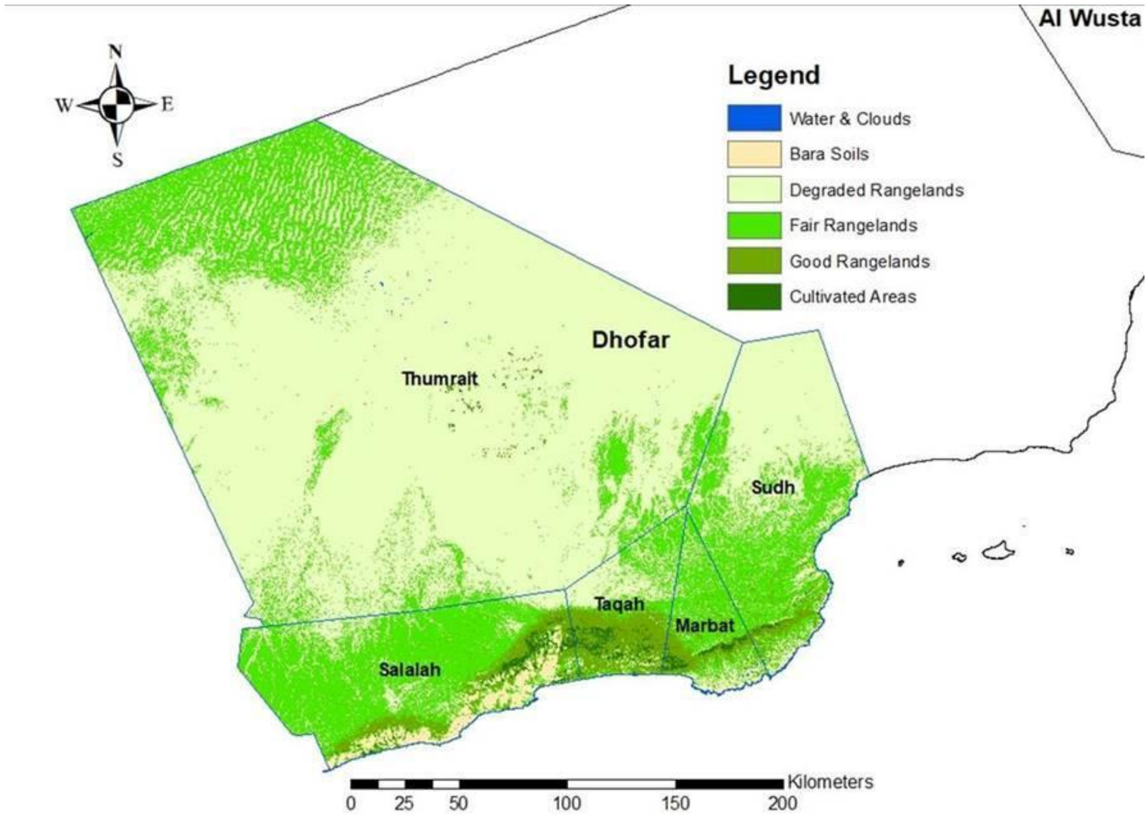

Figure (22) Rangelands condition in an area of 6.7 million ha at southern Oman, (Source; ACSAD 2019b)

Cattle grazing and rangelands types in Oman, photos by the Consultant

Table 5. Evaluation of rangelands condition and productivity in an area of 6.7 million ha at southern Oman, (Source; ACSAD 2019b).

Land Cover	Area Km2	%	Kg/ha
Water & Clouds	48.8	0.1	--
Bare Soils	977.7	1.5	--
Degraded Rangelands	45115.9	67.1	20 – 200
***Fair Rangelands**	17800.5	26.5	201 – 500
Good Rangelands	2762.4	4.1	< 500
Cultivated Areas	511.1	0.8	--
Total	67216.4	100.0	--

*fair rangeland condition that rangeland with plant cover ranging from 25 to 50 % according the Dyksterhuis, 1949 methods

4.2 Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia is distinguished by wide land areas estimated by 2.25 million km2; the diversity of geomorphology, the difference in geological formations, the difference in climate from one region to another and the variation of many natural environments, led to a great diversity in the natural vegetation in the Kingdom. Rangelands cover an area of 170 million ha which represents about 76 % of the country area (Ministry of Agriculture, KSA, 2007)., and they provide the largest and least costly portion of the feed needed for domesticated livestock and wild animal and plays an important role in preserving the soil from erosion and reducing surface runoff of rainwater, thereby increasing water penetration into the ground, renewing groundwater, resisting desert encroachment and conserving the environmental balance in general. In addition, rangelands have a valuable role in providing other needs of KSA citizens such as hunting, entertainment and others.

Much of the arid land area of the Kingdom of Saudi Arabia is used for livestock grazing for at least part of the year. Tremendous reduction at the pastoral grazing lands in Saudi Arabia has been occurred in the last 50 years due to increasing livestock numbers and the large urban development. In addition, the big advancements in the transportation systems in the region also had great impacts on land degradation which led to a severe reduction of vegetation cover, plant density and putting biodiversity under threat (Al-Rowaily, 1999; Barth, 1999; Al-Saud et al, 2005).

Rangeland survey of the eastern Saudi Arabia region conducted by Al-Saud et al. (2007) indicate that 56 % of the rangeland in deteriorated condition and 27 % of the area is in poor rangeland condition. Another study conducted by Al-Rowaily et al., (2018) indicated that Hail and Qassim Regions of Saudi Arabia covering an area about 79610.73 km2 were selected to study the rangeland vegetation and condition. *Haloxylon salicornicum* was the most dominant species, covering more than 56% of the total area. The second prominent community was *Acacia-Lycium shawii*, which covers about 21% of total area. It was found that about 65% of vegetation in the surveyed area is in good or very good condition compared with about 31% in poor or deteriorated condition.

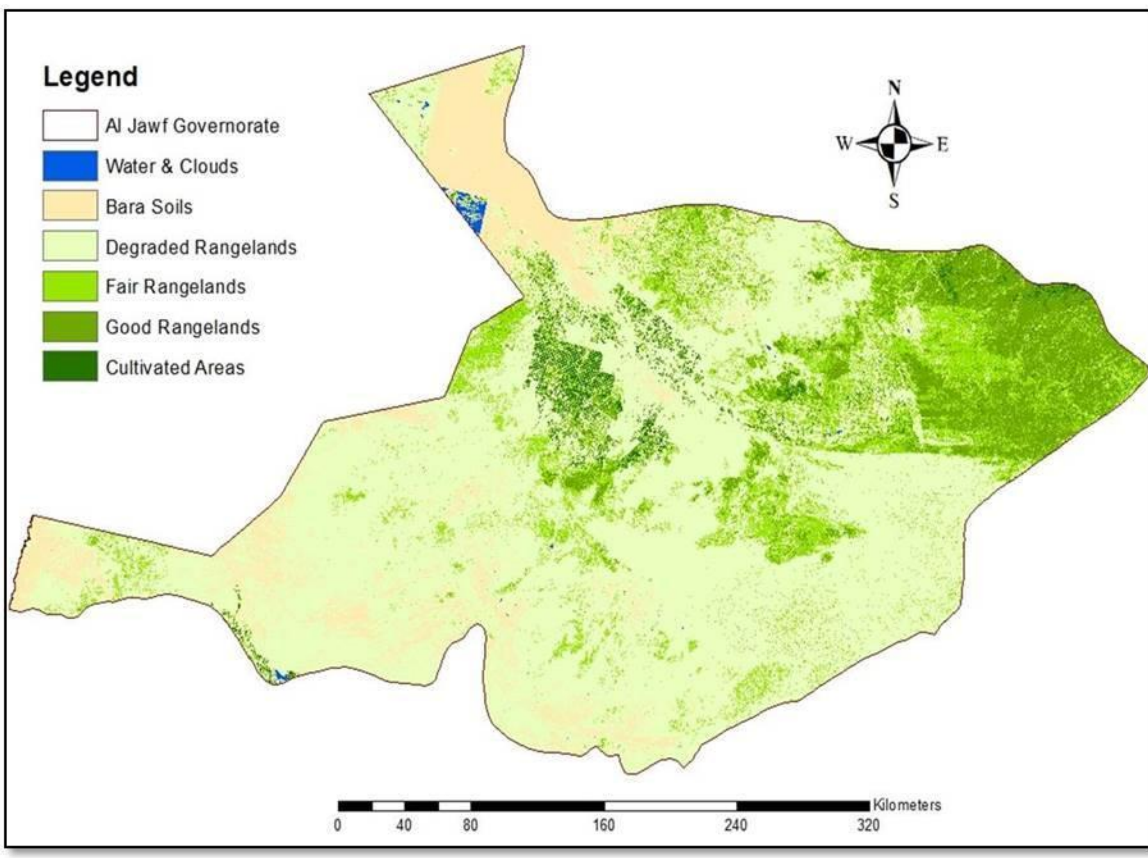

Figure (23) Rangelands condition of Al Jowf, Saudi Arabia with an area of 11.7 million, (Source; ACSAD 2019b).

Table 6. Evaluation of rangelands condition and productivity in an area of 11.7 million ha at Al Jowf , northern Saudi Arabia, (ACSAD, 2019b)

Land Cover	Area km^2	%	Kg/ha
Water & Clouds	242	0.2	--
Bare Soils	13161	11.3	--
Degraded Rangelands	74663	63.9	1 – 100
Fair Rangelands	15108	12.9	101 – 200
Good Rangelands	11791	10.1	<200
Cultivated Areas	1952	1.7	--
Total	116917	100.0	--

4.3 Syrian Arab Republic

In Syria, the rangelands cover some 55% of the country area (18 million hectares) according to ACSAD (2004). About 10 million hectares are usually receiving less than 200 mm precipitation/year (ACSAD, 2004). It is nearly totally devoted to grazing and browsing. Most depressions and Wadi beds that receive extra water from run-on were still cropped until recently with barley, or even wheat. The economy of Syria is based on agriculture, oil, industry and services.

Prior to the outbreak of hostilities, the livestock sector had a significant impact on Syria's economy. It provided more than 30 percent of the total value of agricultural production, 15 percent of the value of agricultural exports, and employed 11 percent of Syria's total labor force, including many low-income families in the rural areas (ACSAD, 2015). Among the more than 8 million people who are rural dwellers, 2.5 million of which are low income earners, more than

35 percent (households) own livestock and derive from it 15 to 100 percent of total family income (ACSAD, 2015). The main sheep producers are Bedouins that run about 65% of the sheep flock in Syria. Their livestock income in the Aleppo steppe for example amounts to 80 to 95% of their total income, providing them with fairly stable earnings. It improves family liquidity and provides a simple banking system. The livestock, mostly small ruminants, get a small of their diet from rangelands. In crop-livestock-rangeland rainfed mixed systems, livestock substitutes for natural and purchased inputs, in addition to producing meat and milk. Until the mid- 1950s, about 65% of the small livestock population was based in the Syrian steppe where feed requirements were covered without any supplementary feed. In the mid-1990s, 75-80% of the Syrian flocks are steppe-range based (Mohamed et al., 2019). However, they do not get most of their feed from the range but mostly from supplementary feed, complements and crop residues. The low contribution of rangelands to livestock feeding is due to the tremendous increase in sheep numbers, but also to the loss of traditional management tools and to the modification of land tenure occupation (Gintzburger et al, 2006). The rangeland livestock sector was therefore also important for poverty reduction in Syria. Regrettably, the agricultural sector in Syria is threatened by the continuing civil war which has had a major impact on food supplies and markets.

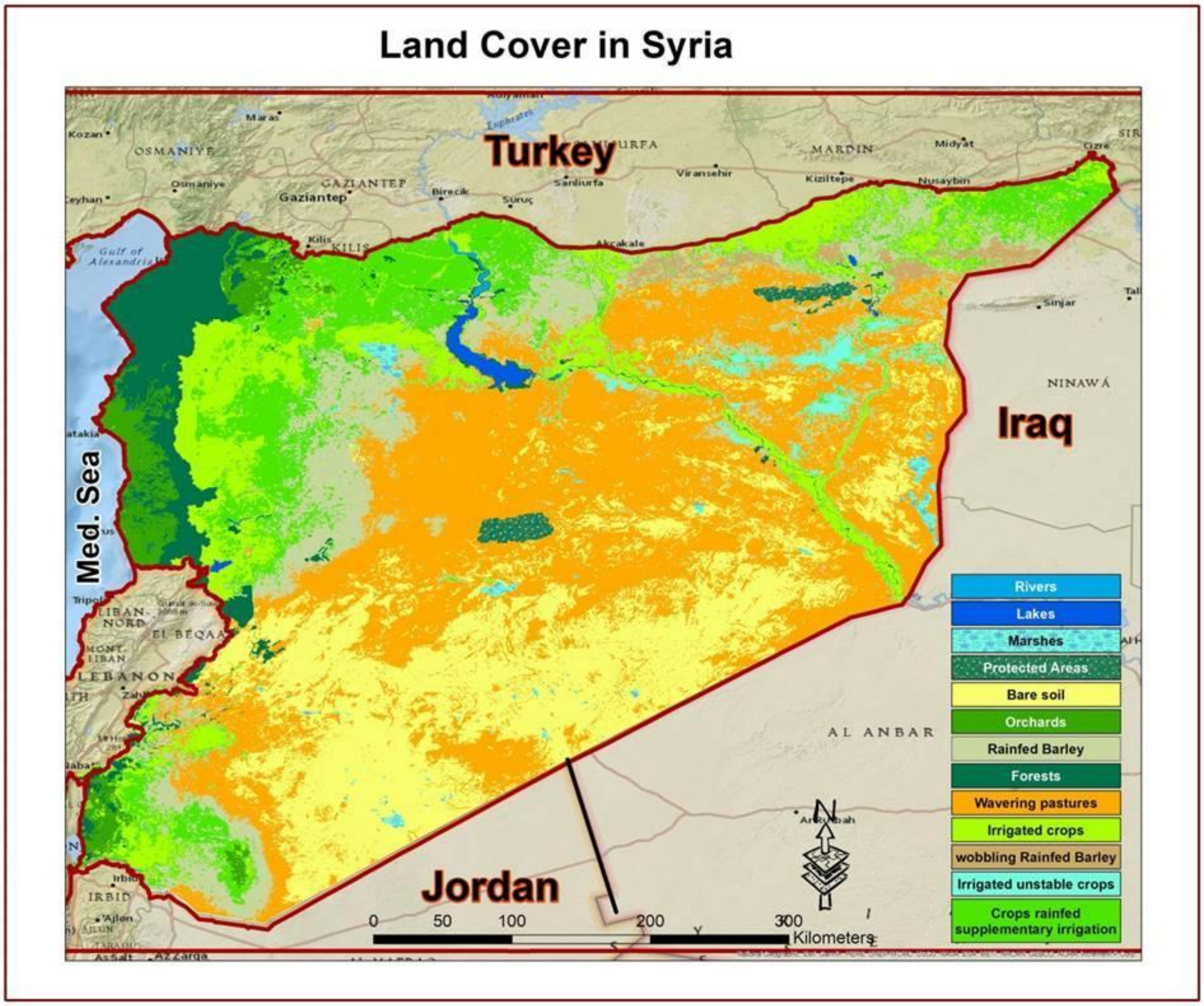

Figure (24) Land cover map of Syria

Rangelands vegetation in the study area includes perennial shrubs, perennial grasses, and annual forbs and grasses. The primary shrubs species common in the study area are *Atriplex halimus, Atriplex leucoclada, Salsola vermiculata, Artemisia herba-alba, Anavasis syriaca, Achillea fragrantissima, and Astragalus spinosus*. For example, annual average forage production in these rangelands type in the Swaida Rangelands Badia ranges from about 48 kg/ha to 204 kg/ha usually half of this amount produced by palatable perennial shrubs (ACSAD, 2004). Plant cover ranged from 11 to 20 % and in general rangelands condition in the area is in poor to fair condition.

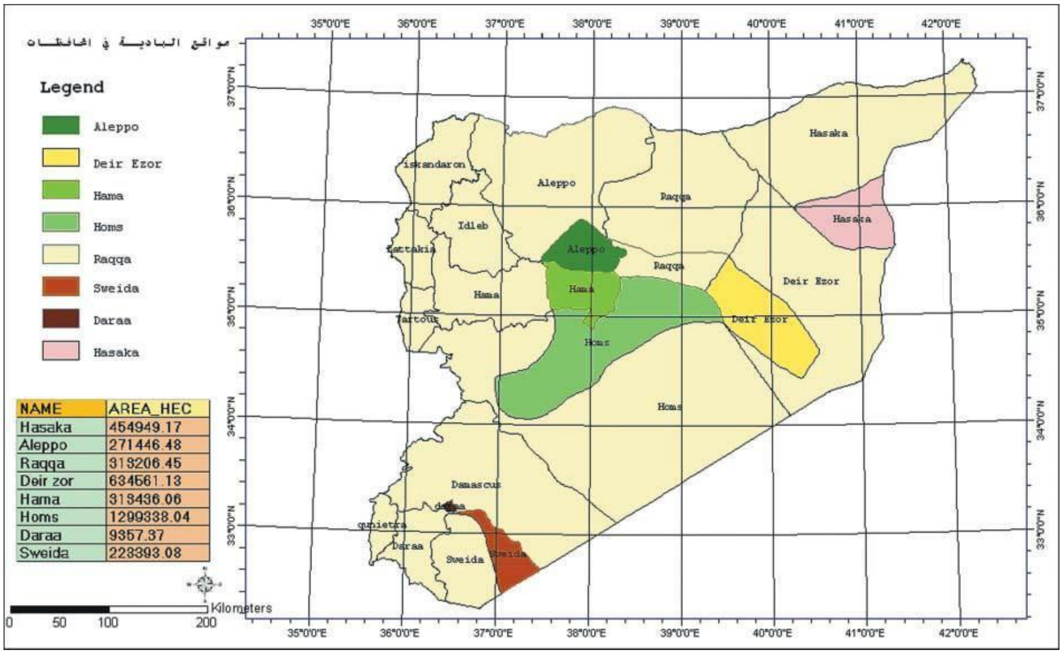

Figure (25) Location and area of the survey of natural resources in the Syrian Badia project ACSAD, 2004 study site where rangeland survey was conducted at the Syrian Badia from 2001 to 2003.

A study conducted by ACSAD (2019) to evaluate changes in Syrian Badia Rangelands vegetation conduction using time series of satellite images from Landsat 8 LI/TIRS C1-Level-2 with 30 m spectral resolution in the period from May, 2013 to March, 2018. Areas receiving less than 200 mm mean annual rainfall (Badia Line) were delineated and a shapefile of the Syrian Badia was created. Estimated area of Syrian Badia was about 10.5 million ha, which represent more than have of the total area of Syrian Arab Republic. Normalized Deference Vegetation Index (NDVI) was calculated for all the images, and rangeland vegetation condition was categorized to degraded rangelands, fair rangeland, and good rangelands based on NDVI values. Degraded rangelands covered about 57 % of the total area in spring season of 2014, however, its area increased to cover about 76 % in spring of 2017.

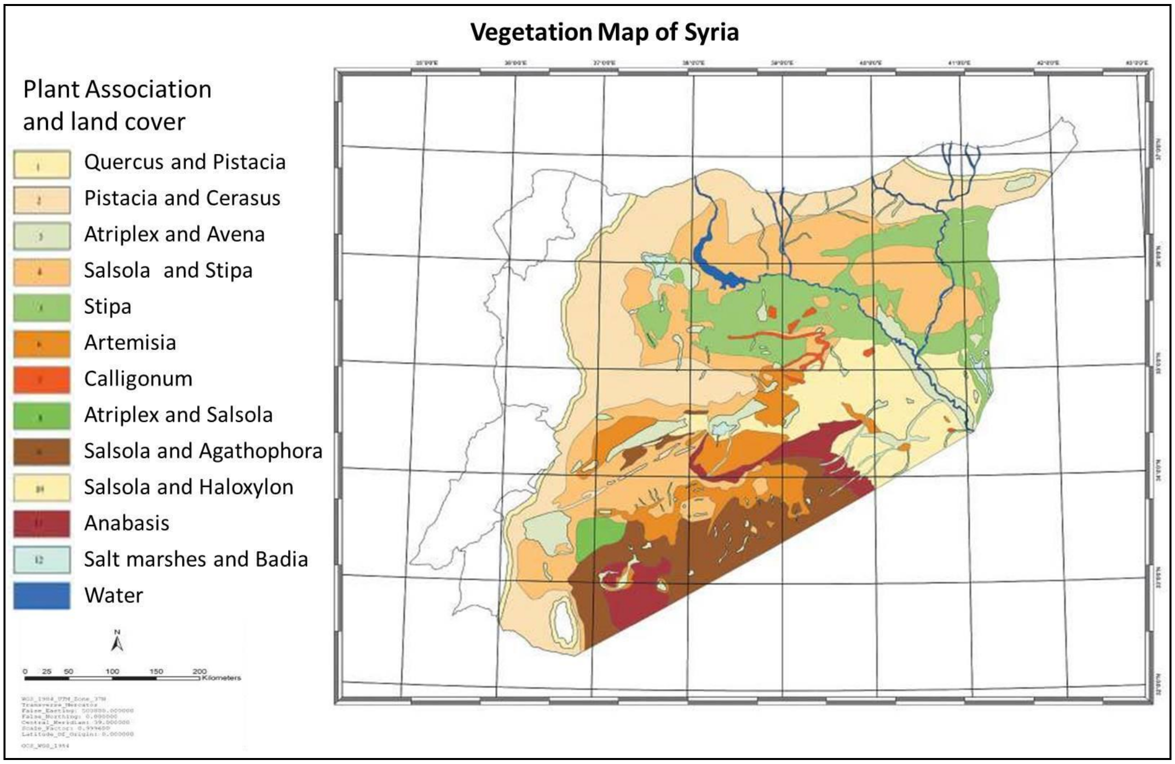

Figure (26) Plant communities map of arid and semi-arid zones in Syria, (Source; ACSAD, 2004 after El-Sankry, 1988).

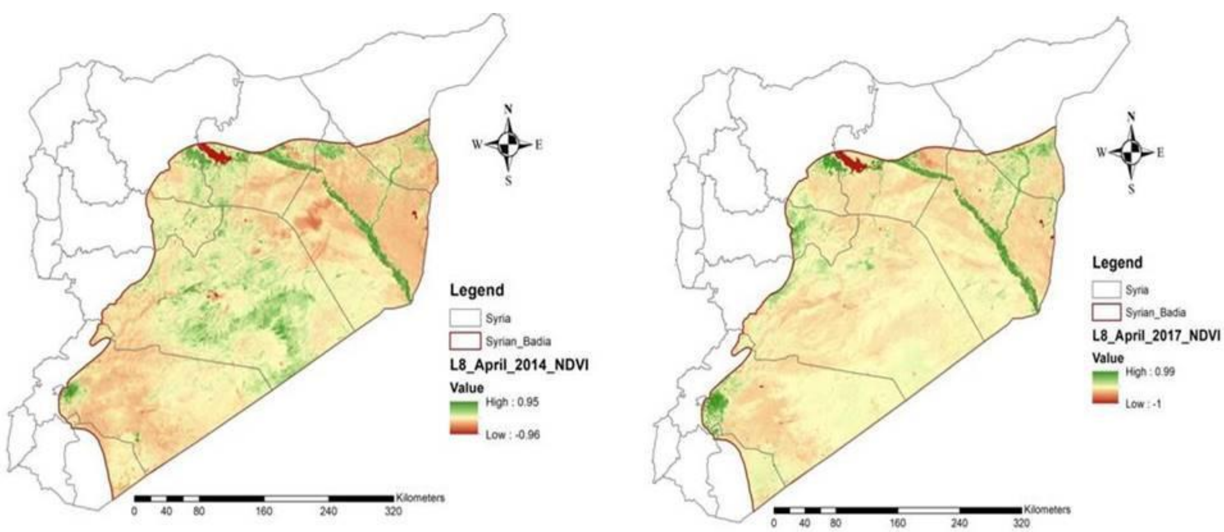

Figure (27) NDVI of the Syrian Badia Rangelands calculated from Landsat 8 satellite imagery in 2014 and 2017, (Source; ACSAD, 2019b).

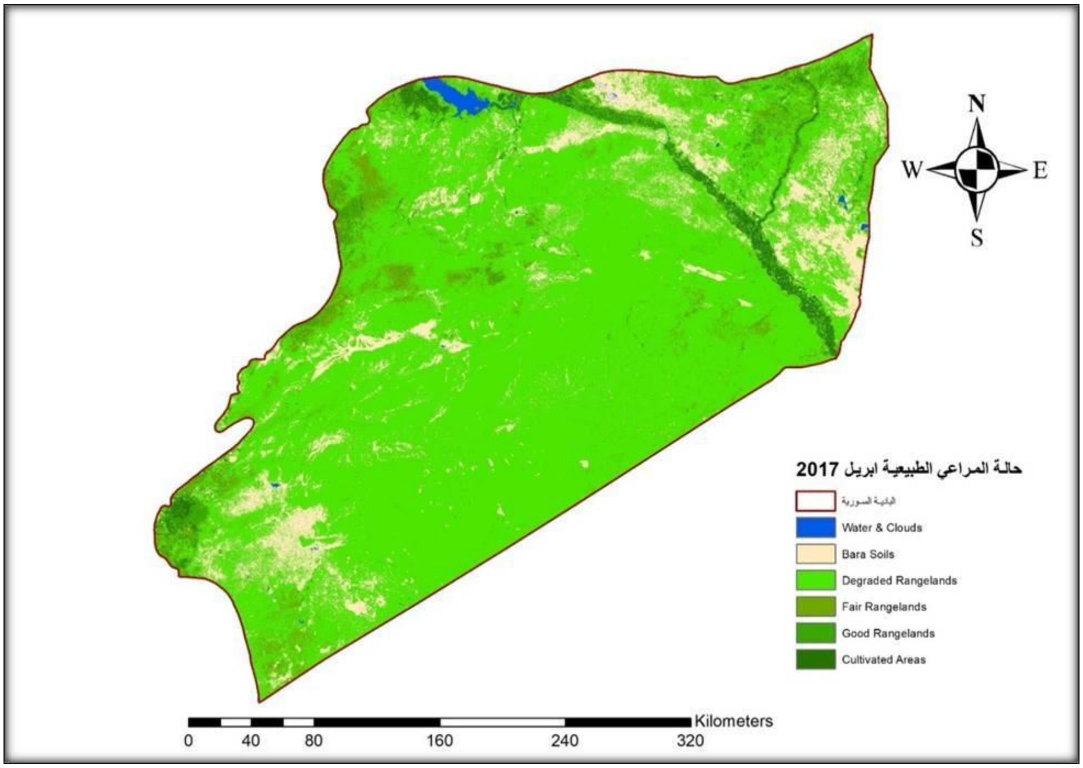

Figure (28) Rangelands condition of the Syrian Badia, Syria with an area of 10.57 million, (Source; ACSAD, 2019b).

Data in (Table, 7) indicate that there were variations in vegetation cover and the primary production in the Syrian Badia Rangelands from the year 2013 to 2018 as a response to variations in precipitation amount from year to another. However, degraded rangelands had represented about two third of the Syrian Badia in most of the analyzed years.

Table 7. Evaluation of changes in the Syrian Badia Rangelands vegetation condition using Landsat 8 satellite imagery from 2013 to 2018 (Source; ACSAD, 2019b).

Land Cover %	May 2013	April 2014	April 2015	April 2016	April 2017	April 2018
Water Clouds	0.89	0.56	0.58	0.52	0.59	0.65
Bare Soils	21.63	7.38	10.72	16.36	12.08	10.15
Degraded Rangelands	73.01	56.74	65.87	72.48	75.90	65.32
Fair Rangelands	2.76	24.30	13.40	6.40	6.42	16.52
Good Rangelands	1.26	9.01	7.23	2.91	3.34	5.26

Cultivated Areas	0.45	2.00	2.20	1.33	1.67	2.1

4.4 The Hashemite Kingdom of Jordan

The Hashemite Kingdom of Jordan is a relatively small country with an area of 88,778 km^2, and a population of 11,183 million (Department of Statistics – Jordan, 2022). Geographical features of Jordan characterized by highland that constituted about 0.6%, plains occupy 11.2%, Badia semi-desert that represents the largest features in Jordan with about 78.4%, territorial water with 0.6%, and 9.2% rift valley and includes all the lands occur under 200 mm rainfall line (Figure,29). Jordan is characterized by a dry climate, hot dry summer, and wet cold winter. The rainy season extends from October to late April and average annual rainfall ranges from 50 mm in the east to 500 mm in the highlands (Ministry of Water and Irrigation, 2014). Rangeland is defined as "all lands registered as such and any other state-owned lands where annual rainfall is below 200 mm and that do not have sustainable irrigation, or the lands confined for public use" (Agriculture Law No. 20 for the year 1973). Based on this, around 80% of the total land area of Jordan is considered as rangeland, which usually supports livestock feeding for only one to three months during normal years; whereas for the rest of the year, livestock are generally raised on barley grain, cultivated fodder plants, and crop residue (Sidahmed 2011). Key data regarding rangeland types, rangeland vegetation type, and rangeland productivity in Jordan is shown in Table (4). It is clear that rangeland production in steppe and Badia ecosystems faced decline downward trend as it decreased from 200 kg/ha in 1990 to 80 kg/ha in 2013, and from 100 kg/ha in 1990 to 40 kg/ha in 2013, for both ecosystems respectively (ACSAD, 1983; ACSAD, 2019b).

In Jordan, the agriculture sector contributes around 2% of the gross national product, while livestock production contributes about of total agricultural production of the Kingdom. The poultry industry is the largest contributor to GDP, followed by the dairy industry. Livestock are considered as a continuous main income stream for 250,000 people (MOA, 2005). Meat from Awassi lambs and mutton represent approximately 52.5% of red meat produced in Jordan. In general, Awassi sheep, is the predominant sheep breed in the country producing an acceptable quality carcass. The fat-tailed Awassi breed also has the ability to perform well in arid and semi-arid areas and has greater heat tolerance and adapts well to periodic feed shortages. The short rainy period followed by a long dry period leads to low forage production in the Hashemite Kingdom. The predominant livestock species in Jordan are sheep and goats. Historically, livestock was considering as a sign of prosperity especially for people living on the Badia and rural area across Jordan. In the past, livestock had a reputation as a currency unit and indicator of wealth.

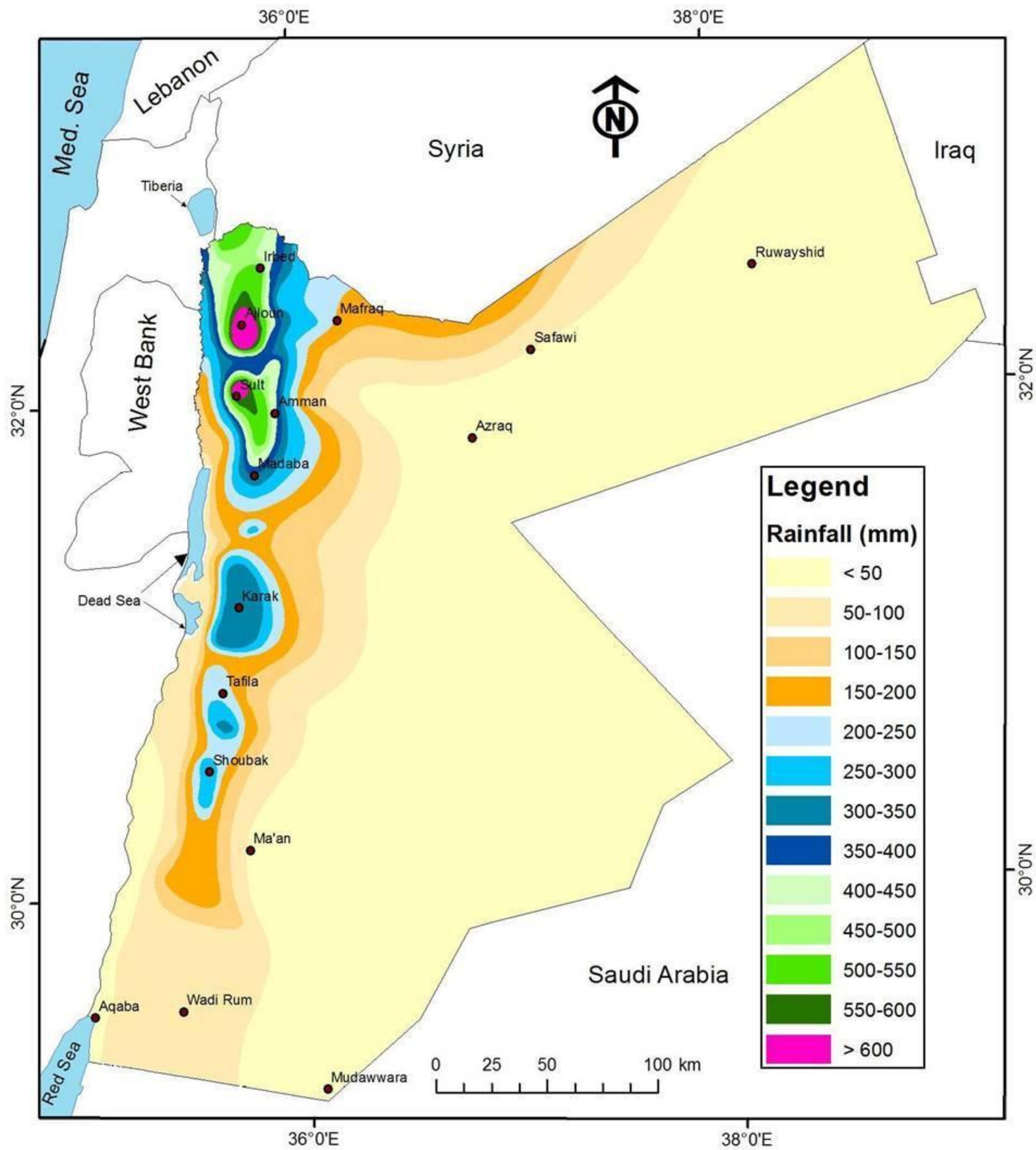

Figure (29) Rainfall distribution in Jordan, (Source; IUCN, 2015).

Land use/cover map of Jordan was prepared by the Royal Jordanian Geographic Center (RJGC) in year 2006, based on the use of digital classification of Landsat images, and the map was published in the Atlas of Jordan (Ababsa, 2013). Later the map (Figure,30) was updated by Al-Bakri et al., (2013). Detailed analysis of land use/cover was made and data was summarized to identify the actual areas of rangelands in Jordan. Also, the map was used to add more details to the sandy areas in the Hammada ecosystem.

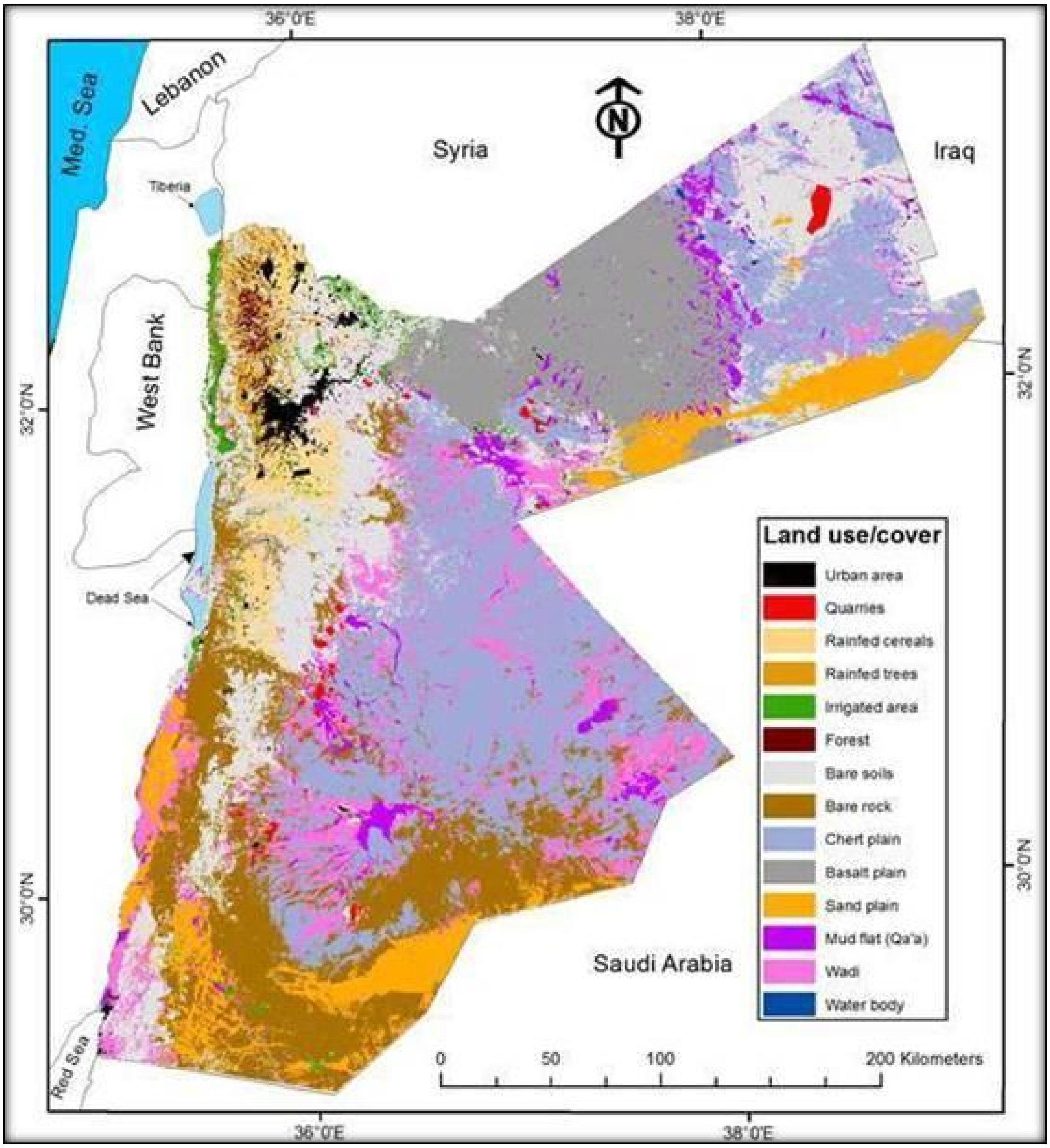

Figure (30) Land use/cover map of Jordan (Ababsa, 2013; Al-Bakri et al., 2013).

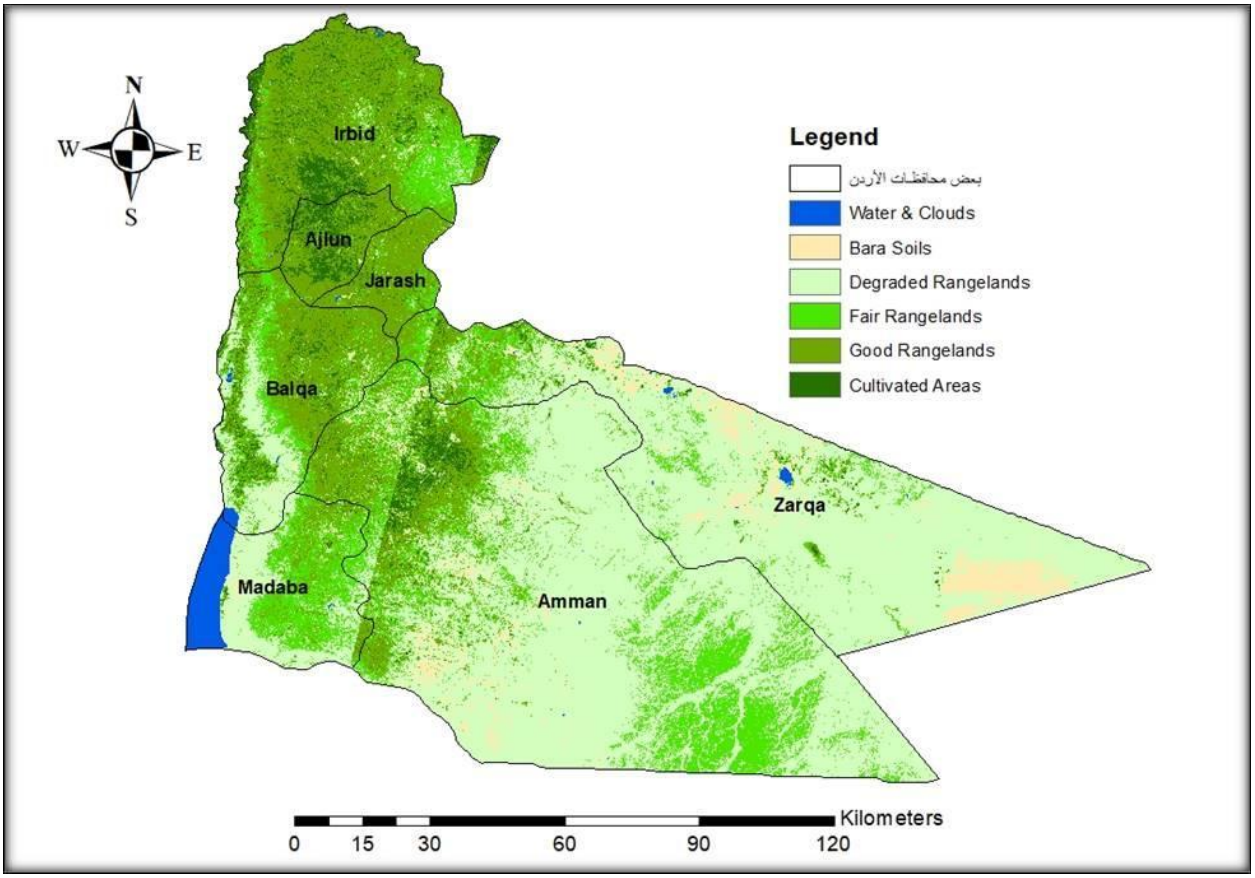

Figure (31) Rangelands condition of some governorates in Jordan, with an area of 1.7 million ha, (Source; ACSAD, 2019b).

Table 8. Evaluation of rangelands condition and productivity in an area of 1.7 million ha at some governorates in Jordan, (ACSAD, 2019b).

Land Cover	Area km^2	%	Kg/ha
Water & Clouds	229	1.4	--
Bare Soils	759	4.5	--
Degraded Rangelands	8644	51.6	50 – 200
Fair Rangelands	2722	16.3	201 – 400
Good Rangelands	3589	21.4	< 400
Cultivated Areas	802	4.8	--
Total	16746	100.0	--

4.5 Republic of the Sudan

The Republic of Sudan is distinguished by a variety of pastoral resources that span large areas in various ecosystems, which makes the rangeland sector in Sudan of economic, social, and environmental importance. Rangelands support the livestock sector, which one of the pillars of the national economy in Sudan, and rangelands represent a source of livelihood and national food security. Rangelands protect the soil and water bodies from erosion, which contributes to the recharge of groundwater. They are the habitat for many wildlife species, and an important reservoir of carbon dioxide sequestration and climate change mitigation.

The area of rangelands is estimated based on the Land Cover Atlas of Sudan coverage Classification (FAO, 2012) at about 68.6 million hectares, or 35.6% of the area of Sudan, which is represented in:

- Herbaceous vegetation represents an area of about 25.9 million hectares, which represents 13.8% of the total area of Sudan.
- Shrubs represent an area of about 22.2 million hectares, which represents 11.8% of the total area of Sudan.
- Tress represents an area of about 18.7 million hectares, which represents 10 % of the total area of Sudan.

Local sheep and cattle grazing at Sudan, photos by the Consultant

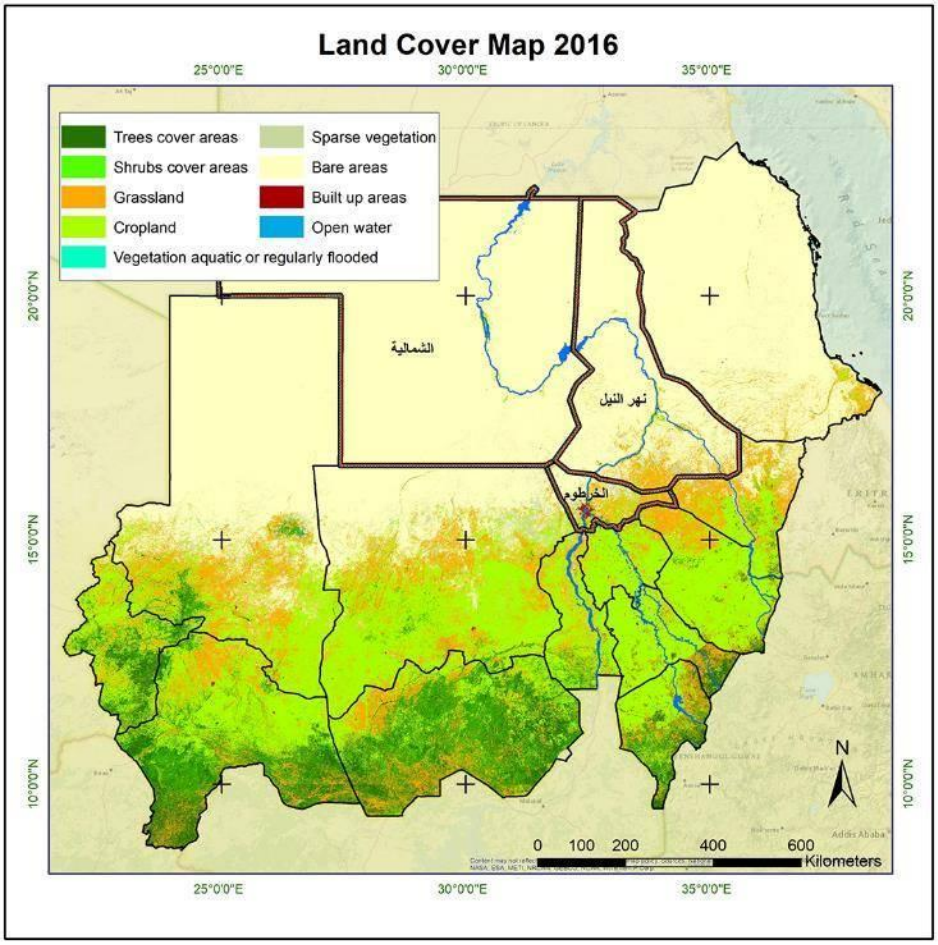

Figure (32) Land Cover map of Sudan with the different natural vegetation types, (Source; ACSAD, 2019c)

Results of field studies and rangelands evaluation maps of the states of Khartoum and Nile River indicated that the current rangeland areas were 567000 ha for the state of Khartoum which represent 26% from the state area, and 423000 ha in the state of Nile River, which represent 3.5 % from the state area. Degraded rangelands area was estimated by 385000 ha and 111000 ha in the state of Khartoum and Nile River, respectively, and the good rangelands condition areas was estimated by 182000 ha and 312000 ha in the state of Khartoum and Nile River, respectively as shown in rangelands conditions maps of the state of Khartoum and Nile River, which were prepared by ACSAD in 2019 (Figures 33 and 34).

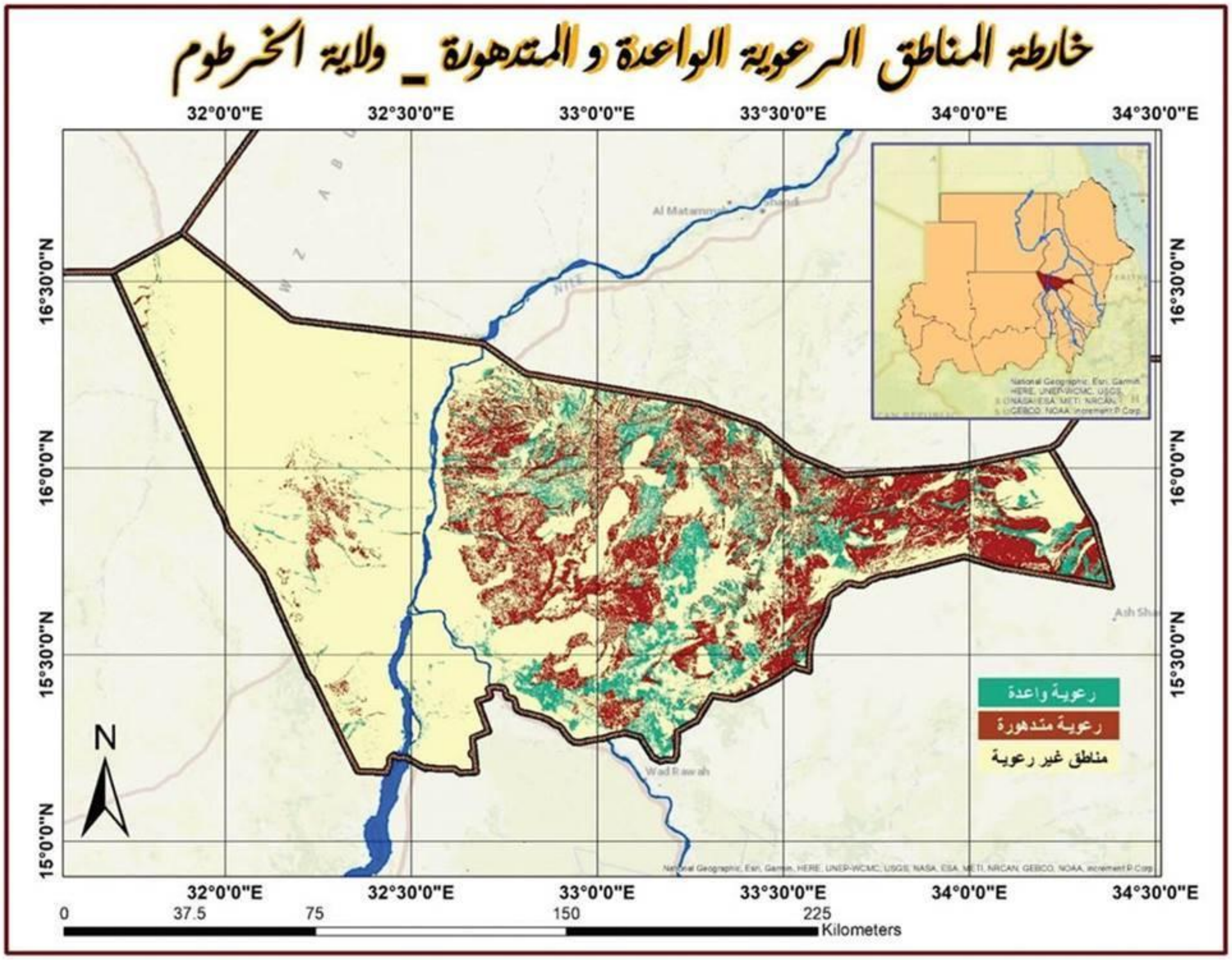

Figure (33) Map of promising and degraded rangelands areas in the state of Khartoum, (Source; ACSAD, 2019c).

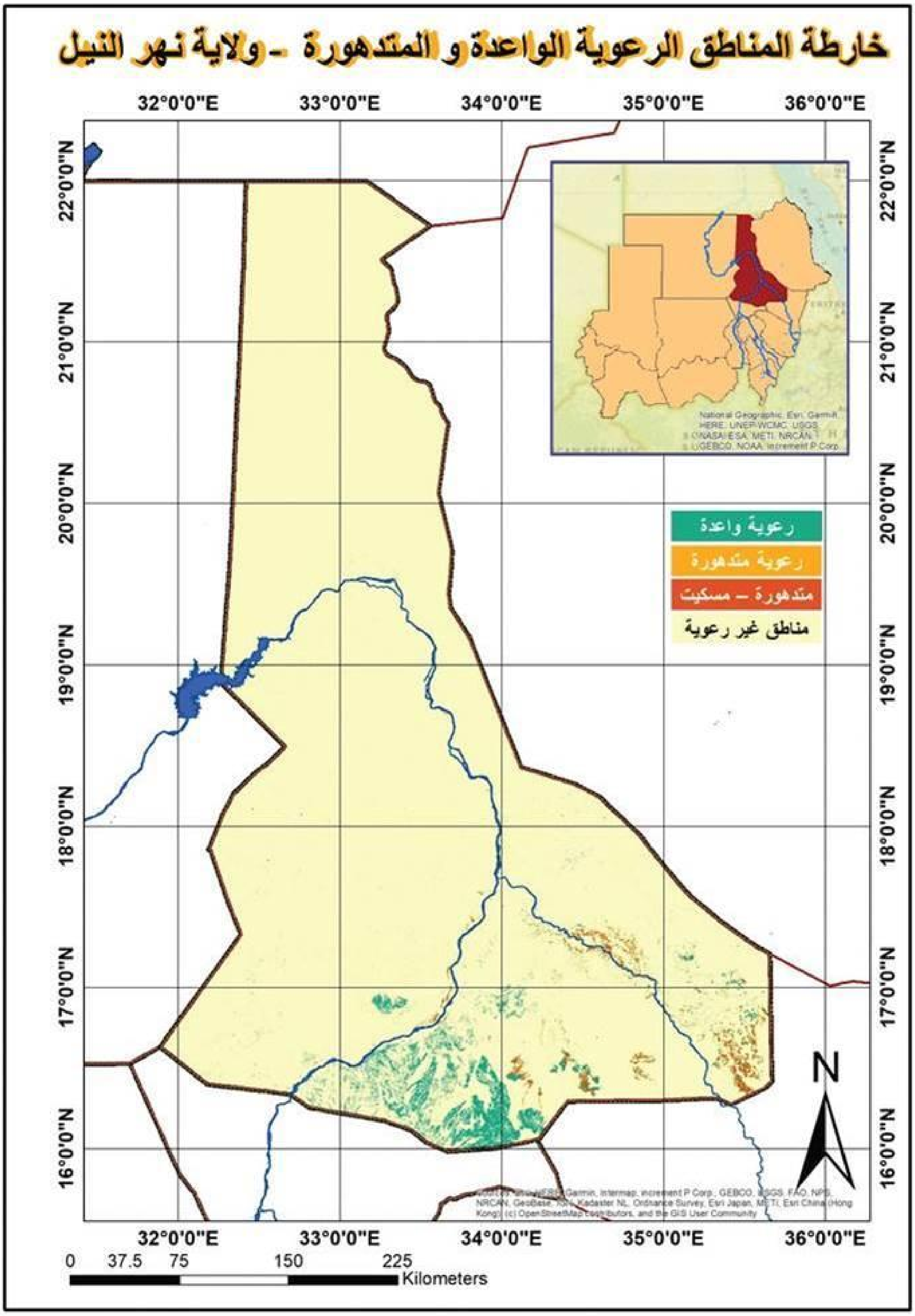

Figure (34) Map of promising and degraded rangelands areas in the state of Nile River, (Source; ACSAD, 2019c)

Results of recent rangeland vegetation evaluation of the state of Nile River, Sudan indicated that plant density of annual and perennial forbs plant species ranged from 0 to 103 plant/m2 and the average of plant density of forbs and grasses was 24.56 plant/m2, however, plant density of shrubs was 104.24 shrub/ha (ACSAD, 2019c). Total plant productivity from forbs, grasses, and shrubs range from 20 to 1400 kg/ha of dry matter with an average of plant production for the state of Nile River of 508 kg dry matter/ha. Grazing capacity estimated for the state ranged from 0.01 to 0.37 animal unit/ha with an average of 0.12 animal unit/ha, in another word the area needed for standard animal unit ranged from 2.7 to 160 ha in the state of Nile River with an average of 24 ha/animal unit.

Results of detailed rangeland vegetation survey of the state of Khartoum, Sudan showed that plant density of annual and perennial forbs plant species ranged from 3.38 to 270 plant/m2 and the average of plant density of forbs and grasses was 71.2 plant/m2, however, plant density of shrubs was 62 shrub/ha. Total plant productivity from forbs, grasses, and shrubs range from 90 to 2401 kg/ha of dry matter with an average of plant production for the state of Khartoum of 736 kg dry matter/ha. Grazing capacity estimated for the state ranged from 0.02 to 0.58 animal unit/ha with an average of 0.18 animal unit/ha, in another word the area needed for standard animal unit ranged from 3.5 to 57 ha in the state of Khartoum.

In general, rangelands vegetation in the studied states at Sudan during 2018 to 2019 faced different impacts led to its deterioration, changes in its environment and declined its area, and disappearing of several important range plant species, moreover, some of these plant species had faced endangered and non-desirable unpalatable plants showed up. Rangeland degradation also includes overgrazing, changing rangeland plant composition, range shrubs degradation which represents important resource for camel grazing during dry periods, expanding in agriculture projects and rainfed cultivation in the rangelands. Rangelands degradation study conducted by ACSAD indicated that rangelands degraded area in the states of Khartoum, Nile River, and Northern during the period from 2003 to 2016 was estimated by about 3 million ha (figures 35 and 36).

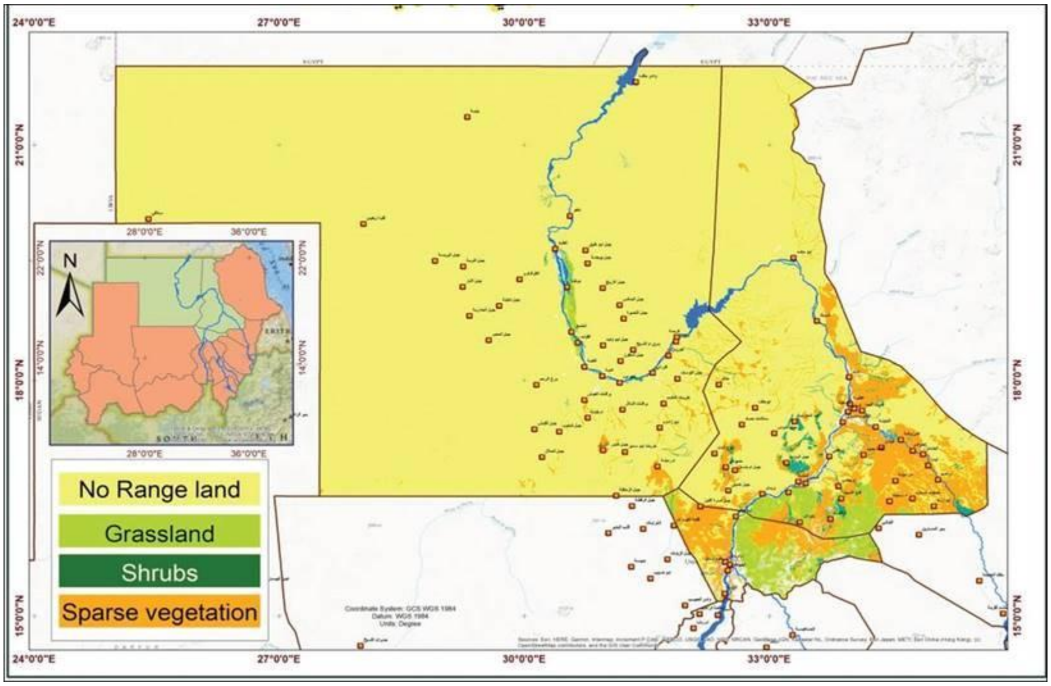

Figure (35) Map of land and plant cover degradation for the states of Khartoum, Nile River, and Northern in 2003, (Source; ACSAD, 2019c)

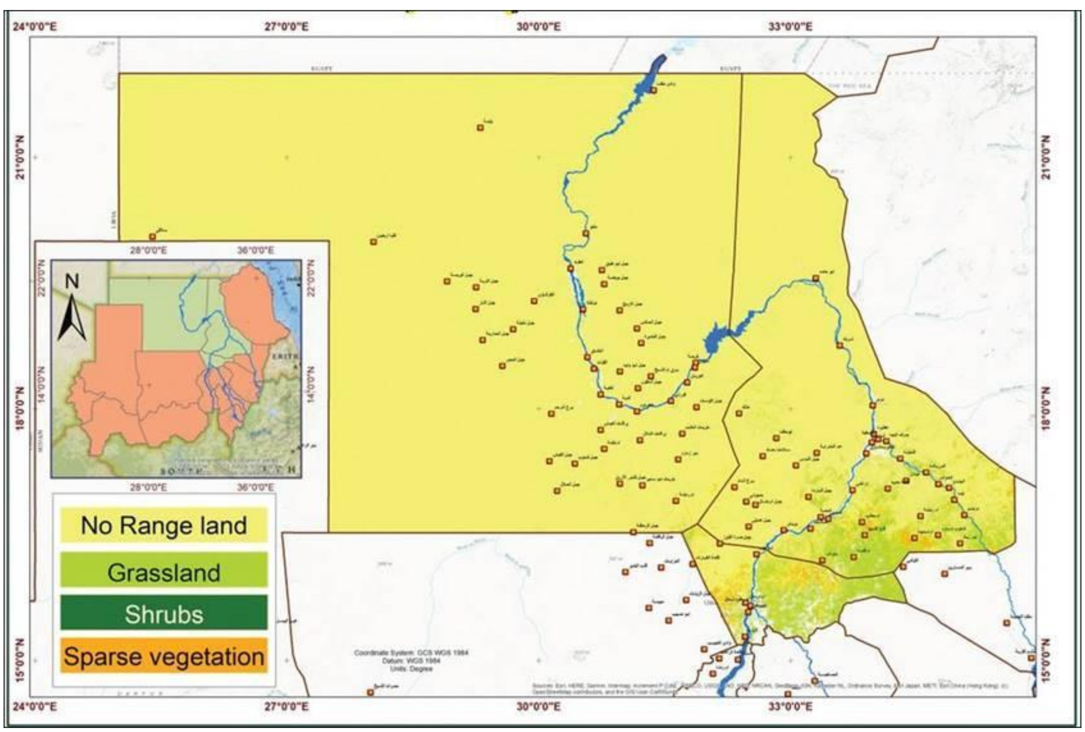

Figure (36) Map of land and plant cover degradation for the states of Khartoum, Nile River, and Northern in 2016, (Source; ACSAD, 2019c)

Rangeland assessment of Central and South Eastern Region

There are four states within the central and South Eastern region of Sudan which include: Blue Nile, Gezira, White Nile and Sinnar. While Sinnar and the White Nile States are low rainfall savannahs, the Blue Nile is a high rainfall savannah, and Gezira is in the semi-desert zone. Gezira State covers an area of approximately 26 thousand square kilometers and belongs to an arid climatic zone where rainfall and evapotranspiration yield a negative annual water balance. The annual rainfall is variable and ranges between 420 mm in the south and 250 mm in the north. However, the current evapotranspiration rate is very high (2300 mm per annum) and the current ratio of evapotranspiration to maximum evapotranspiration is predicted to increase by 11%.

Blue Nile State is located in the southeastern part of Sudan, which is a savannah with heavy rainfall that receives between 700 and 975 mm of rain annually. During the past decade the average precipitation has decreased to 450 - 500 mm per year (Blue Nile State NAP, 2013). At the same time, the region experienced an increase in the cycle of flood and drought as well as an increase in temperature and wind speed. Blue Nile State constitutes the grazing area in the main dry season for a very large number of livestock from inside and outside the state. The secession of South Sudan created a critical situation for many pastoral groups that used to spend the dry season in South Sudan, as they found no other alternative but Blue Nile State. Other groups, due to the inability to move with their animals, are also forced to spend the rainy season within the state.

Rangelands constitute an important resource for the inhabitants of the White Nile State, and there are several types of shepherds in the state, but the majority of them combine the two crafts of agriculture and herding, and a small group of them depend on grazing as a main craft, and these herdsmen live in fixed villages and they differ in the composition of the herd and the numbers of animals, where it is considered about 95% of smallholders. The big livestock owners are concentrated in the western regions of the muddy plains, and their herds are dominated by raising cows and wandering among the natural pastures in the Al Quoz sandy area in the autumn, and they also head south to the mechanized farming areas in the south of the state. In the summer, these shepherds head to the White Nile and concentrate on the islands and the Nile shore to graze the Nile weeds, as well as rely on concentrated feed.

4.6 Arab Republic of Egypt

The country is geographically related to two regions; North Africa and southwest Asia. Egypt has two coastlines on both the Mediterranean Sea and the Red Sea. It is located between latitudes 22º and 32º N and longitudes 25º and 34º E and covers a land area of 1001 449 km2. The longest straight-line distance in Egypt from north to south is 1024 km while that from east to west measures 1240 km. The country has more than 2900 km of coastline on the Mediterranean Sea, the Gulf of Suez, the Gulf of Aqaba and the Red Sea. Egypt is divided into 27 governorates which include 4 city governorates (Cairo, Alexandria, Suez and Port Said), 9 governorates of lower Egypt in the Nile Delta region, 8 governorates of Upper Egypt along the Nile River south from Cairo to Aswan and 5 frontier governorates covering Sinai and the deserts that lie west and east of the Nile.

Like other countries in the LAS region, the Arab Republic of Egypt is an arid country that tends to be subject to drought and has large areas of semi-desert and desert lands. Rangeland in the country is estimated by 4 million ha (AOAD, 2018), however recently the rangeland area in Egypt including the area that have natural vegetation and provide ecosystem services was estimated by about 7 million ha (Figure, 37) according to (DRC, 2020). The rangelands in the country located in three main areas: the North West Coast of Mediterranean sea, Sinai Peninsula, and Halaib and Shalatin area in the southeast of Egypt.

Most of rangeland areas in Egypt occur in arid lands with average rainfall from range from less than 50 to 200 mm, and their condition in most cases is degraded to poor desert rangelands which have been under ongoing overgrazing for years; however, rangelands are still primary source of forage for over one million sheep, goats, and camel. These livestock represent the major source of income for most of the population of four governorates in Egypt.

Rangelands have a vital and strategic importance to Egypt as they provide the country with high value ecosystem services including water supply, preserving soils from erosion, reducing surface runoff of rainwater, renewing groundwater, resisting desertification, and decreasing sand encroachment.

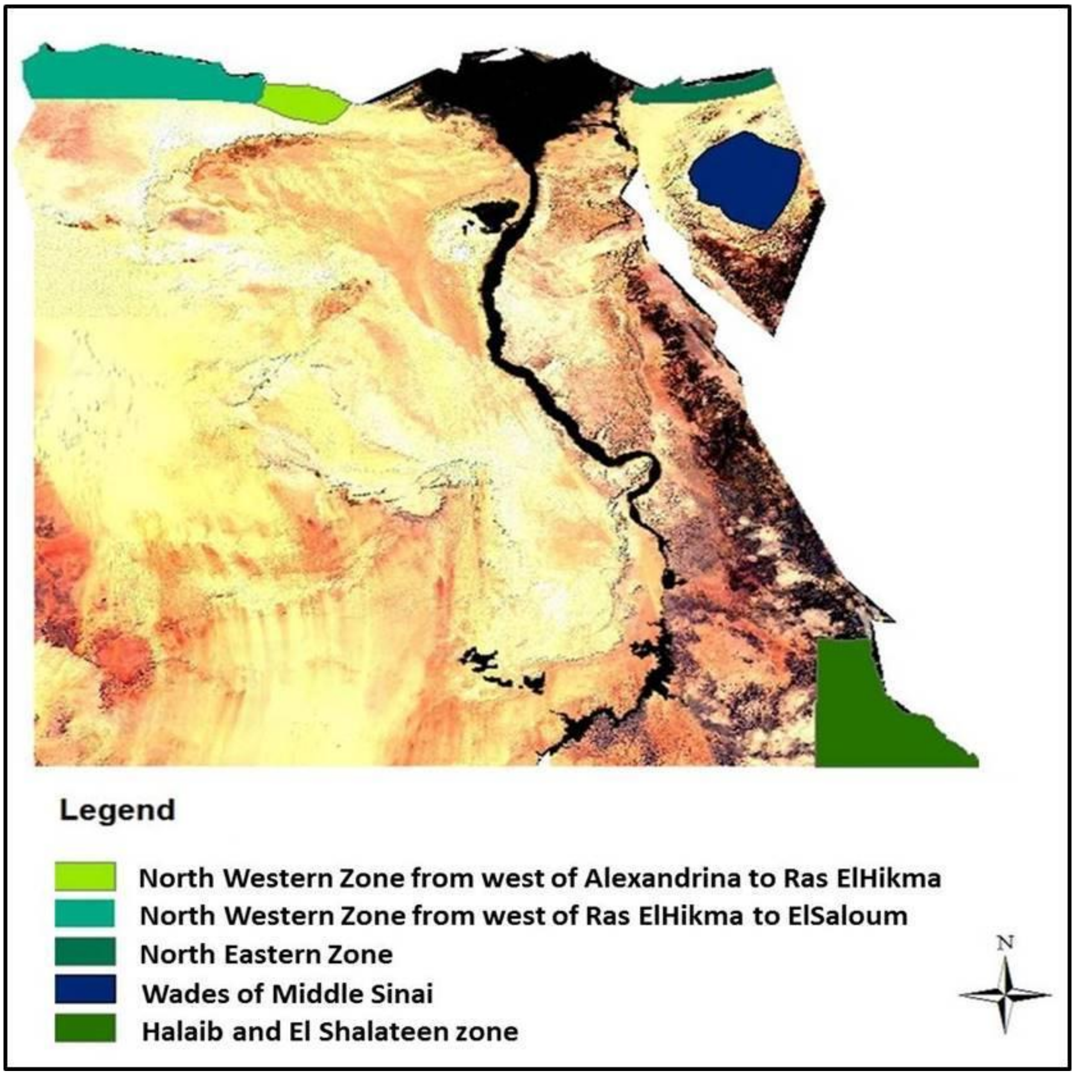

Figure (37) Illustrated map of rangeland distribution over the Egyptian Desert Lands, (Source, DRC, 2020).

Egypt has wide varieties of ecosystems and landscapes, reflecting variations in climate where the low rainfall is not evenly distributed over seasons and regions with high evaporation and evapotranspiration responsible for significant water losses especially in the southern portion of the country.

In light of the geography and geologic history of Egypt, four major physical regions referred to as agro-ecological zones are distinguished as follows, the North Coastal Zone, the Nile Valley and Delta, the Inland Sinai Peninsula and Eastern Desert, and the Western Desert. These agro-ecological zones (Figure 38) have specific attributes of resource base, climatic features, terrain and geomorphic characteristics, land use patterns and socio-economic implications. Since significant variations in the environmental characteristics are apparent in each zone, the active factors and processes of land degradation and their impact are necessarily variable.

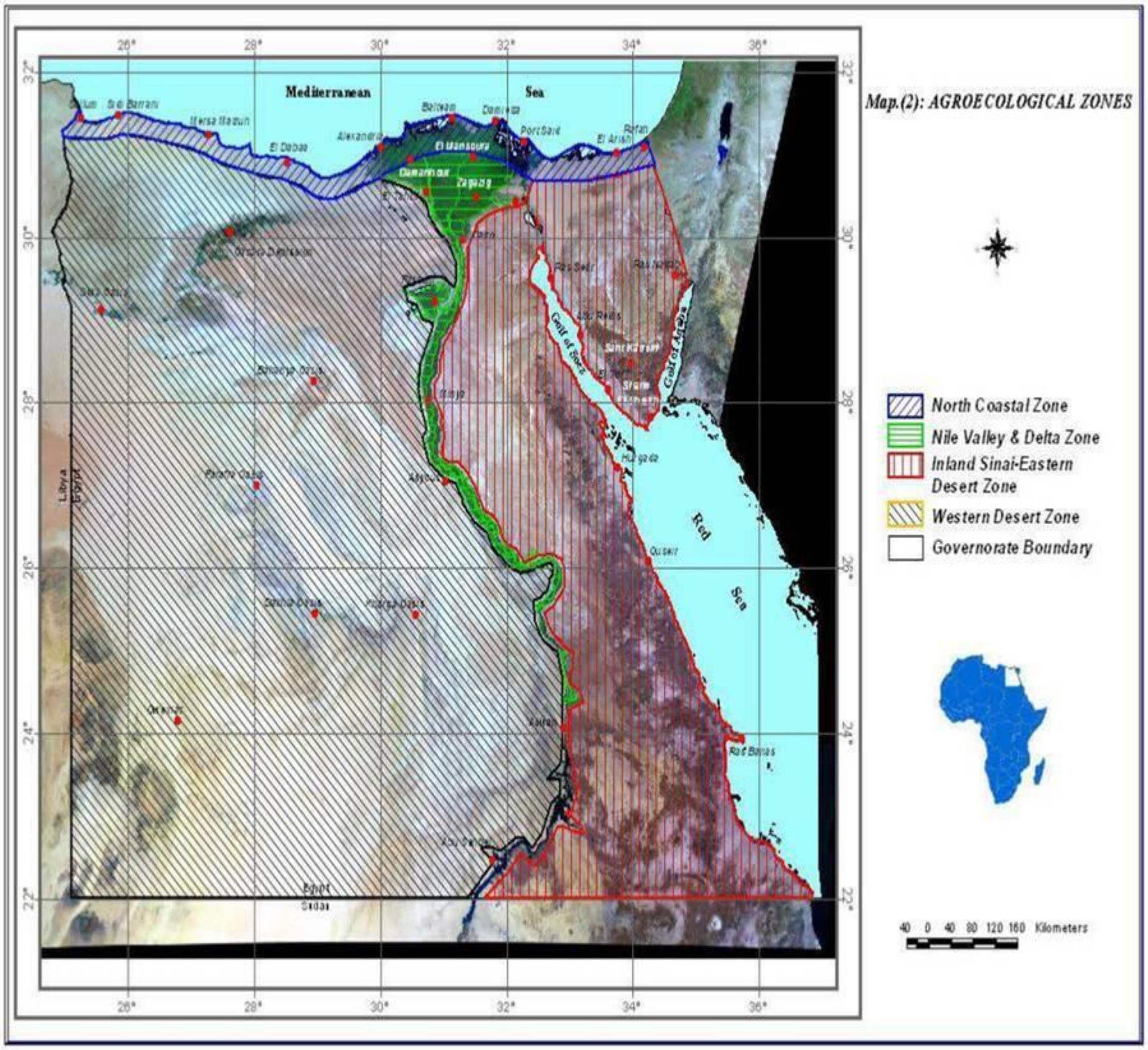

Figure (38) Agro-ecological Zones of Egypt

Flora of Egypt comprises about 2121 species of vascular plants including 27 cultivated species. This means that the number of wild species, about 2094 native and naturalized species under 712 genera and 121 families, divided as follows: 16 species representing pteridophytes, six species Gymnosperms, 1637 species Dicots, 435 species Monocots. From these species 61 species are endemic only in Egypt and this number represents about 2.9% of the total Egyptian flora , this means that the flora of Egypt have rich diversity in spite of growth of the dry zones in the country . This plant diversity may be due to the diversity of habitats in Egypt. Gramineae (Poaceae) is the largest family which contains 277 species (including 27 cultivated species) followed by Compositae (233), Cruciferae (230), Caryophillaceae (102), Chenopoiaceae (85), Scrophulariaceae (77), Euphorbiaceae (62), Boraginaceae (57), and Labiatae (55) and Umbellifrae (51) species. The largest genera are :Eupherbia (42), Astragalus (32), silene (24), Convolvulus (23), Allium and Plantago (22each), Fagonia and Lotus (20each), Trifolium (19), Cyperus and Medicego (18 each), Heliotropuim (17), Atriplex, Bromus and Centaurea (16 each), Vicia (15), Anthemis, Indigofera, Salsola and Stipagrostis (14each), Eragrostis, Erodium and Veronica (13each), Bellevalia, Helianthemum and Solanum (12each), Amaranthus, Kickxia, Launaea, Reseda and Trigonella (11each), Acacia, Juncus, Muscari, Ranunculus, Trebulus and Zygophyllum (10 each) and the rest of genus contain less than ten species and many of these genus are represented by only one species. A striking feature in Egypt's flora is the large number of genera in proportion to that of the species amounting to about 3 species per genus. This is a very low figure compared to the average global proportion which amounts to about 14. The generic index, i.e., the number of genera per 100 species is relatively high which points to the marginal conditions of Egypt in respect to many genera, and also indicates the lack of accumulation and differentiation centers in Egypt (Täckholm, 1974, Boulos 1995, Zahran and Willis, 2009).

Sinai Peninsula is characterized by the largest number of endemic species for up to 37 species, including four species grown in certain other Egyptian geographic areas and the rest (33 species) grows only in Sinai, The other of endemic species in Egypt distribute as follows: 5 species in the Eastern Desert only, 4 species in the Eastern Desert and other areas of Egypt, one species in the Western Desert, 6 species in the River Nile, 3 species in the River Nile and other areas of Egypt, three species in the oases, three species in the oases, and other areas of Egypt, four species in the Mediterranean coast and other areas of Egypt, one species in Elba Mountains.

Egypt is the meeting point of floristic elements belonging to at least three phytogeographical regions: the African Sudano- Zam besian; the Asiatic Irano- Turanian; the Afro- Asiatic Saharo-sindian and the Euro- Afro- Asiatic Mediterranean.Although most of the greater part of Egypt is Saharan in vegetation, the proportion of Saharan plants is relatively small as compared to other phytogeographical regions. The tropical neighborhood, the high temperatures and the abundance of hydrosegetal habitats are responsible for the high grasses in Egypt. However, notable numbers of the genera of Gramineae are represented by tropical wides and weeds such as *Desmostachya, Eragrostis, Tetrapogon, Pennisetum, Lasiurus, Cymbopogon, Hyperrhenia, Dicanthium* and *Elusine*. Many of the Leguminosae genera are purely tropical (e.g., *Acacia*) and others are purely Mediterranean. A considerable portion of the genera of the Compositea is paleotropical, while a large portion of the Cruciferae's genera are truely Saharan (e.g. *Anastatica, Moricandia, Savignya, Schouwia, Zilla, Farsetia, Notoceras*, *Morettia, Eremobium, Schimpera, Maresia, Carrichtera*, and *Koeniga*. Although Caryophillaceae is mainly Mediterranean-Irano-Turanean, it also has a few interesting genera in the Saharan region (i.e.,Gymnocarpos, Petranthus), and in the Sudanian region (e.g., *Robbairea, Polycarpaea, Sphaerocoma*, and *Cometes*). The Umbelliferae has Irano-Turanean species in Egypt (e.g., *Pycnocycla*, *Ducrosia,Zosima* and *Malabiala*), and almost no tropical representatives. The tropical influence on Egypt's flora is marked not only in the scores of genera and species of Paleo-tropic origin, but in the occurrence of some tropical families known in the Middle East only from Tropical Arabia (e,g., Pedaliaceae, Ebenaceae, Podostemaceae, and Salvadoraceae). Other Predominantly tropical families include Capparidaceae, Asclepiadceae, Moringaceae, Menispermaceae, Nyctaginaceae, Amaranthaceae, Loranthaceae, Commelinaceae, Hydrocharitaceae and Cyperaceae. Unfortintly, no vegetation map was developed for Egypt yet; however, the Egyptian habitat sub-systems is illustrated in figure (39) according to Harhash et al., (2015)

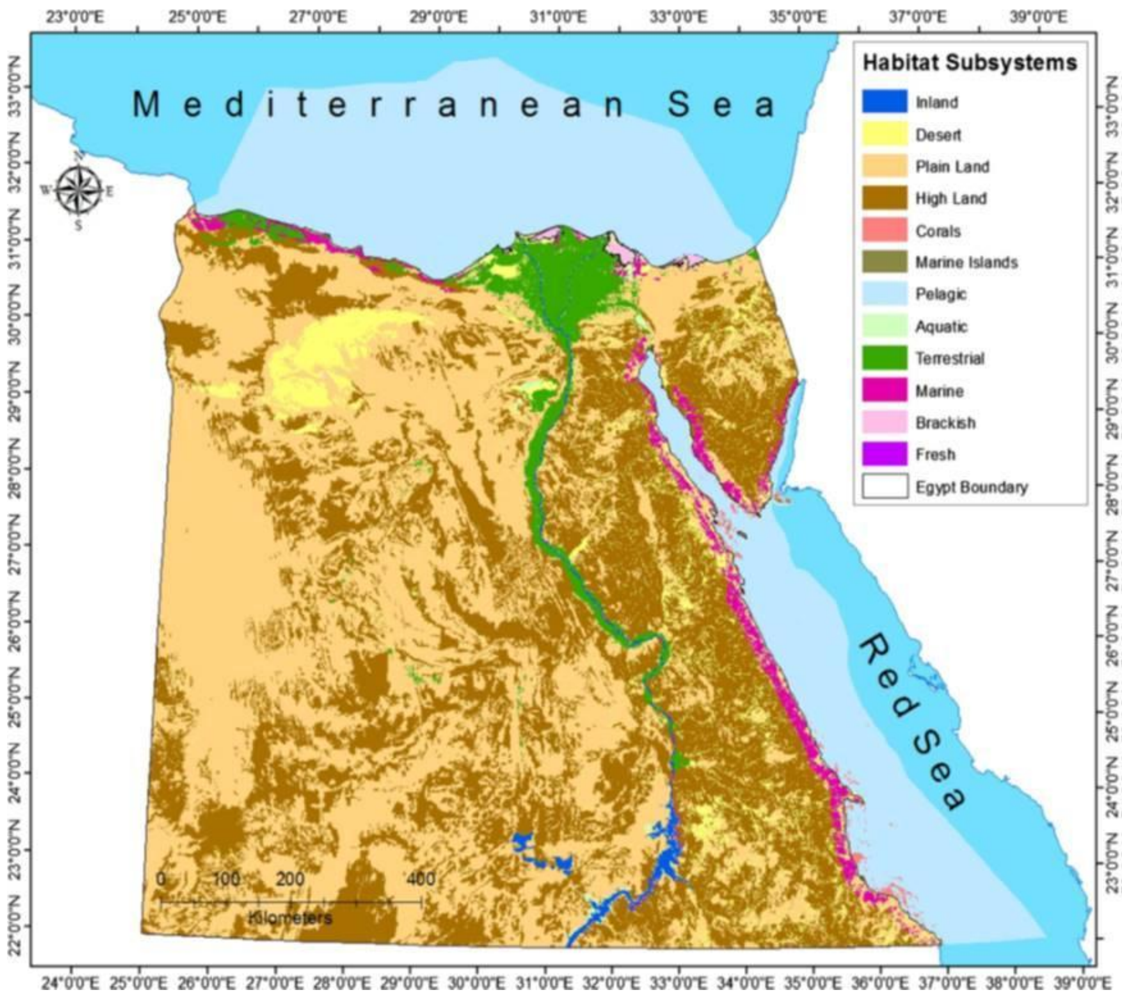

Figure (39) Egyptian habitat Sub-systems, (Source; Harhash et al., 2015)

The annual feed production of the rangelands varies between nil in poor rainfall years to 30-40 Feed Unit (FU) with an average of 20 FU/acre/ year (DRC, 2015). On the basis of the barley acreage an estimated production of 230 FU/Acre of barley, the carrying capacity of the area extending from Ras El-Hekma to Salloum was estimated at about 93000 sheep unit- (SU) year while the actual number of small ruminants raised at the time was about 214000 SU, indicating that the actual production of rangelands can only support about 44% of the actual small ruminants raised. This also indicates that at least about 60% of feed staff requirements came from outside resources. Any shortage in the supply from feeds of outside the region would have to be offset from rangelands because the grazing animal will be maintained on the rangelands causing more deterioration of rangelands and lower production of grazing herds. A study by

DRC, (2015) estimated the consumable productivity of some plant communities in south west of Sidi Barrany, Marsa Matrouh between 20-30 Kg/dry matter / Acre / year. The average productivity of the whole area was estimated as 25 kg/Acre/year. This area is a part of natural poor degraded range type.

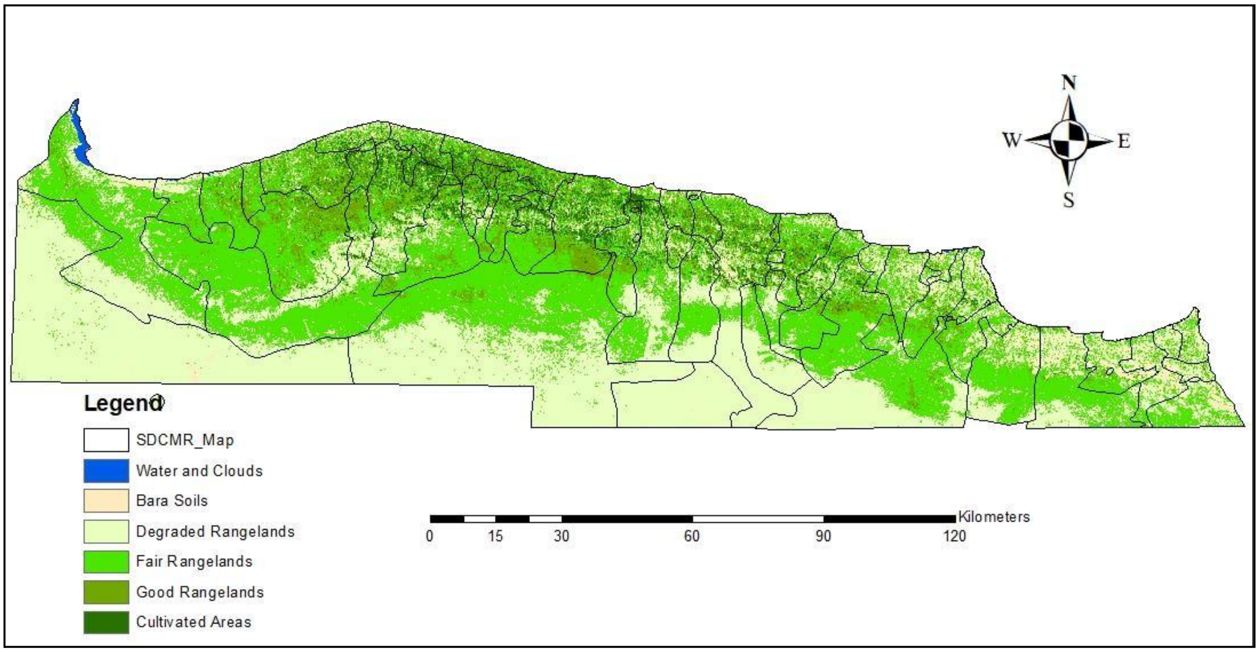

Figure (40) Rangelands condition of the Northwestern coastal zone of Egypt, with an area of 1.3 million ha, (Source; ACSAD, 2019b).

Table 9. Evaluation of rangelands condition and productivity in an area of 1.3 million ha at the Northwestern coastal zone of Egypt, (ACSAD 2019b).

Land Cover	Area km^2	%	kg/ha
Water & Clouds	32	0.3	--
Bare Soils	456	3.6	--
Degraded Rangelands	5349	42.0	10 – 150
Fair Rangelands	5090	40.0	151 – 300
Good Rangelands	1289	10.1	< 300
Cultivated Areas	512	4.0	--

Total	12728	100.0	--

Sheep and goat grazing at Wadi Umm Ashtan, Northwestern coastal zone, Egypt, spring, 2015, photo by the Consultant

Recently there is a great attention to restore rangelands in Egypt and a national strategy for the sustainable rangeland development and management is under preparation as a response to the 2030 Egyptian vision that targeted exiting from the narrow valley and increasing the inhabited areas in Egypt to 25%. The impetus of achieving and maintaining the Egyptian national and food security, improving the people livelihoods, led to starting large scale desert lands reclamation national projects, industrial development, and establishing new cities adjacent to rangelands make rangeland restoration actions are highly needed in the country.

5

The principle rangeland ecosystem

services in the LAS region

The principle rangeland ecosystem services in the LAS region:

Ecosystem services are the many and varied benefits to humans provided by the natural environment and from healthy ecosystems. Such ecosystems include, for example, agroecosystems, forest ecosystems, grassland ecosystems and aquatic ecosystems. The Millennium Ecosystem Assessment (MA), a major UN-sponsored effort to analyze the impact of human actions on ecosystems and human well-being, identified four major categories of ecosystem services: provisioning, regulating, cultural and supporting services. Although the level of ecosystem services is reduced because the ecosystem is highly degraded, the current ecosystem goods and services that are obtained from LAS rangelands would include:

Provisioning services:

Food production, livestock product, and plant production

Rangeland provide several provisioning services such as forage for livestock and wildlife, medicinal plants, honey bee, fuel, Arabic gum, ...etc), wildlife, livestock and wildlife products, genetic resources including crop improvement genes, and health care, and soil conservation. Sheep and goats' numbers in the LAS region was about 275 million heads in 2016, and 70 % of which are raised under rangeland ecosystems. Camels' numbers in the LAS region was 16.6 million heads in 2016, 90 % of which are raised in rangeland ecosystems. Recent estimate by the Ministry of Environment, Water, and Agricultural in the Saudi Arabia showed that camel herd in the country reached about 2 million head of camels and their market value could reach around

20 billion SAR equal to USD 5.3 Billion. Rangelands provide this huge herd of sheep, goats, and camels with at least one third of their annual nutritional needs.

The northwestern coastal desert of Egypt provide provisioning services in the form of medicinal plant, around 204 plants of this regions have medicinal properties (Heneidy & Bidak, 2004), Fuel wood (ElKady, 1980) and food, for example Terfezia claveryi is an edible fungus with high economic value and it is sold at the price of US$ 10.50/kg to the retailers (Bidak et al, 2015). But the ecosystem services also are facing threat due to overgrazing (Heneidy, 1992), urban development (Abd El-Kawy et al., 2011) and new intensive agriculture farming (Kassas, 1972).

Rangeland livestock is the largest subsector of the Sudanese domestic economy and is a growing contributor to exports; it has in recent years consistently provided more than 60% of the estimated value added to the agricultural sector, and is a substantially more important contributor to agricultural GDP than crop farming. Animal production, herding camel and sheep, has traditionally represented one of the main agricultural activities for the inhabitants of the southern provinces of Morocco; it accounts for 67% of the sector's GDP in the region, according to 2013 figures.

Livestock production played a vital role in the Syrian economy before the crisis, contributing 40 percent of the total agricultural production and absorbing 20 percent of rural employment. It generated approximately USD 450 million per year due to exports, with Syria being a significant exporter of sheep to the Kingdom of Saudi Arabia and the Gulf States. Sheep comprised the majority of the livestock population before the crisis, while cattle and goat populations were smaller (FAO, 2017).

Water provisioning:

According to (Myint & Westerberg, 2014), the Jordanian rangelands serve as watersheds that receive rainfall, yield surface water, and replenish groundwater throughout the region east and south of the western Jordan highlands. Result of their study indicated that there will be an increasing in annual safe yield abstraction rates within the Zarqa River Basin by 13 to 14 per cent, at an estimated value of 189.5 million JOD to society over a 25 year time horizon. The authors also reported that the benefits associated with carbon sequestration within the Zarqa river basin are estimated at a value of up to 38 million JOD (53 million USD) over a 25 year project cycle.

Regulating services:

Rangelands provide several regulating services including, carbon sequestration and climate regulation, mitigation of floods and droughts, soil stabilization, waste decomposition and detoxification, and purification of water and air. Properly managed of the 336 million hectares rangelands of the United States are estimated to have the capacity to store 19 million metric tonnes of C per year (Schuman and Derner, 2004). This means one ha of properly managed rangelands has the capacity to store 0.0565 metric tonnes of C per year. Based on this approach, if the 425 million hectares of rangelands in the LAS countries properly managed, they can have the capacity to store 24 million metric tonnes of C per year.

Dust storms that originate in one part of the Arab region may impact another part. Conservation of natural rangeland vegetation and improving the vegetation cover of the rangelands has been identified as a major element in sand and dust storms mitigation. The impact of sand and dust storms on national and regional economies cannot be overestimated. Due to the complexity of how sand and dust storms impact various socio-economic sectors in to different extents, few data regarding budgetary losses is available. A 2009 study suggests that increased dust-storms would result in annual losses of 12.7 billion USD in GDP per annum in the MENA region alone. Considering that Iraq, Kuwait, Saudi Arabia, Syria, and Jordan as a sub-region are more heavily affected by sand and dust storms than the MENA, the amount of annual GDP losses must be significantly higher. Dust concentration and storms cost MENA over 150 billion USD annually and over 2.5 percent of GDP for most countries in the region (World Bank, 2019).

Cultural services:

Rangelands provide several recreational experiences including ecotourism, outdoor sports, camping, and recreation. The total economic contribution of the cultural services provided by rangelands is limited in most of the Arab countries. However, the total value of tourism and recreation for a network of 728 protected areas across 800,000 km^2 in New South Wales, south-eastern Australia was estimated at $AUD 3.3 billion per annum.

Supporting services:

These include services such as nutrient cycling, primary production, soil formation, habitat provision and pollination. These services make it possible for the ecosystems to continue providing services such as food supply, flood regulation, and water purification. Dispersal of seeds, maintenance of plant biodiversity, existence values for rare plants, maintenance of fauna biodiversity, hunting, and viewing existence values for rare wildlife

For instance, rangelands in Yemen provide fuel-wood, a source of energy for the rural poor population, fodder for livestock (cattle, camels, goats, sheep and donkeys) and medicinal plants. In addition, rangelands offer services and functions which support economic production processes such as habitat for wildlife, pollinators, soil erosion prevention and soil maintenance, carbon sequestration and watershed properties. Based on data availability and the value of goods and services produced in Yemen, the value of rangelands was estimated at USD 3,386 million; this excludes the value of fuel wood and carbon sequestration (UNDP, 2014).

Camels grazing in Saudi Arabia, photo by the Consultant

Collecting of medicine plants (*Citrullus colocynthis*) at southeast Egypt, photo by the Consultant

Healthy rangelands site in Oman, water production, photo by the Consultant

6

DPSIR analysis in the LAS region

Drivers, Pressure, State, Impact and Response (DPSIR) analysis in the LAS region

Detailed reviews of literatures were conducted to provide a regional analysis of Drivers, Pressure, State, Impact and Response in relation to rangeland environmental health and identify priority challenges to rangeland health. The Driver–Pressure–State–Impact Response (DPSIR) framework for integrated environmental reporting and assessment, developed by the European Environmental Agency (EEA) in 1999, has since been widely adopted in the study of environmental problems (Carr et al., 2017). DPSIR is a framework that includes, identifying the Drivers and Pressures which affect the socio-ecological system which ranging in scale from global systems to localized watersheds; monitoring the State; focusing on the economic and social Impacts of change; and finally, identifying the Responses and the possible societal interventions. The following is the DPSIR analysis in the LAS region:

6.1 Drivers

6.1.1 Population:

Human population of LAS countries has shown high increase rate under shrinking natural resources; Arab countries population has increased from about 275 million in the year 2010 to about 425 million in 2020.

6.1.2 Governance and land tenure:

Weak governance, common land tenure, and unsuitable livestock policies are drivers. The primary type of land tenure for extensive rangeland areas in the Arab region is open grazing. Usually, the lands are owned by the government/state and grazing is done in common with the rights of using the lands by the Bedouin tribes and local communities. Under communal grazing systems each individual herder wants to maximize his or her number of livestock while the costs of rangeland degradation derived from large herds of livestock are shared by the whole community. Consequently individual herders have no incentives to care for rangeland conditions, leading to a tragedy of the commons. Hence, government policies, programs, and subsidies on common rangelands have created disincentives rather than incentives in many countries (Holechek, 2011). Livestock/Fodder policies have been a major factor in many countries and have driven massive growth in livestock numbers, far beyond the capacity of the rangeland to sustain. For instant, government subsidies of barley led to increasing livestock number and creating more pressure on the rangelands (ACSAD, 2015). Another example was multiplication of water points to extend grazing areas without taking in the consideration the consequent increase of livestock numbers as there were no clear land tenure and high demand for livestock products. Moreover, it is difficult for herders to implement good rangeland practices if they do not have security over their land as under unclear tenure systems the herders have no motivation to invest and sustainably mange rangelands.

6.1.3 Climatic change:

Climate change study in LAS region for the period from 2006 to 2099 showed that the daily average temperature and daily maximum temperature will be increased by 2.5Cº and the average daily minimum temperature will be increased by 2.7 cº. There will be also large changes in average rainfall and distribution in the Arab region as a result of climate change. According to ESCWA (2017) maps of projected temperature changes (compared to the reference period 1985–2005) over the Arab Domain for the different time periods and the two RCP what are those scenarios scenarios are presented in Figure (41). As can be seen, all projections show that temperatures will rise over the Arab region during this century. The general change in temperature for RCP 4.5 shows an increase of 1.2 °C–1.9 °C at mid-century and 1.5 °C– 2.3 °C by end-century. For RCP 8.5, temperatures increase to 1.7 C–2.6 °C for mid-century and 3.2 °C–4.8 °C towards end-century.

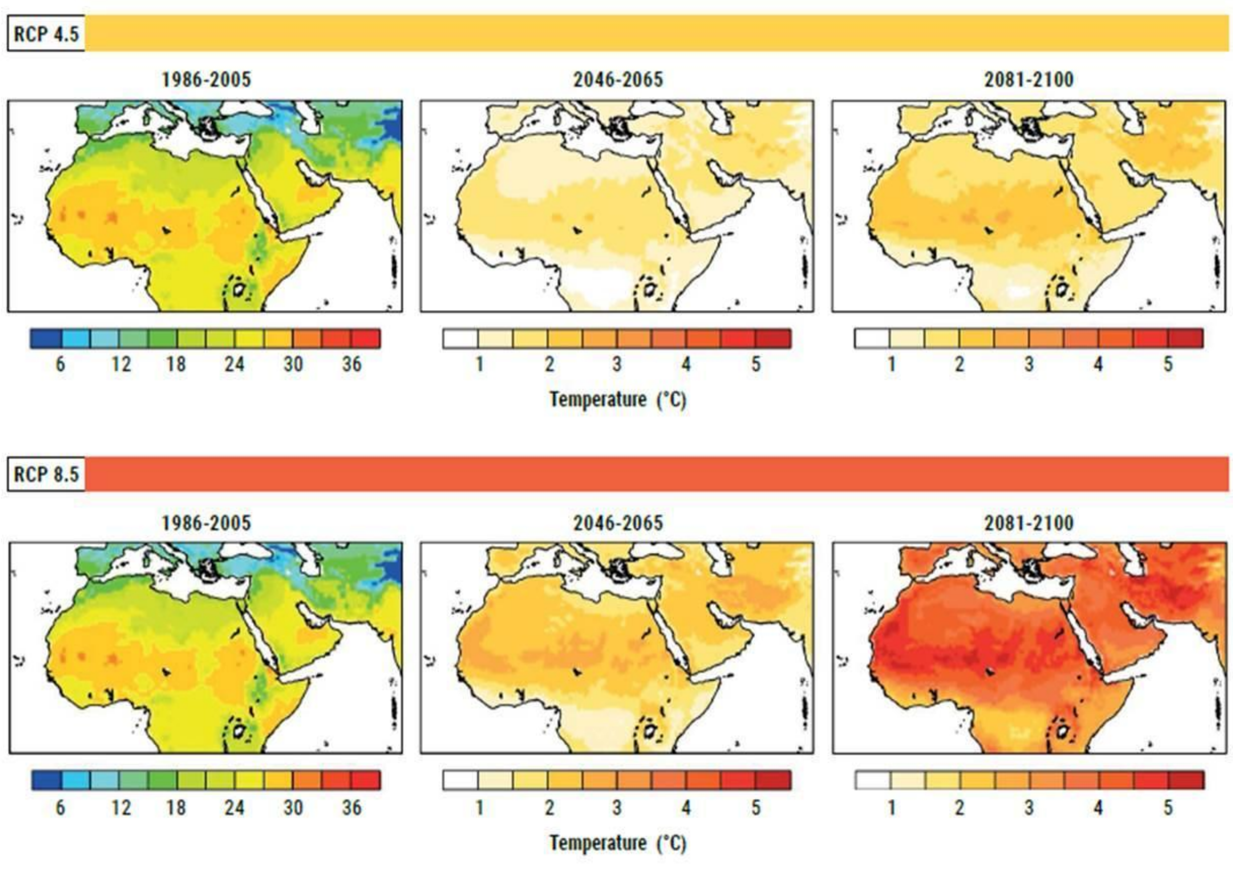

Figure 41. Mean change in annual temperature (°C) for mid- and end-century for ensemble of three RCP 4.5 and RCP 8.5 projections compared to the reference period, (Source: ESCWA, 2017).

The maps in Figure (42) show the spatial extent of projected precipitation change over the Arab region averaged for the three-member ensemble, for the mid- and end-21st century sub-periods; considering the two RCP emissions scenarios. Precipitation changes vary considerably across the Arab Domain with no universal trend for annual results as well as at the seasonal level. Decreasing trends can be seen in most of the Arab region at mid-century. By the end of the century, both scenarios suggest a reduction of the average monthly precipitation reaching 8–10 mm in the coastal areas of the Arab Domain, mainly around the Atlas Mountains in the west and upper Euphrates and Tigris rivers in the east. Some areas, however, show increasing precipitation trends, such as the south-eastern Arabian Peninsula and some parts of the Sahel (ESCWA, 2017).

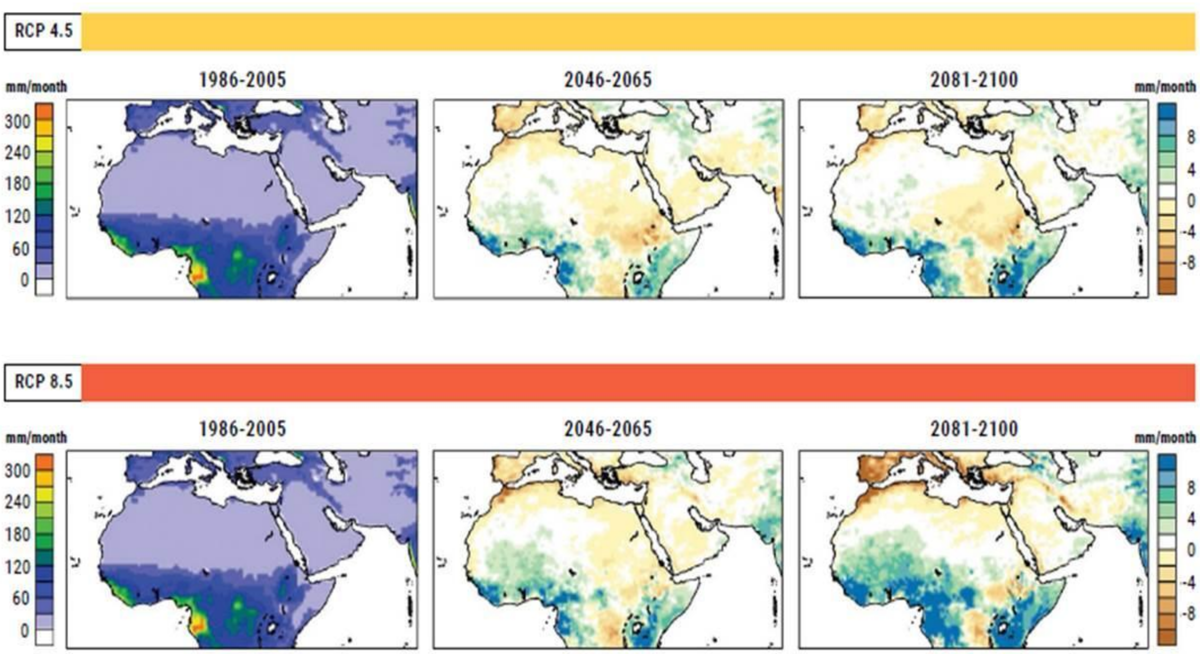

Figure 42. Mean change in annual precipitation (mm/month) for mid- and end-century for ensemble of three RCP 4.5 and RCP 8.5 projections compared to the reference period; (Source: ESCWA, 2017).

Climate change is a potential driver of drought leading to a higher drought frequency and greater aridity. Most of LAS rangelands occur in arid and semiarid zones, and drought has been a problem confronting rangeland livestock production in the region. For example, a study what is the study? showed that drought occur every three years or less over about two third of Oman country. Most of the Arab counties located within the Hyper arid, arid and semi-arid zones receiving average rainfall of up to 400mm with a winter growing season of 60-120 days; the dry lands support the livelihoods of 60% of the total population (ACSAD, 2011). The Arab region is subject to frequent droughts; agriculture is the major and sensitive sector of the economy, consumes most of the water resources, rangeland and rainfed crops strongly affected by precipitation fluctuations; rangelands areas in the Arab countries that receive an annual amount of rainfall range between 120/150 – 400 mm are considered vulnerable areas to drought (Erian et al, 2006). In Sudan, areas were crops depend on monsoon season for replenish their water requirements, the rainfed agriculture uncertainty increased within the annual amount range of rainfall that vary between 200 - 550 mm (ACSAD, 2008).

The study again what is the study?? of the drought frequency in the Arab region in the period from 2000 to 2010 as shown in figure (43), illustrate the following results ACSAD (2011):

1.6. An area of about 348 million ha (that represent 25.64% of the total area of Arab region) was a subject to drought for less than 2 years out of 10 years,

1.7. An area of about 509 million ha (that represent 37.57% of the total area of Arab region) was a subject to drought for 2 - 4 years out of 10 years,

1.8. An area of about 291 million ha (that represent 21.48% of the total area of Arab region) was a subject to drought for 4 - 6 years out of 10 years,

1.9. An area of about 162 million ha (that represent 11.92% of the total area of Arab region) was a subject to drought for 6 - 8 years out of 10 years, and

1.10. An area of about 46 million ha (that represent 3.39% of the total area of Arab region) was a subject to drought for more than 8 years out of 10 years.

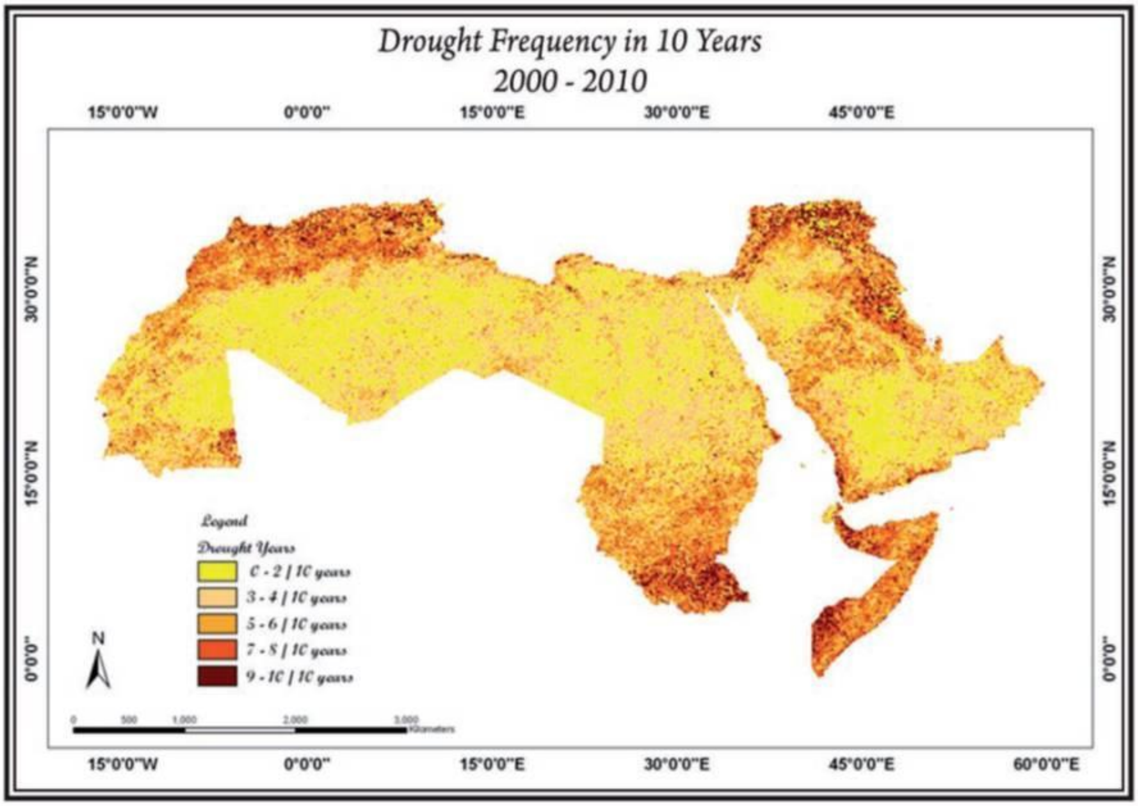

Figure (43) Drought Frequency during the Agriculture Seasons 2000 – 2010, (Source; ACSAD (2011).

6.1.4 Lack of institutional and executive government organizations for rangeland management:

In most of LAS countries there is lack of specialized governmental agencies responsible for the rangeland ecosystems, in addition to, disappearing the traditional rangeland management system used to be common in the LAS such "Hima", consequently the absence of effective rangeland management plans for achieving the SRM resulting in land deterioration. The traditional system of rangeland use in most of the LAS countries played a major role in environmental conservation and natural resource management. Under this system, each tribe or group of tribes had a well-defined area. The right of control over the use of rangeland and water resources was vested in the tribe's members. In the case of scarcity of natural resources, members of neighboring tribes were allowed to share the available pasture and water. The movement of nomads and livestock was organized according to defined routes and timings.

Resources were efficiently managed and well protected, tribe members were committed to the management systems, conflicts were resolved and penalties against offenders defined. The change to public ownership of rangelands has caused a break-down in the traditional management system. The absence of any alternative system guaranteeing the protection and conservation of natural resources and the lack of responsibility for the use of rangelands have led to land deterioration.

6.2 Pressures

5.2.1 Overgrazing and poor grazing management:

This is a common pressure on the LAS rangelands, as livestock grazing animals are in continuous increase with almost no regulation of rangelands utilization in most of the LAS countries. High livestock densities and lack of rotation or any suitable grazing systems are not given rangelands periods to rest and regenerate which led to intensify pressure on rangelands due to increased soil compaction by the livestock, overgrazing, making rangelands vulnerable to soil erosion and nutrient depletion. Poor grazing management is very common in most of the LAS countries. Continuous grazing whereas pastures are not given periods to rest and regenerate as a results of land tenure, governance, and absence of grazing management has been a big pressure on the LAS rangelands.

The following analyses were conducted using FAOSTAT, (2020) data. Sheep and goats numbers in the LAS region was about 275 million heads in 2016, and 70 % of which are raised under rangeland ecosystems. Camels’ numbers in the LAS region was 16.6 million heads in 2016, 90 % of which are raised in rangeland ecosystems. Cattles numbers in the LAS region was about 55.7 million heads in 2016 and 30 % of which are raised in rangelands. Camels’ number in Algeria for example has increased from less than 150,000 heads in 1980 to more than 400,000 heads in 2019 (Figure, 43). Also sheep number has increased from about 13.4 million heads in 1980 to about 29.4 million heads in 2019 (Figure, 44). In Morocco, even the increasing trend was not as high as in Algeria sheep numbers have increased from 16.5 million heads in 1980 to about 21.6 million heads in 2019 (Figure, 45).

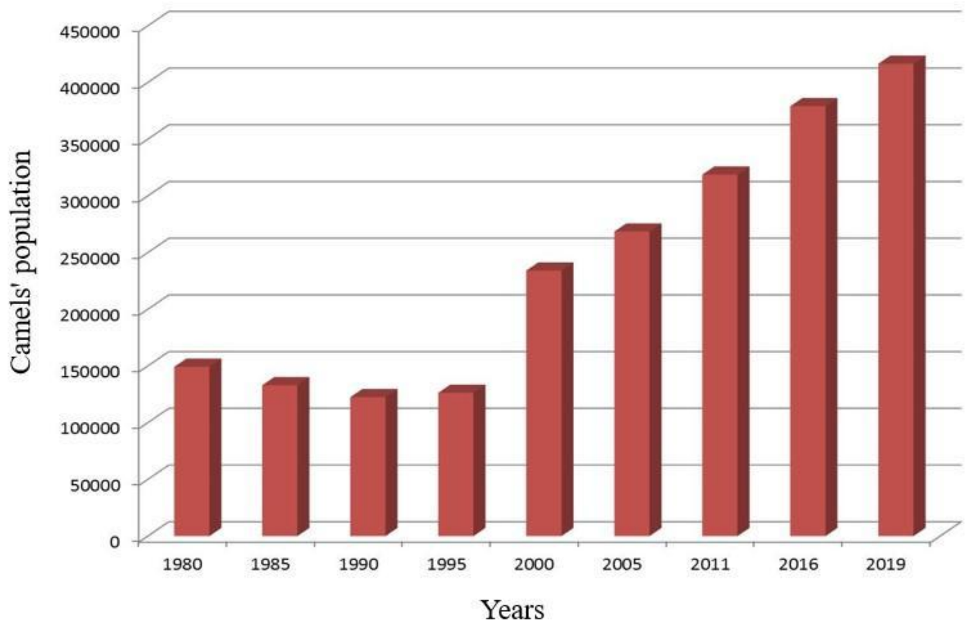

Figure (44) Changes in camels population from 1980 to 2019 in Algeria, (Source; FAOSTAT, 2020).

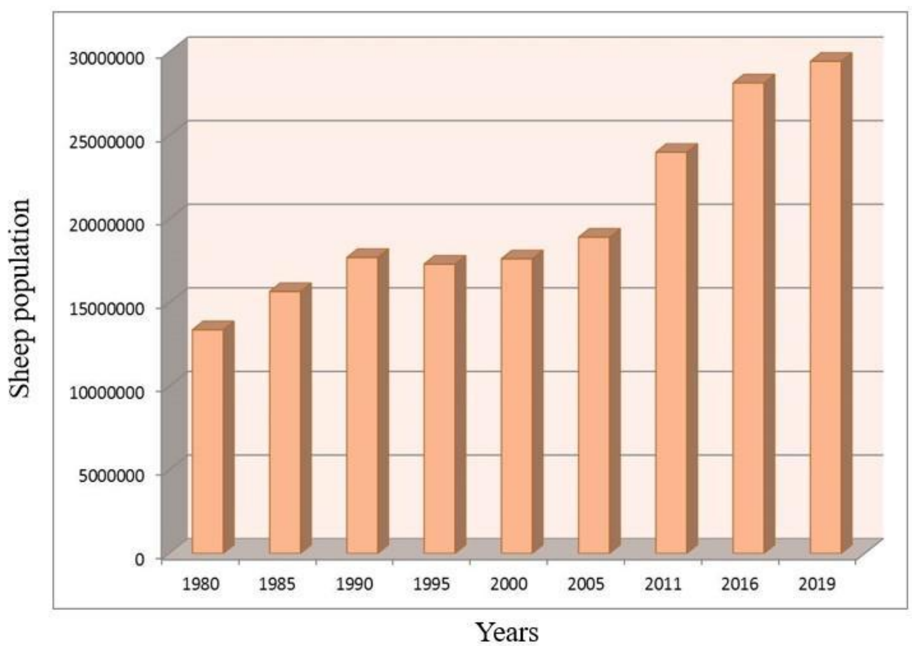

Figure (45) Changes in Sheep population from 1980 to 2019 in Algeria, (Source; FAOSTAT, 2020).

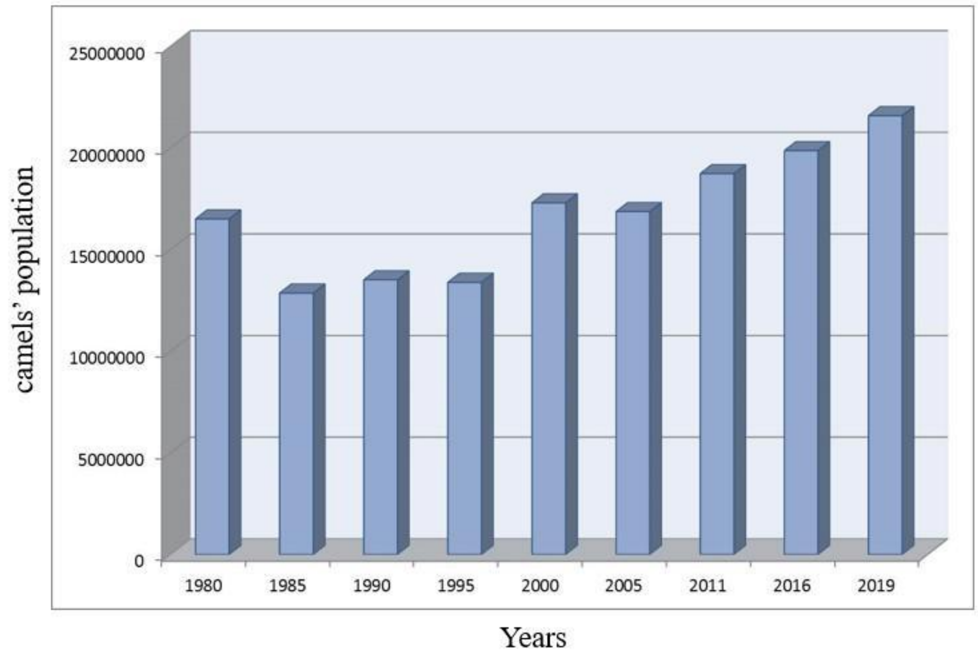

Figure (46) Changes in camels' population from 1980 to 2019 in Morocco, (Source; FAOSTAT, 2020).

Sheep overgrazing in central Saudi Arabia, photo by the Consultant

6.2.2 Transformation of rangelands to agriculture and cultivated lands:

Studies please mention examples have shown that cultivating of field crops such as wheat, barely, sorghum, and orchard trees such as olive and figs; represent a major pressure on LAS rangelands health. Over the past few decades, many countries, especially in the Gulf region, have been heavily subsidizing agricultural development in order to achieve self-sufficiency in basic food crops, regardless of the national natural resource base. Incentives include the setting of very low land and water prices for crop production and very high crop prices. Moreover, most countries have invested heavily in irrigation infrastructure. Agricultural development policies have resulted in the expansion of agriculture and especially of cultivated land on rangeland (FAO, 2010). The expansion of rain-fed mixed farming to rangelands and the increasing pressure of livestock are major problems in Yemen, Egypt, Jordan, Syria, Iran, Iraq, Tunisia, Algeria, Sudan, and Morocco.

Agricultural practices are often water demanding. Cultivation of rangelands can also compromise rangeland quality through nutrient mining, increased soil compaction and disturbance of soil structure. In Sudan, agriculture-associated practices, such as over-cultivation of croplands, slash and-burn practices, shifting cultivation as well as misuse of irrigation water, leading to rangelands degradation (Abdi et al., 2013). Converting the high valuable rangeland areas to crop farming usually consume the most important ecosystem elements, which is water. It also uses the small patches of relatively more humid land, which are vital components of the rangeland system; hence, the remaining rangelands cannot be managed sustainably.

After the discovery of fossil fuel, the increase in its price during the second half of the past century and the accompanying economic development of Saudi Arabia, the agricultural sector has been heavily subsidized. Support has included the construction of dams, the allocation of arable land free of charge to investors for agricultural development, the setting of low prices for fodder to assist nomads to overcome drought effects, and the drilling of many deep boreholes. Approximately 6000 specialized agricultural projects have been launched for a total of approximately US$12 billion, and many shareholdings agricultural companies have been created. The peak of agricultural development was reached in 1995 with a growth rate of 8.6 percent and a cultivated area of 1.7 million ha. However, the absence of regulations on environmental protection and poor environmental awareness has resulted in the deterioration of renewable natural resources. The huge agricultural expansion has been achieved at the expense of rangelands, forests and marginal areas, the intensive use of groundwater resources and the excessive use of pesticides and fertilizer (FAO, Saudi Arabia country report, 2005).

In a 810000 ha coastal lowlands of Eastern Saudi Arabia study area which was located at a semi-arid region at Al Hassa Governorate with an average annual precipitation of 86 mm for the coastal areas and increasing to about 100 mm for the inlands with high evaporation rates. Change detection results indicated that agriculture land and dense vegetation areas have increased by approximately 65.11 % from 1985 to 2014 (ACSAD, 2017).

6.2.3 Urban development and encroachment in rangelands:

Urban development including housing, industrial, roads, and other type of urban development has been a pressure on rangelands in several Arab countries. Infrastructure development and urban settlement means that most rangelands are now grazed continuously and are not given frequent short periods of rest and recovery. It is a basic principle of rangeland ecology that, even if grazing pressure is light, continuous grazing will cause degradation. Khalifa (2015) reported that several changes have impacted the ecosystem at northwestern coast of Egypt include transformation from extensive to intensive agro-pastoral systems, increasing the rate of urbanization, and frequent drought periods. He conducted as study at the northwestern coast of Egypt to evaluate changes in vegetation composition and rangeland productivity at Wadi Umm Ashtan in 2004 and 2015 as influenced by changes in land use and variable precipitation. Results indicated that tremendous changes have been noticed from spring of 2004 to spring of 2015, average vegetation cover at the different parts of the Wadi declined from about 24 % in 2004 to 15 % in 2015. The Wadi has faced increasing in urban encroachment rate whereas several tourism development and land urbanization projects have been established.

At Al Hassa Governorate, Saudi Arabia study area, the second highest change was recoded to urban, roads, and built up areas with an increase by 40.76 % from April, 1985 to March, 2014. Important land cover types such sabkha and salt marshes areas from the standpoint of providing ecosystem services have faced downward trend from 1985 to 2014. Most of the expansion in urban, roads, and built up areas was at the expense of sabkha and salt marshes class particularly at the coastal zone (ACSAD, 2017).

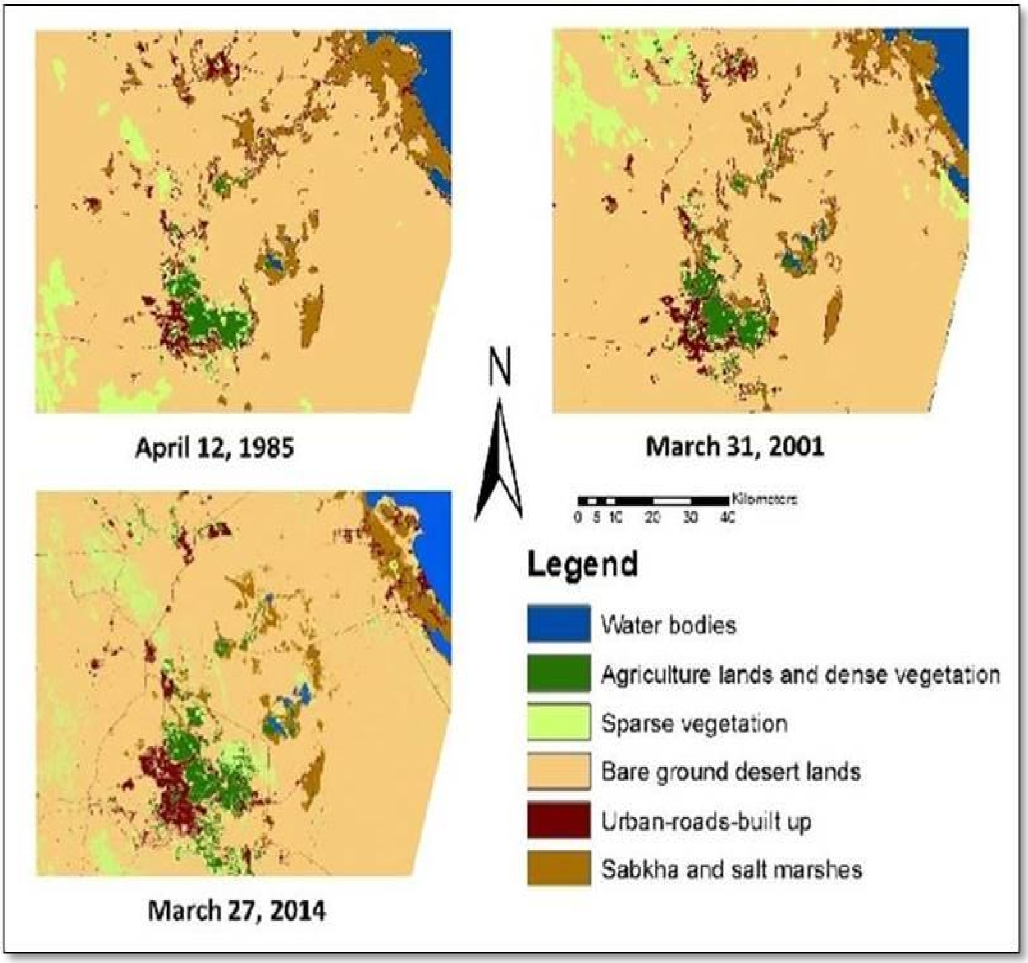

Figure (47) Land use/land cover map of the study area of part of Al Hassa Governorate at 1985, 2001, and 2014, produce from change detection of Landsat satellite imagery.

5.2.4 Shrub encroachments and invasive plant species:

Several studies again mention examples reported that shrub encroachment like mesquite (*Prosopis juliflora*) in some countries of LAS such Sudan, Egypt, Saudi Arabia, Somalia, Oman, and Yemen which resulted in negative impact on rangeland heath and productivity. Mohamed (2019) reported that mesquite encroachment had negativity impacted the rangelands condition in southeastern Egypt, whereas areas with high mesquite cover were associated with lower *Panicum turgidum* coverage (2.48). Given the danger of mesquite plants to rangelands and the environment in the Arab region, ACSAD issued an introductory bulletin on mesquite trees within the invasive plant database, which also made it clear that Sudan is one of the Arab countries most affected by the mesquite invasion as it impact both rangeland and cultivated lands.

For example, the area of lands that were invaded by Mesquite in Tokar Delta in eastern Sudan was estimated at 297 thousand acres out of the total area of Tokar Delta, which is estimated at 406 thousand acres. In a recent study (Nzumira, 2014) to assess the changes occurring in the vegetation cover of mesquite trees and the extent of their invasion of the Gash delta lands in eastern Sudan, it was found that the mesquite trees covered an area of 142 thousand hectares of the total area of the Gash Delta, which is estimated at about 372 thousand hectares in the period between year 1979 and 2013.

Mesquite encroachment at, southeastern Egypt, Source, Mohamed et al., 2015).

Mesquite encroachment at, southwestern KSA, photo by the Consultant

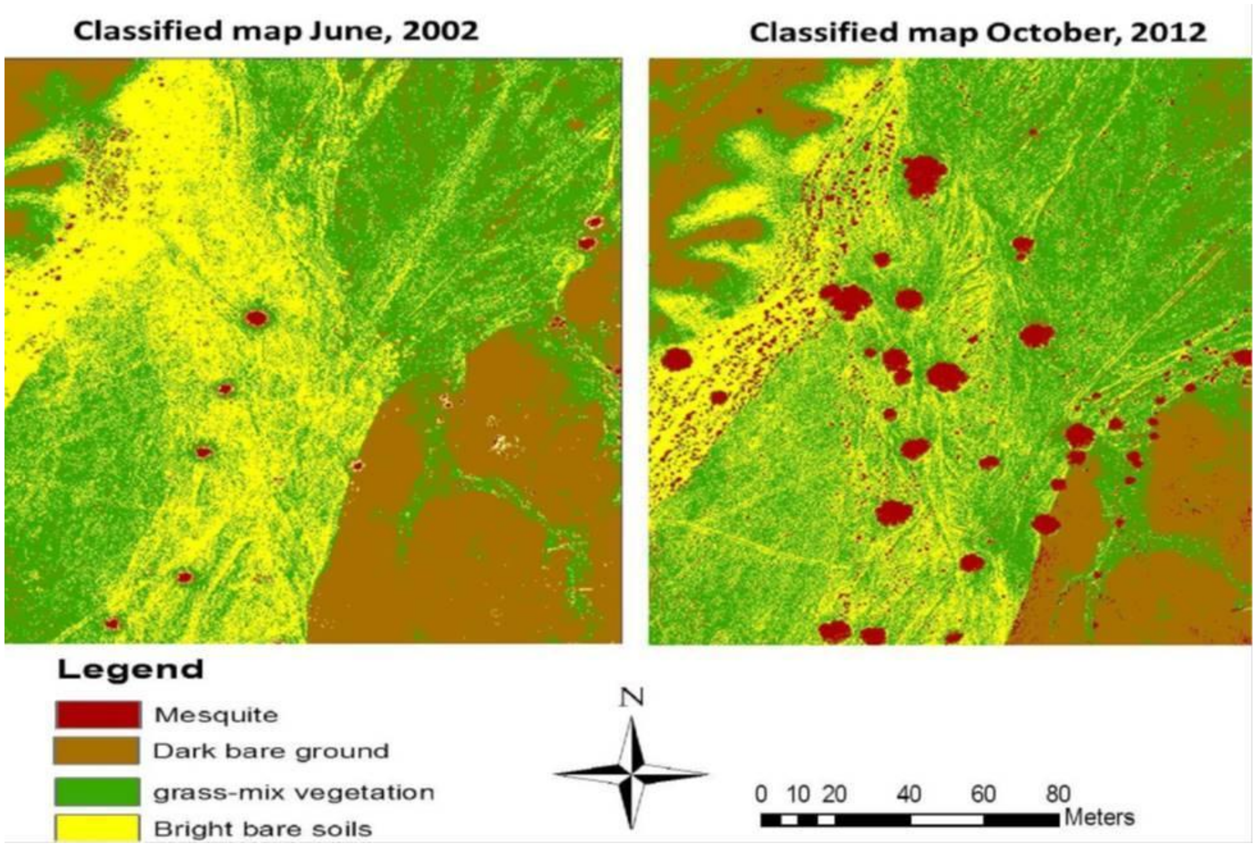

Figure (48) Changes in mesquite cover from June, 2002 classified QuickBird satellite image and October, 2012 classified World View-1 satellite image at Halaib, southeastern Egypt, (Source; Mohamed et al., 2015).

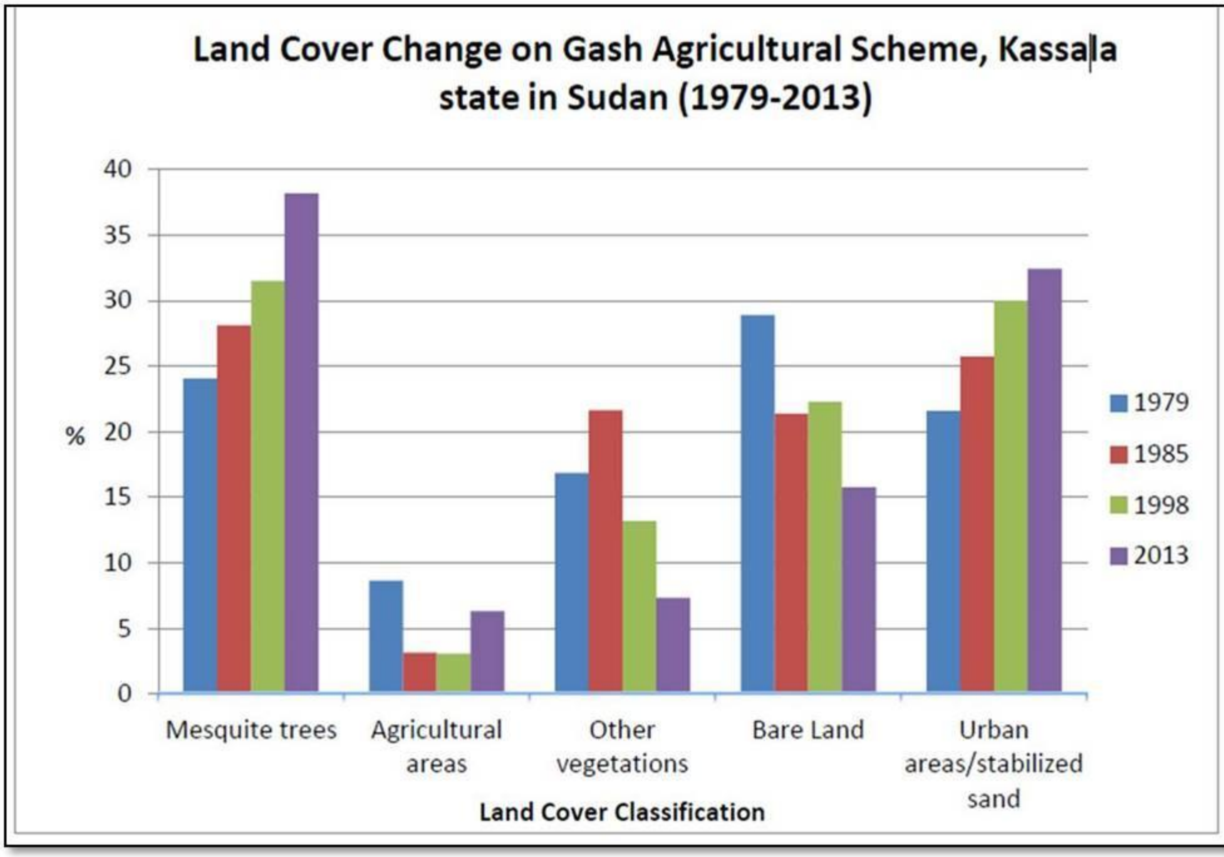

Figure (49) the graph shows the Mesquite trees changes against other classes in Kassala region, Sudan from 1979 to 2013, (Source, Nzumira (2014).

6.2.5 Fire wood harvesting:

This includes uprooting and cutting some shrubs species for getting fuel for heating or for cooking food. This is still very common across the LAS regardless of the economic condition of the country. In north eastern Aleppo, Syria, it was estimated that about 100 kg of dry fuel wood from *Noaea mucronata* and *Haloxylon scoparium* range every third day by women and children to provide each range dweller and nomadic family with woodfuel which sufficient for cooking for two to three days (Gintzburger et al., 2006).

Fire wood harvesting in Saudi Arabia, local rangelands shrubs and trees at under great danger of extensive fire wood harvesting as the local shrubs and trees woods are highly preferably by people for using in the Barbecue

The Ministry of Environment, Water and Agriculture in the Kingdom of Saudi Arabia is making great efforts to stop logging and cutting shrubs and trees to preserve the natural vegetation cover and rangelands.

6.3 State:

State of rangelands in the Arab region can be assessed and presented through the three criteria, 1) soil stability which can be evaluated by assessing some characteristics including bare ground, gullies, wind erosion, soil surface erosion, and land degradation, 2) hydrologic function (the capacity of an area to capture, store, and safely release water from rainfall), and 3) assessment of biotic factors such as annual plant production, invasive plants cover, reproductive capability of perennial plants, biodiversity loss, and rangeland plants cover.

Vegetation cover changes and estimation land degradation in the Arab region from 2000 to 2018 produced by remote sensing showed that 20.9 % of the region had experienced a degree of land and vegetation degradation from light to high degradation. It was estimated that about 73 % of Saudi Arabia rangelands (146 million ha) is degraded. Rangelands degraded area in the states of Khartoum, Nile River, and Northern of Sudan during the period from 2003 to 2016 was estimated by about 3 million ha. Rangelands vegetation in those states of Sudan during have been facing different negative impacts led to its deterioration, changes in its environment and declined its area, and disappearing of several important range plant species, moreover, some of these plant species had faced endangered and non-desirable unpalatable plants showed up. Rangeland degradation also includes overgrazing, changing rangeland plant composition, range shrubs degradation which represents important resource for camel grazing during dry periods, expanding in agriculture projects and rainfed cultivation in the rangelands. Widespread erosion due to droughts and scarcity of water resources leading to desertification is very common in LAS countries. Wood harvesting through uprooting and cutting some native trees and shrubs species for getting fuel for heating or for cooking food or drinks are still very common on most of the Arab rangelands even in highly oil producers countries.

Rangelands areas in the Arab countries that receive an annual amount of rainfall range between 120 to 400 mm are considered vulnerable areas to drought. About 37 % of the Arab region was subject to drought for 4 - 6 years or more out of 10 years. Blue Nile State, Sudan is mainly a savannah ecosystem with heavy rainfall that used to receive between 700 and 975 mm of rain annually. During the past decade the average precipitation has decreased to 450 - 500 mm per year. At the same time, the region experienced an increase in the cycle of flood and drought as well as an increase in temperature and wind speed. Drought precipitation fluctuations strongly affect the hydrologic function and led to negative impacts of rangeland ecosystem functions.

Rangelands productivity trend of in Al-Hamad ecosystem in four different Arab countries from 1980 to 2019 showed high downward and reduction in rangeland productivity particularly from perennial shrubs. The highest reduction in rangeland productivity was noticed in Jordan whereas rangeland plant production decreased from 590.5 kg/ha in spring season of 1982 to 95 kg/ha in the spring season of 2019. Plant cover, plant density, and rangeland condition in general also experienced high levels of deterioration. For example, 80 % of Al-Hamad ecosystem northern in Saudi Arabia was in deteriorated rangeland condition. Jordanian steppe and Badia experienced high reduction in biomass production which decline from 200 kg/ha and100 kg/ha in 1990 to 80kg/ha and 40kg/ha in 2013, respectively.

5. 4 Impacts:

5.4.1. Reduction in rangelands productivity (livestock, plants, water … ect.)

Rangelands productivity in the LAS has been depleted as a result of the negative impact of biotic and abiotic factors. Large areas of what classified as rangelands in the Arab region have a productivity of 5 kg/ha (ACSAD, 2015). Excellent and good rangelands areas decreased from 30 % to about 15 % from the year 1986 to 2001. Estimation of the rangeland productivity had declined to less than one third of the regular rangeland plant production, and the actual carrying capacity in Saudi Arabia showed that current grazing capacity is three times than the sustainable stocking rate (KSA National Strategy for Rangelands). Morocco’s 65 million hectares of rangelands are the primary source of animal food, providing 30 percent of the overall requirements. Livestock includes about 17 million sheep, 5.3 million goats, 2.7 million cattle, and about 200,000 camels. The estimated total loss of forage production ranged from 26 to 44 million units in steppe rangelands, and from 32 to 54 million units in forest rangelands. Degradation of cropland and rangeland in Morocco exacts an estimated annual cost of US$91 million to US$178 million, or an average of US$134 million about 0.4 percent of GDP in 2000 (Croitoru, and Sarraf , 2010).

Increasing human population in some parts of the Libyan rangelands has led to the exploitation of these lands with irrigated crops to meet the needs of the population that has in turn led to decreasing areas of rangeland. For example, in the western rangeland, a large part of the area receiving 200 mm rainfall has been converted to cultivation of field crops. In addition, there has been a transfer of animals to low rainfall areas with consequent overgrazing, resulting in the extinction of many plants and exposure of the area to erosion and the emergence of surface rocks, especially in the high elevations and on slopes (Al-bukhari et al., 2018).The productivity of rangelands was degraded on the eastern rangelands of Libya both due to overgrazing and the elimination of the sources of seeds from pastoral plants. This led to a deficit in fodder units in the western region of the eastern rangeland, estimated to be about 285 feeder units per hectare per year for feeding a total of 908,199 head of sheep, camels and goats

5.4.2. Land degradation, Loss of biodiversity, and desertification

Land degradation stretches to about 30 % of the total global land area and about three billion people reside in degraded lands. The annual global cost of land degradation due to land use/cover change (LUCC) and using land degrading management practices on static cropland and grazing land is about 300 billion USD (Nkonya et al., 2016). Sub-Saharan Africa (SSA) accounts for the largest share (22 %) of the total global cost of land degradation. Only about 46 % of the cost of land degradation due to LUCC—which accounts for 78 % of the US$300 billion loss is borne by land users and the remaining share (54 %) is borne by consumers of ecosystem services off the farm (Nkonya et al., 2016). It was estimated that the cost of overall environment degradation in Saudi Arabia is estimated at 3.1 percent of its GDP annually, with a mean estimate of USD 23 billion per year, while the cost of land degradation amounts to SAR 2.1 billion equivalents to 0.07 percent of GDP and comes predominantly from the loss of rangeland and forest degradation. The total crop loss due to land degradation was estimated by 790 million tons and 891 million USD (ACSAD, 2016).

5.4.3. Sand encroachments and sand and dust storms

Dust storms lift millions of tons of dust into the atmospheric boundary layer. Such large quantities of dust cause severe air pollution, reduced visibility; airport shut downs, and increased traffic and aircraft accidents. Other environmental impacts of dust include reduced soil fertility and crop damage, reduced solar radiation on the surface and as a consequence decreased efficiency of solar devices, damaged telecommunications and mechanical systems, increased occurrence of respiratory diseases, and other impacts on human health (Prakash, 2015). Located in the dust belt, the Arabian Peninsula is a major source of atmospheric dust. Frequent dust outbreaks and some 15 to 20 dust storms per year have profound effects on all aspects of human activity and natural processes in this region. It was estimated that the total amount of dust generated by the storm to have reached 94 Mt (Prakash, 2015).

Sand, and to lesser extent dust, are damaging and costly to the oil and gas infrastructure of Kuwait,, with an economic cost estimation of US$9.36 million, a total of 5159 nonproductive lost hours, and 347,310 m3 of annual sand removal. A risk assessment identified three sectors with the highest risk indices: drilling, project management, and maintenance. Sand encroachment also constituted a high risk. Mitigation of sand storms using a hybrid biological–mechanical system was shown to be cost-effective with an equivalent saving of 4.6 years of sand encroachment (Al-Hemoud, 2019). However, ecological restoration of rangelands and improving natural vegetation cover could highly reduce the negative impact of sand and dust storm on people heath and infrastructure.

5.4.4. Food security and countries stability:

This includes conflict over limited rangelands resources among livestock owners and herders, and conflict between famers and herders. Causes of conflicts in Darfur, Sudan can be summed up as follows: expansion of cultivation at the expense of rangelands due to increase in population and the prevailing climatic conditions, drought and desertification and its impact on rangelands and pastures all resulted in the decrease of the carrying capacity of the remaining rangelands, animal Routes are seriously affected by the dissolution of the native administration, scarce water resources and a lack of development and livelihood options (El Tohami, 2018). The same author also reported that competition for scarce resources has always been a catalyst for conflict between different rural groups, increased human and livestock population pressures, displacement by mechanized agricultural schemes, reduced and unreliable rainfall, desertification, soil depletion and soil erosion are ongoing and the general trend for displacement to the south and to the cities and increased frequency of local level clashes

5.4.6. Immigration and losing the rangelands endogens knowledge

The phenomenon of migration from rangelands areas to the cities considered one of the biggest challenges that facing the achievement of sustainable management and development of the rangelands. This is due to the poor productivity and deterioration of the pastures and consequently the low standard of living of pastoralists and livestock herd owners, which leads to the reluctance of young people to work in the field of pastures and to migrate to cities to search for better opportunities. As a result of the severe deterioration of the rangelands and their transformation into a fragile ecosystem, the failure to implement major development projects in the rangelands areas, increasing the poverty, and the restriction of big projects and economic development to major cities and urban areas in the Arab countries. This led to more migration from the countryside and rangeland areas to the cities and losing of the inherited local experiences in the management and development of rangelands in many Arab countries.

5.5 Responses:

The causes of rangeland degradation in the developing countries are complex in time and space and associated with interactions between pastoralists, governance and policy, and environmental factors. It is often difficult to separate the interaction between climate- humans induced rangeland degradation. However, there are several instants whereas responses have helped to improve rangelands in the LAS countries. Rangelands protection, rehabilitation, and restoration experiments and projects have been implemented in the several areas of rangelands in the Arab region leading to achieve successful responses in different aspects including, adopting traditional rangeland management systems i.e. Hima, using participatory approach and community rangeland management, controlling and restoring the damaged rangeland ecosystem, direct rangeland reseeding with native range plant species combined with water harvesting techniques, and introducing of financial incentives in the form of payments for agricultural-environmental services. Other successful responses in the policy level that have been developed in some of the Arab countries include adopting rangeland associations' policies in Morocco and preparing the Jordan Rangeland Strategy.

Saudi Arabia is taking forward steps to regulate and sustainably manage rangelands, preserve plant diversity and rehabilitate degraded rangelands. Some of the country successful responses including develop the Strategy and National Action Plan for Rangelands and Forests (2017-2037). The strategy was launched in 2017 with a vision and mission focusing on sustainable rangeland management to improve KSA's vegetative cover, conserve biodiversity, and control factors leading to degradation. Moreover, National strategy for environment and national strategy for rangelands in Saudi Arabia were developed and lunched recently.

7

Examples of successful responses to rangeland degradation through policy and investment

Examples of successful responses to rangeland degradation through policy and investment

Two kinds of costs are involved in assessments of the economic impact of rangeland degradation.

The first is the income foregone as the result of prior rangeland degradation.

The second is the cost of controlling and restoring rangeland damage. Establishment cost for 1 ha of improved rangeland by direct seeding of *Salsola vermiculata*, *Atriplex leucoclada, A. halimus, A. canescens*, and *Haloxylon persicum* in Syrian Badia was 19 USD as estimated by Louhaichi et al (2016) using figures and data from 2010. Investment cost for improved rangeland with shrub transplantation was US$300 - 313/ha, and it included protection cost for an area of 500 ha usually two guards are hired throughout a year, nursery cost for seedlings, cost of equipment for planting, and irrigation as estimated by Louhaichi et al (2016) using figures and data from 2010.

Louhaichi et al (2016) suggested that the introduction of financial incentives in the form of payments for agricultural-environmental services can increase the economic viability and enhance the adoption of sustainable rangeland management practices and is a better alternative to the unsustainable state subsidies for fodder purchases and barley cultivation on rangelands. The same authors stated that incentive payments in the form of payment for agri-environmental services of US$240/ha per year can increase the adoption rates of all the new management practices to 100%.

Rangeland vegetation rehabilitation and development project was applied in 1000 ha of desert rangeland at the northern Badia of the Governorate of Al-Mafraq, Jordan in 2005. The project was implemented by the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) in collaboration with the Jordanian Ministry of Agriculture and local community. The primary outcome of implementing ACSAD approach in rangeland development of the project area was increasing rangeland productivity from less than 100 kg/ha to 1500 kg/ha after three years of adopting the rangeland rehabilitation and management scheme. Plant cover and plant density were highly improved and measured 43 % and 79 plant/m^2, respectively. Direct rangeland reseeding with native range plant species combined with water harvesting techniques achieved the highest net return of 30.7 Jordanian Dinar per hectare (ACSAD, 2015).

Hima: The Arabic word 'Hima' means protected place. In Islamic law, it signifies a natural area that is set aside permanently or seasonally for the public good and cannot be privately owned. For more than fourteen hundred years, Hima areas have been used to help conserve natural resources and biodiversity in the Arabian Peninsula and adjacent areas (IUCN, 2007). An ex-ante cost-benefit analysis of large-scale rangeland restoration through the Hima system within the Zarqa River Basin, Jordan was presented in a paper by Myint & Westerberg (2014), drawing on experience from a pilot initiative by IUCN and the Jordanian Ministry of Agriculture (MoA) since 2010. The study showed that to net present value (NPV) benefit to pastoral communities is 12 million JOD (17 million USD) at a benchmark discount rate of 5 per cent. The benefit cost ratio is 2:1, indicating that pastoral communities will enjoy 2 JOD of benefit for every JOD they invest in implementing the Hima system. Because of the significant societal benefit associated with enhanced groundwater infiltration, net-benefits to the community are estimated to be in the order of 144 to 190 million JOD (165 – 200 million USD). The study also has shown that large-scale adoption of the Hima approach piloted by IUCN, based on improved local level governance to enable pastures to be grazed and rested systematically within the Zarqa River Basin, may deliver between 144 and 290 million JOD worth of net-benefits to Jordanian society, using discount rates between 2.5 and 8 per cent.

The costs and benefits of restoration and protection in the LAS region:

An ex-ante cost-benefit analysis of large-scale rangeland restoration through the Hima system within the Zarqa River Basin, drawing on experience from a pilot initiative by IUCN and the Jordanian Ministry of Agriculture (MoA) since 2010 was presented in IUCN, Sustainable Drylands Landscapes Management: Mapping Rangeland in Jordan (2015). The ecosystem services that arise from rangeland restoration are valued using a combination of stated preference, avoided costs, replacement cost and market prices approaches. The economic analysis has built on high-resolution remote sensing, GIS, and biophysical soil and water assessment tools, and was elaborated to rigorously calibrate the impact of land use changes on forage availability, ground water infiltration, carbon sequestration, and sediment stabilization.

The valuation study built on the experience of existing initiatives in the Bani Hashem area, which was chosen as a pilot study site by IUCN and the Jordan MoA to illustrate the benefits of Hima site restoration. The MoA has ownership over the site, located in the Zarqa Governorate approximately 12 km northwest of Zarqa City. To identify the total area suitable for Hima restoration in the Zarqa River Basin, areas which had existing rangelands belonging to the state and areas with rainfall levels between 100 and 200 mm were selected. Approximately 109,093 ha were estimated to be suitable for potential Hima restoration, of which areas with the greatest potential in terms of the rainfall gradient.

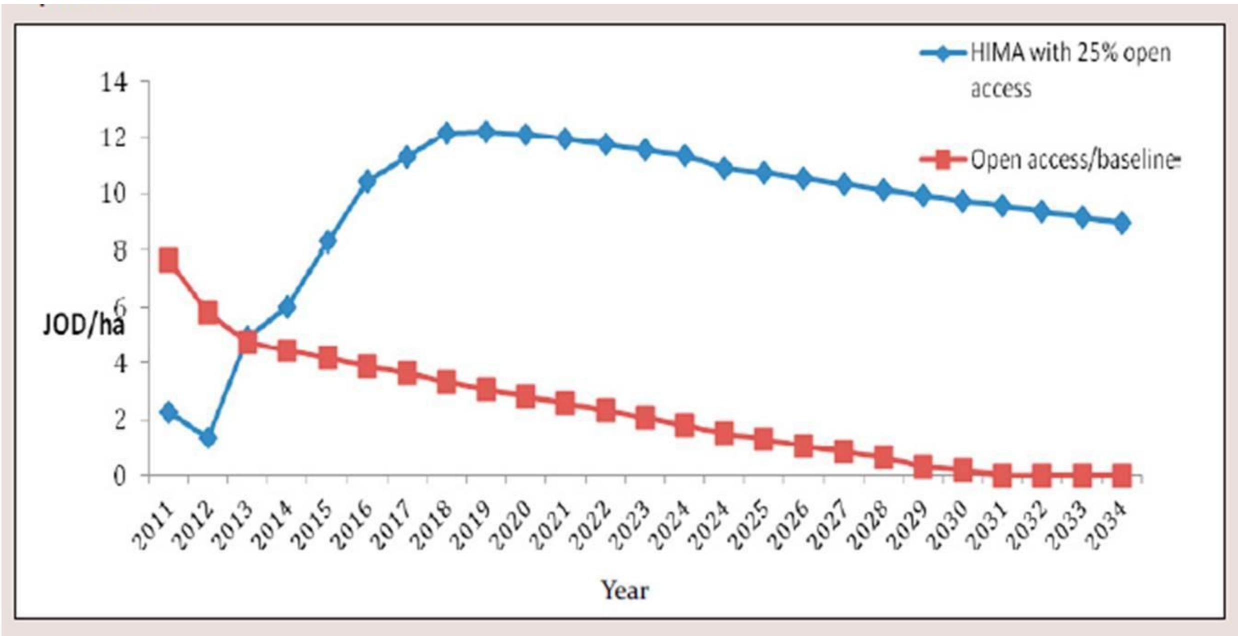

Figure (50) Present value returns to the baseline scenario versus restoration through the Hima system with 25 % open access, from, IUCN (2015).

It could be projected that about 25 % of the LAS rangeland areas could have fit for application of the Hima restoration approach suggested by IUCN (2015). Total rangelands area in the Arab countries estimated by 375 million ha in 2017; 25 % of these area could have the potential to be managed under the Hima with 25 % open access approach IUCN (2015).We used the Jordan case study results to estimate the costs and benefits of restoration and protection at the regional scale of LAS region and we roughly estimated the value at the LAS countries.

Data presented in Table (11) and figure (51) show the projected present value benefits and costs associated with large-scale Hima restoration over a 25 year time horizon in million USD at 5 % discount rates in 25 % of LAS countries rangeland area.

Table 10. Present value benefits and costs associated with large-scale Hima restoration in JOD over a 25 year time horizon at 5 % discount rates. Adopted from IUCN (2015).

Area	Welfare economic value of natural forage	Present value of additional groundwater infiltration	Present value benefit of avoided reservoir sedimentation	Present value benefit of enhanced carbon sequestration	Total Present value benefits	Present value implementation costs	Present value management costs	Total present value costs	Net present value
109093 ha	21100000	188500000	7600000	6900000	224100000	800000	9300000	10100000	214000000
1 ha	193.4	1727.9	69.7	63.2	2054.2	7.3	85.2	92.6	1961.6

JOD = Jordanian Dinar

Table 11. Present value benefits and costs associated with large-scale Hima restoration over a 25 year time horizon in million USD at 5 % discount rates in 25 % of LAS countries rangeland area.

Country	Rangeland area (1000 ha)	Projected restoration of 25 % of the area (1000 ha)	Welfare economic value of natural forage	Present value of additional groundwater infiltration	Present value benefit of avoided reservoir sedimentation	Present value benefit of enhanced carbon sequestration	Total Present value benefits	Present value implementation costs	Present value management costs	Total present value costs	Net present value
Algeria	32500	8125	2200	19655	793	719	23367	83	969	1053	22313
Bahrain	0	0	0	0	0	0	0	0	0	0	0
Comoros	10	3	1	6	0	0	7	0	0	0	7
Djibouti	200	50	14	121	5	4	144	1	6	6	137
Egypt	4000	1000	271	2419	98	88	2876	10	119	130	2746
Iraq	3385	846	229	2047	83	75	2433	9	101	110	2324
Jordan	800	200	54	484	20	18	575	2	24	26	549
Kuwait	136	34	9	82	3	3	98	0	4	4	94

Country	Rangeland area (1000 ha)	Projected restoration of 25 % of the area (1000 ha)	Welfare economic value of natural forage	Present value of additional groundwater infiltration	Present value benefit of avoided reservoir sedimentation	Present value benefit of enhanced carbon sequestration	Total Present value benefits	Present value implementation costs	Present value management costs	Total present value costs	Net present value
Lebanon	16	4	1	10	0	0	12	0	0	1	11
Libya	13300	3325	900	8043	324	294	9562	34	397	431	9131
Morocco	24850	6213	1682	15028	606	550	17866	63	741	805	17061
Mauritania	13800	3450	934	8346	337	305	9922	35	412	447	9475
Oman	1350	338	91	816	33	30	971	3	40	44	927
Palestine	161	40	11	97	4	4	116	0	5	5	111
Qatar	50	13	3	30	1	1	36	0	1	2	34
Saudi Arabia	170000	42500	11507	102810	4147	3760	122225	434	5069	5510	116715
Somalia	42000	10500	2843	25400	1025	929	30197	107	1252	1361	28836
Sudan	48195	12049	3262	29147	1176	1066	34651	123	1437	1562	33089
Syria	8185	2046	554	4950	200	181	5885	21	244	265	5620
Tunisia	4715	1179	319	2852	115	104	3390	12	141	153	3237
UAE	305	76	21	184	7	7	219	1	9	10	209
Yemen	7000	1750	474	4233	171	155	5033	18	209	227	4806
Total	374958	93740	25381	226761	9147	8294	269584	958	11181	12152	257431

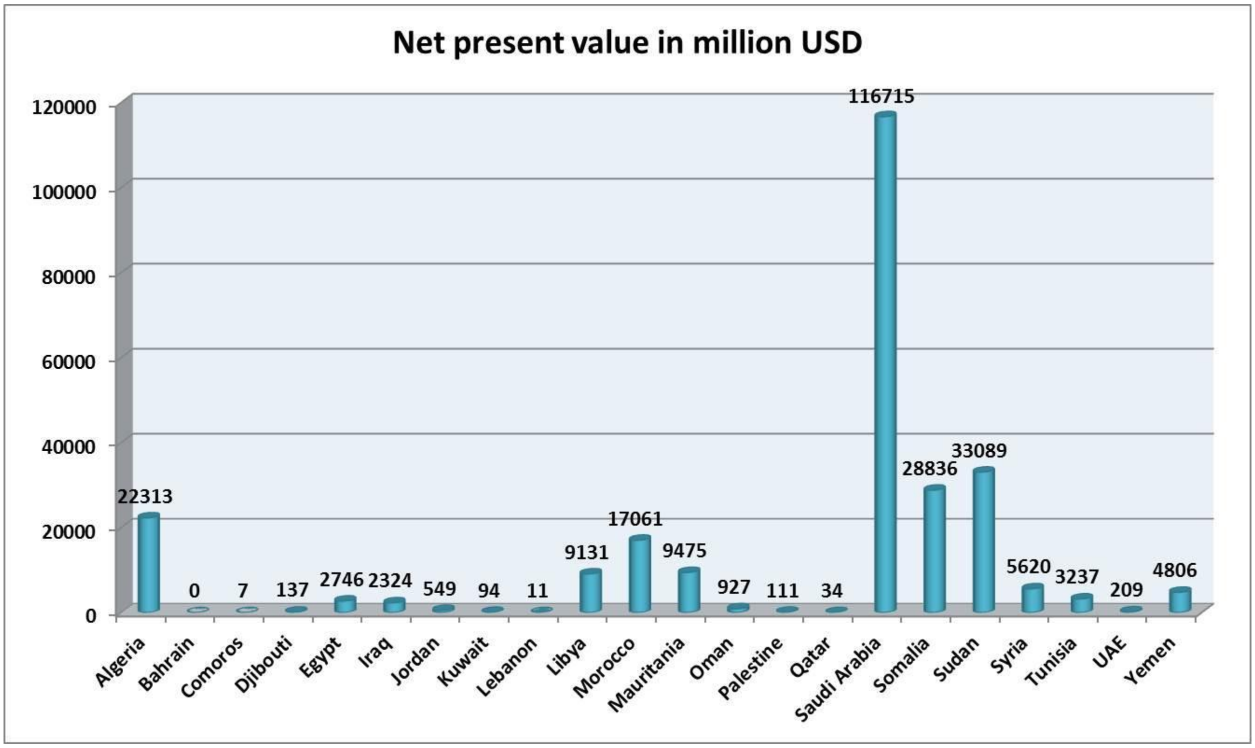

Figure (51) Present value benefits and costs associated with large-scale Hima restoration over a 25 year time horizon in USD at 5 % discount rates in 25 % of LAS countries rangeland area.

Watersheds ecosystems (Wades) at the Arab region are very important and they have high potential for rangeland restoration. In the northwestern coast of Egypt at 1.3 million ha rangeland area, the number of Wades was estimated by 218 Wades that represent important component of the development of the area as water harvesting using cement dykes applied at the water and create suitable environment for growing fruit trees such olive and figs, and the upper streams parts of the Wadi are used for grazing.

Figure (52) Watersheds (Wades) in Northern Tohama at southwestern Saudi Arabia.

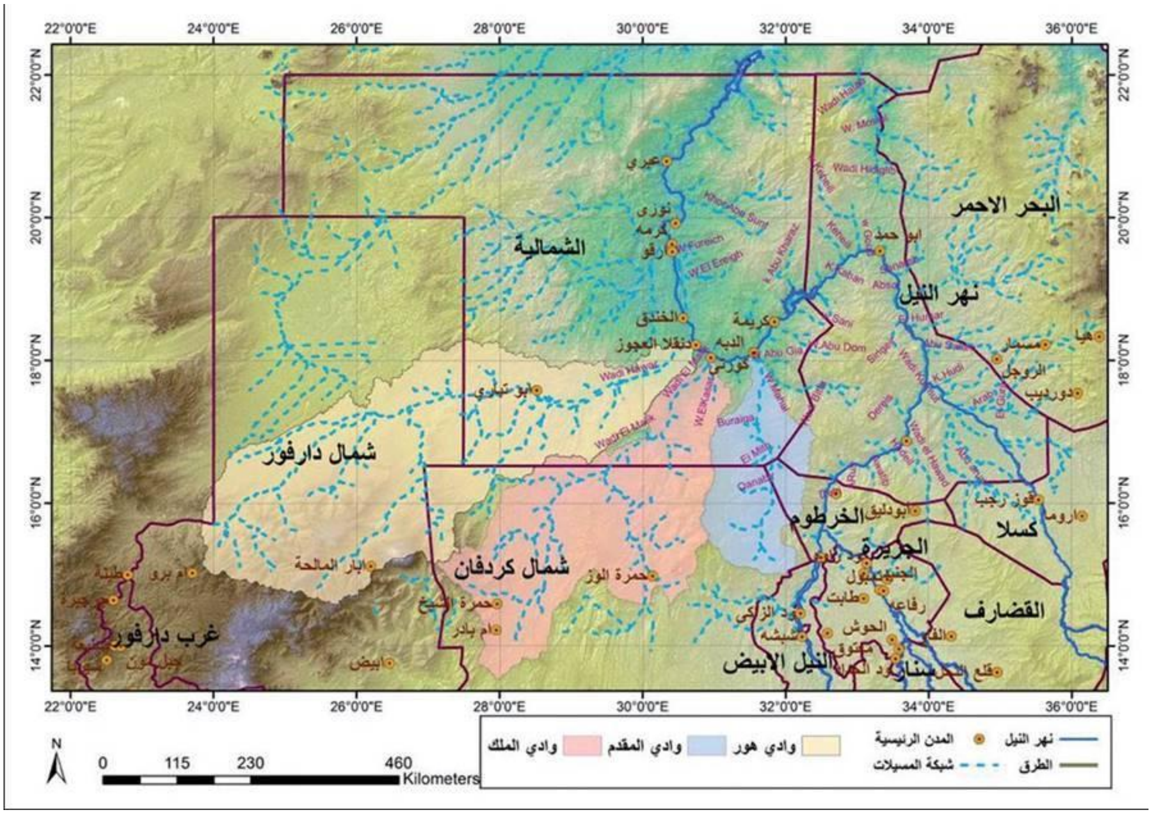

Figure (53) Watersheds (Wades) in Northern Sudan

Water harvesting using cements dykes in Wadi ecosystem at northwestern coast of Egypt, photo by the Consultant

Wades in Riyadh, Saudi Arabia, it is very important ecosystem with high socioeconomic value however, it is still under developed, photo by the Consultant

Native trees and shrubs are facing water erosion and wood cutting, poor rangeland management, southwestern, Saudi Arabia, photo by the Consultant

8

Recommendations for prioritising rangeland restoration

Recommendations for prioritising rangeland restoration

The most prominent plans to be included in rangeland development plans to achieve sustainable rangeland management:

- ✔ Spatial determination of rangeland areas, development of rangeland maps and vegetation cover and identification of appropriate grazing capacity for each rangeland site.
- ✔ A national plan to rehabilitate and restore rangelands.
- ✔ A national plan to expand rainwater harvesting and make optimal use of it for the developing of rangeland and livestock production.

- ✔ Adopting a plan to prevent logging and uprooting of range shrubs and to use alternatives to firewood such as gas stoves and kerosene.
- ✔ A national plan for the genetic improvement of sheep and goats, numbering of grazing animals and the provision of veterinary services and linking those serveies to the response of herders to the management and improvement of rangealnd plans.
- ✔ A plan to protect and moniroing vegetation and regulate grazing**.**

Support needed to develop national policies to achieve sustainable development of rangelands and achieve land degradation neutralization goals:

1.11. The need for support in developing a national strategy and law to develop and manage rangelands.

1.12. Support in establishing a national institution for rangeland management and development and setting up an organizational structure, tasks and action plan.

1.13. Training on remote sensing technologies and modern methods in assessing rangeland health and developing sustainable management plans for rangelands.

1.14. Capacity buidling and training of national cadres in the field of developing, rehabilitating and restoring rangeland in desert and arid regions.

1.15. Developing the National Plan for Neutralizing Land Degradation in rangeland areas and adopting and implementing means of Neutralizing Land Degradation.

1.16. Support the efforts of NGOs, associations, and cooperatives and increase the role of these organizations in working towards achieving sustainable development of rangelands**.**

Some regional recommendation at LAS level:

1. LAS member states to agree on a regional framework policy for rangeland restoration, as a mechanism to promote green investment in the region (e.g. at the intersection of climate change, biodiversity loss and desertification).
2. LAS to work with private businesses and financial institutions to promote public-private partnerships for large scale rangeland rehabilitation.
3. LAS to establish a regional rangeland observatory, which will track selected metrics of rangeland health and sustainable rangeland development.

4. LAS to provide knowledge and practice leadership for innovative approaches to rangeland restoration, including community based approaches and securing communal resource rights.
5. LAS to reach agreement on a common definition of rangelands in the Arab region and to adopt a regional rangelands monitoring and inventory program.

References

Abdi OA; Glover EK; Luukkanen O. 2013. Causes and impacts of land degradation and desertification: case study of the Sudan. International Journal of Agriculture and Forestry, 3(2):40-51.

Abo-Hassan, A. A. 1981. Rangeland management in Saudi Arabia. Rangelands 3 (2): 51-53.

ACSAD (2008). “Potential Land use Map of Sudan – Phase 1: Eastern part”. Published in the Arab Center for the Studies of Arid Zones and Dry Lands, Final Report (in Arabic).

ACSAD (2011). Drought Vulnerability in the Arab Region: Case Study- Drought in Syria.

ACSAD (2015). The study of current rangelands condition and their development methods in the Arab countries (in *Arabic*).

ACSAD (2016). “Desertification Bulletin” Published in the Arab Center for the Studies of Arid Zones and Dry Lands.

ACSAD (2016). Monitoring and evaluation of changes in plant cover and land degradation in the Arab Countries using remote sensing technology.

ACSAD (2019a) Monitoring and evaluation of changes in land degradation in the Arab Countries using remote sensing technology. Techincal Report.

ACSAD (2019b) Evaluation of Rangeland Condition in the Arab Countries using remote sensing and mathematical models. Techincal Report.

ACSAD (2019c) Potential GIS maps of land cover/ land use in the state of Sudan. Techincal Report.

Al-Bakri J. 2015. Mapping Rangeland in Jordan for selecting high potential rangeland sites for investment. Study in the framework of the “Sustainable Dryland Landscapes: Closing the Knowledge-Policy Implementation Gap” Project.

Al-bukhari, A.; Hallett, S.; Brewer, T. A Review of Potential Methods for Monitoring Rangeland Degradation in Libya. Pastoralism 2018, 8, 1–14.

Al-Hemoud, A.; Al-Dousari, A.; Misak, R.; Al-Sudairawi, M.; Naseeb, A.; Al-Dashti, H.; Al-Dousari, N. 2019. Economic Impact and Risk Assessment of Sand and Dust Storms (SDS) on the Oil and Gas Industry in Kuwait. Sustainability, 11, 200.

Allen, V.G., Batello, C., Beretta, E.J., Hodgson, J., Kothmann, M., Li, X., McIvor, J., Milne, J., Morris, C., Peeters, A. and Sanderson, M., 2011. An international terminology for grazing lands and grazing animals (The Forage and Grazing Terminology Committee). Grass and Forage Science. 66: 2-28.

Al-Rowaily S.L., (1999). Rangeland of Saudi Arabia and the “tragedy of commons”. Rangelands 21. pp.27-29.

Al-Rowaily S.R., A.M. Assaeed, S.A. Al-Khateeb, A.A. Al-Qarawi, and F.S. Al Arifi (2018). Vegetation and condition of arid rangeland ecosystem in Central Saudi Arabia. Saudi J Biol Sci., 25(6): 1022–1026.

Al-Saud, T. bin Saud, S.L. Al-Rowaily, F.S.N. Al Arifi, A.M. Assaeed, S.A. Al-Khateeb, A. Al-Mahari, and A.A. Al-Qarawi. (2005). Rangeland survey in Saudi Arabia. Remote Sensing. International Conference on Advanced Remote Sensing for Earth Observation Systems. International Society for Photogrammetry and Remote Sensing (ISPRS), May 7-11, 2005, Riyadh, Saudi Arabia.

Al-Saud, Turki bin Saud, S.A. Al-Khateeb, S.L. Al-Rowaily, F. S.N. Al Arifi, A.M. Assaeed, A.A. Al-Qarawi. (2007). Rangeland of Eastern Region. The International Conference on the Arabian Oryx in the Arabian Peninsula, The 23rd meeting of the Saudi Biological Society, Riyadh, 21-23 April, 2007. pp. 51.

AOAD (2017). Arab Agricultural Statistics Yearbook -Vol 37.

AOAD (2018). Arab Agricultural Statistics Yearbook.

Barth, H.J., (1999). Desertification in the Eastern Province of Saudi Arabia. J. Arid Environments. 43:399-410.

Croitoru, L. and M. Sarraf .2010. The Cost of Environmental Degradation Case Studies from the Middle East and North Africa.

Davies J., Ogali C., Laban P. and Metternicht G., 2015. HOMING IN ON THE RANGE: Enabling Investments for Sustainable Land Management. Technical Brief 29/01/2015. Nairobi: IUCN and CEM. vi+23p.

DRC (2015) Egyptian National Action Program to Combat Desertification. Desert Research Center, Cairo, Egypt.

DRC (2020) Rangeland development committee, technical report, Desert Research Center, Cairo, Egypt

El Tohami AEA . 2018. Conflicts and Natural Environment of the Sudan with some Emphasis on Darfur Region. Virol Immunol J (2): 000146.

Erian, W.F., F.S. Fares, T. Udelhoven and B. Katlan, (2006). "Coupling Long-term NDVI for Monitoring Drought in Syrian Rangelands", The Arab Journal for Arid Environments, (1),: 77-87.

Gintzburger, G., Le Houérou and Saïdi, S. (2006). Near East-West Asia arid and semiarid rangelands. Sécheresse 17 (1-2):152-68.

Holechek, J. L., R. D. Pieper, and C. H. Herbel. (2011). Range management: principle and practices. 6th ed. Prentice-Hall Book Co., Upper Saddle River, NJ.

ILRI, IUCN, FAO, WWF, UNEP and ILC. (2021). Rangelands Atlas. Nairobi Kenya: ILRI

IUCN (2015). Sustainable Dryland Landscapes Management: Mapping Rangeland in Jordan. 2015.

IUCN. (2007). Al-Hima, A way of life. Amman, Jordan: IUCN.

Louhaichi, M., Yigezu, A.Y.,Werner, J., Dashtseren, L., El-Shater, T. and Ahmed, M. (2016). Financial incentives: possible options for sustainable rangeland management?. Journal of Environmental Management, Vol. 180, pp. 493-503.

Lund, G. H. (2007). Accounting for the world's rangelands. Rangelands 29, 3–10.

Mohamed A. H. 2018. Using high spatial resolution satellite imagery to evaluate the impact of mesquite invasion on desert rangeland at southeastern Egypt. J. Bio. Env. Sci. 13(3), 167-176.

Mohamed AH, El Shesheny MA, Hendawy SH, Mahmoud HS. (2015). Assessing Mesquite Cover Change in Southeastern Egypt using High Resolution Satellite Images. Current Science International 4(3), 351-357.

Mohamed, A. H., A. S. El Hawy, M. N. Sawalhah, and V. R. Squires. (2019). Middle East and North Africa Livestock Systems. In Livestock management strategies and challenges' Livestock production, eds by Squires and Bryden. Nova Science Publishers, New York.

Mohamed, A. H., M. A. El Shesheny, S. H. Hendawy, and H. S. Mahmoud. (2015). Assessing Mesquite Cover Change in Southeastern Egypt using High Resolution Satellite Images. Current Science International, 4 (3): 351 – 357.

Myint, M.M., & Westerberg, V. (2014). An economic valuation of a large-scale rangeland restoration project through in Jordan. Report for the ELD Initiative by International Union for Conservation of Nature, Nairobi, Kenya. Available from: www.eld-initiative.org.

Nkonya E., Mirzabaev A., von Braun J. (2016). Economics of land degradation and improvement: an introduction and overview. In: Nkonya E., Mirzabaev A., von Braun J. (eds.). Economics of land degradation and improvement – a global assessment for sustainable development. p.1–14.

Prakash, P.J., Stenchikov, G., Kalenderski, S., Osipov, S., Bangalath, H., 2015. The impact of dust storms on the Arabian Peninsula and the Red Sea. Atmos. Chem. Phys. Discuss. 15, 199–222.

Reeves, M.C.,Washington-Allen, R.A., Angerer, J., Hunt, R., Kulawardhana, R.W., Kumar, L., Loboda, T., Loveland, T., Metternicht, G., Ramsey, D.R., (2015). Global view of remote sensing of rangelands: evolution, applications, future pathways. Land Resources Monitoring, Modeling, and Mapping with Remote Sensing, Remote Sensing Handbook. CRC Press.

UNDP (2014). Final report of Updating Yemen's National Biodiversity Action Plan through Biodiversity Valuation and Integration of Climate Change Project.

United Nations Economic and Social Commission for Western Asia (ESCWA) et al. 2017. Arab Climate Change Assessment Report – Main Report. Beirut, E/ESCWA/SDPD/2017/RICCAR/Report.

World Bank. 2019. Sand and Dust Storms in the Middle East and North Africa Region - Sources, Costs, and Solutions. Washington, DC.

Zohary , M. (1973). Geobotanical Foundations of the Middle East . 2 vols. Gustav Fischer Verlag.