INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 14, No. 6, p. 310-320, 2019
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Using satellite imagery and field analyses for mapping plant communities in a desert rangeland, Egypt

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Article published on June 30, 2019

Key words: Arid land vegetation, Plant cover, Landsat 8, NDVI, Altitude level, Matrouh.

Abstract

Desert rangelands in Egypt like in many countries are being stressed as results of overgrazing due to animal numbers expand to meet the growing human population on a shrinking resource base. The primary objectives of this study were to use vegetation field survey and satellite imagery to identify and map plant communities in the studies areas at the North Western Coast of Egypt, and to study the effect of the different altitude levels on rangeland vegetation composition and attributes. Details botanical survey was conducted at two study areas at the North Western Coast in spring of 2014. Information from these survey included identifying the dominant plant community, the primary native plant species, plant composition, plant cover, and other vegetation measurements. Landsat 8 satellite image was analyzed and NDVI was calculated for the study areas and used as a base map in combination with the field data for the classification vegetation maps in the area. Results indicated that In West Matrouh study area, NDVI values ranged from -0.73 to 0.417 and in East Sidi Barani study area, NDVI values ranged from 0.075 to 0.382. Six plant community were identified in the study areas i.e. one plant community was dominant in each altitude level. In general, average plant density was significantly higher in East Sidi Barani study area compared with West Matrouh study area. There were also significant differences in the average plant cover percentage among the first and the third altitude level at both of the study areas.

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Introduction

Egypt lies on the northeastern side of Africa, bordered on its northern coast by the Mediterranean Sea and on its eastern coast by the Red Sea. It comprises an area of about 1 millionkm2, made up as follows: Nile valley and delta about 4% of the total; Eastern desert area about 22%; Western desert area about 68%; and the Sinai Peninsula area about 6% (NAP, 2015). Egyptian Desert Rangelands are located in three main parts of the country i.e. the Northwestern coast, Sinai Peninsula, and Southeastern region. Overall, natural vegetation in those areas are being stressed as animal numbers expand to meet a growing human population on a shrinking resource base The North Western Coast is characterized by dry Mediterranean climate and extends from Alexandria in east to El Sallum at the west for about 500km, and from the seashore inland for about 70km. This coastal belt is the richest part of Egypt in flowering plants, 50% of the total number of species of the Egyptian flora Tackholm (1974). Most of these species are annuals, however, perennial grasses, forbs, and shrubs are the primary forage for rangeland livestock grazing (El-Shesheny, 2007). Bidak *et al.* (2015) indicated that the direct goods and services provided by these native plants included sources of food, medicine, and energy; indirect vegetation services included promotion of biodiversity, water storage, and soil fertility. The plant diversity in this ecosystem provided economic service benefits, such as sources of fodder, fuel-wood, and traditional medicinal plants. The natural range vegetation depends mainly on rainfall, which varies greatly from year to year and in its distribution during the rainy season. The various rangelands types and their productivities on the region are closely associated with edaphic and climatic characteristics Migahid & Ayyad (1959); Zahran & Girgis (1971); El- Monayeri *et al.* (1979); Reiad *et al.* (1996), and El-Toukhy *et al.* (2002). The common livestock types in the area including goats, camels and sheep. Livestock in the study area depend mainly on the natural vegetation to provide their nutrient requirements. Rangeland productivity depends on various factors including climate, soil, botanical composition and rangeland management practices such as grazing patterns, stocking rates and livestock grazing distribution.

The number of plant species in this belt and the different Wadis forms about 55% of the total number of species that constitutes the Egyptian flora, which is estimated to be 2121 species (Boulos, 1995) out of which 154 species are confined in their distribution in Egypt to it. Most of these species are annual weeds that flourish during the rainy season, giving the area a temporary annual grassland aspect. During the longer dry period, there are only the characteristic woody shrubs and perennial herbs, that constitute the scrub vegetation of the area, scattered sparsely in parts and grouped in denser more distinct patches in specially favored habitats. Deterioration in plant diversity in the North Western coastal zone is primarily observed in the cushion growth form acquired by under-shrubs and shrubs which are the main perennial elements of the natural plant cover (Khalifa, 2015).

Degradation of the rangeland is evident in many parts of Egypt as a result of a long history of overgrazing, low erratic rainfall and long drought periods, expansion of rainfed cultivation particularly barley, wheat and horticultural crops in the favorable rangeland areas, in addition to increasing uprooting of trees and woody shrubs for fuel. It is common to see overgrazed areas in the coastal region. Such overgrazing will lead to the deterioration of vegetation, specially the palatable species (Batanouny & Zaki, 1973). Desert rangeland fragmentation is increasing throughout the world (Schlesinger *et al.*, 1990). Changes in redistribution of nutrients, biomass, water, and species composition are usually the consequences of this fragmentation. Because such changes impact most of arid and semi-arid lands around the globe, it's important to rapidly and effectively assess those changes (DeMers *et al.*, 2010). The first step in an inventory and monitoring rangeland program is to develop a vegetation map (Holechek *et al.,* 2011).

Remote sensing and GIS technologies have been wildly used for mapping and monitoring land and natural resources. Remote sensing data has been used

for monitoring vegetation cover (Ramsey *et al*. 2004), establishing stocking rate (Hunt and Miyake 2006), characterizing grassland productivity (Reeves *et al*. 2006), determining rangeland trend in terms of soil loss, decreased cover, and change vegetation composition (McGlynn and Okin 2006; Washington-Allen *et al*. 2006). Land cover/land use changes were effectively mapped and evaluated in several parts of the globe using geospatial technologies. The advantages of using remote sensing for mapping and inventory of earth resources may include the large ground coverage of satellite images, the multiple spectral information the satellite images can afford, the temporal resolution of satellite data, the digital format of the images and the long time extent of the satellite data archives. Depending on the required scale and type of information, land use and land cover data can be produced using various remote sensing data including, AVHRR, Moderate Resolution Imaging Spectroradiometer (MODIS), Landsat satellite images, and high and very high resolution satellite imagery.

Although there are several studies of remote sensing application in arid and semi-arid regions, particularly for monitoring rangelands vegetation conditions, assessing soil degradation, and classifying and assessing land cover/land use changes, few studies have been conducted to use remote sensing data for land cover and land use changes in the North West Coast of Egypt. Therefore, the main objectives of this study are to use vegetation field survey and satellite imagery to identify and map plant communities in the studies areas at the North Western Coast of Egypt, to study the effect of the different altitude levels on rangeland vegetation composition and attributes, and to participate on the establishment of GIS data base and producing vegetation maps of the North Western Coast of Egypt.

Materials and methods

Study area description

The North Western Coastal Zone (NWCZ) of Egypt which extends from Alexandria westward to El Sallum is considered the richest part of the country in flowering plants species, owing to its relatively high rainfall. The area has about 254 Wadis running from south to north and represent suitable environment for cultivation fruit, vegetables, barley, and growing native rangeland plants. Two study areas from the NWCZ were selected to conduct this research (Fig. 1). The first study area located to the west of Marsa Matrouh city and the second study area was located to the east of Sidi Barani city. The climate in the study area is classified as arid with mild winter and warm summer, which belongs to the Mediterranean coastal region of Egypt that is warm coastal desert climate. The occasional short rainstorms occur in winter and most of the days are sunny with mild temperature. The distribution of average annual rainfall in the study area shows a maximum rate over the Mediterranean coast with a rapid decrease toward the south. The rainfall along the NWCZ is not even, and the average annual precipitation ranges between 102mm at El-Sallum in the west to180mm at Alexandria in East. The amount of rainfall shows steady decrease in the inland direction where it reaches about 50mm or less within the southern limit of the defined study area.

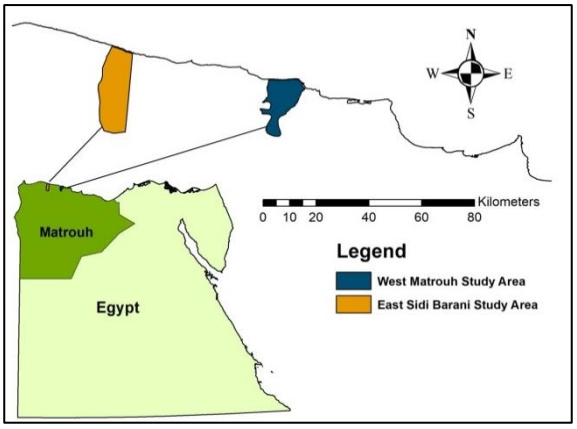

Fig. 1. Location of study areas used for vegetation survey, mapping, and characterization plant communities in North Western Coast Zone of Egypt.

Rangeland vegetation measurements

The plant life in the West Matrouh and East Sidi Barani study areas were surveyed in the spring of 2014. Ten list and counting quadrates at each altitude level (60 quadrates in total) were used to study the natural vegetation composition and attributes. The size of the quadrates was 20m² as described by

Ibrahim (1995) and commonly used in the region. The placentation of the quadrates was randomly selected vertically on the vegetation degrading in nature. The following measurements were determined in order to evaluate the vegetation characteristics.

Plant composition

Plant species and families were fully identified to the families level and named according to Tackholm (1974) updated by Boulos (1995). Plant density (plant/ m^2), plant coverage (%) and plant frequency (%) were calculated according to the following equations as described by Hanson & Churchill (1965) and Mueller-Dombois & Ellenberg (1974).

$$\text{Plant density (plant/ m}^2) = \frac{\text{Number of individual species}}{\text{Total area (100 m}^2)}$$

$$\text{Plant Cover (\%)} = \frac{\text{The area occupied by the species}}{\text{The whole investigated area}} \times 100$$

$$\text{Frequency (\%)} = \frac{\text{Number of occurrence of the individual species}}{\text{Number of occurrence of whole species}} \times 100$$

Landsat Satellite Image

Landsat 8 OLI image for the study area were acquired from USGS website (http://earthexplorer.usgs.gov) at no charge. Description of satellite imagery and bands which were used to mapping plant communities in study areas is shown in table (1).

Table 1. Summary of Landsat Satellite imagery used in this study (images were downloaded from USGS).

Dataset Type	Acquisition date	Band	Spatial resolution	Band width
LandSat 8 (OLI_TIRS)	March 27, 2014	Band 2 Blue	30m	0.452 - 0.512µm
		Band 3 Green	30m	0.533 - 0.590µm
		Band 4 Red	30m	0.636- 0.673µm
		Band 5 NIR	30m	0.851 - 0.879µm

Digital Elevation Model (DEM)

The SRTM DEM of 1 arc second (often quoted as 30 m) was downloaded from the website of U.S. Geological Survey (USGS) and used in this study to classify the study areas to the different elevation levels. The horizontal datum of the SRTM data is WGS84, and the vertical datum is the mean sea level determined by the WGS84. Shape-files of West Matrouh and East Sidi Barani study areas were prepared in ArcGIS 10.4 and used to extract the SRTM DEM for the study areas as shown in fig. (2). Elevation in West Matrouh study area ranged from -6 to 194m and in East Sidi Barani study area ranged from 0 to 158m.

Normalized Difference Vegetation Index (NDVI)

NDVI was calculated using the following equation:

$$\text{NDVI} = \frac{\text{NIR - RED}}{\text{NIR + RED}}$$

Where NIR and RED are reflectance in the near infrared and the red bands, respectively.

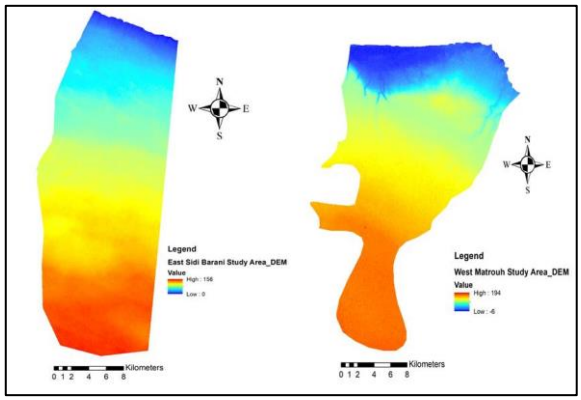

Fig. 2. Digital Elevation Model of West Matrouh and East Sidi Barani study areas

Results and discussions

Rangeland vegetation survey analyses

Data presented in table (2) showing plant composition, palatability and plant duration of three different altitude levels at West Matrouh study area, Egypt during the spring season of 2014. It's indicated that there were 23 plant species presented in this study site which belong to 12 plant families and most of the plant species are palatable (18 plant species) and 5 species were unpalatable. The plant species of Poaceae and Asteraceae families were most represented by 5 and 4 plant species, respectively. In addition there were three plant species of Brassicaceae and two plant species from Chenopodiaceae and Fabaceae families. There were one plant species for the rest of the plant families (7 families). Among the 23 plant species 8 species were perennial, 5 of which were palatable and the other 3 were unpalatable. The other 15 species were annuals, of which 13 were palatable and 2 were unpalatable.

Data also showed that areas with altitude from 51-100 m had the highest number of plant species; however by increasing sea level elevation the plant species number was decreased.

These results are in accordance with those obtained by Abou-Deya and Salem (1990) El- Mathany at West Matrouh, and El-Morsy and Ahmed (2010) in Wadi Umm El- Rakham at West Matrouh.

Table 2. Plant composition, palatability and plant duration of three different altitude levels at West Matrouh study area, Egypt.

N.	Studied sites at the different elevation levels (level 1 from 0 – 50, level 2 from 51 – 100, level 3 from 101 – 200m).					Level 1	Level 2	Level 3
	Family	Scientific name	Vernacular name	P	Du			
1		*Sonchus oleraceus*	Goodeid	P	An	√	√	×
2	Asteraceae	*Silybum marianum*	Shoak el-gamal	Up	Pr	√	√	×
3		*Scorzonera alexandrina*	Dabbaah	Up	An	×	√	×
4		*Anacyclus alexandrines*	Sorret el-kabsh	P	An	×	√	×
5	Apiaceae	*Deverra tortuosa*	Qazzah	P	Pr	√	√	×
6		*Maresia pygmaea*	Shigara	P	An	√	√	×
7	Brassicaceae	*Cardaria draba*	Lislis	P	An	√	×	×
8		*Carrichtera annua*	Gileglaag	P	An	×	×	√
9	Caryophyllaceae	*Gymnocarpos decandrum*	Gurad	P	Pr	√	√	×
10	Chenopodiaceae	*Haloxylon salicormicum*	Rimth	Up	Pr	√	√	√
11		*Noaea mucronata*	Shoak el-hanash	P	Pr	√	×	√
12	Fabaceae	*Trigonella stellate*	Gargas	P	An	×	√	×
13		*Medicago polymorpha*	Oqqeil	P	An	×	√	√
14	Geraniaceae	*Erodium hirtum*	Timmeir	P	An	×	√	√
15	Liliaceae	*Asphodelus microcarpus*	Basal el-onsal	Up	Pr	√	√	√
16	Plantaginaceae	*Plantago cylindrical*	Yanam	P	An	×	√	×
17		*Phalaris minor*	Ain el-qoot	P	An	×	√	√
18		*Aegilops kotschyi*	Shaeer el-faar	P	An	√	√	√
19	Poaceae	*Hordeum leporinum*	Abu shtirt	P	An	×	√	√
20		*Aristida caerulescens*	-	P	Pr	√	×	×
21		*Cutandia memphitica*	Khaafoor	P	An	×	√	×
22	Salvadoraceae	*Salvia aegyptiaca*	Thalaba	Up	An	×	√	×
23	Solanaceae	*Lycium shawii*	Awsag	P	Pr	×	√	√

P = palatability Up = Unpalatability Pr = Perennial An = annual Du = duration √ = Presence x = Absence

Data presented in table (3) showing plant composition, palatability and plant duration of three different altitude levels at East Sidi Barani study area, Egypt during the spring season of 2014. It's indicated that there were 30 plant species presented in this study site which belong to 16 plant families and two third of the plant species are palatable (20 plant species) and one third of the plant species were unpalatable. The plant species of Asteraceae, Chenopodiaceae and Poaceae and families were most represented by 5 plant species for each family. In addition there were two plant species of Brassicaceae and Fabaceae families. There were one plant species for the rest of the plant families (11 families).

Among the 30 plant species 14 species were perennial, 8 of which were palatable and the other 6 were unpalatable. The other 16 species were annuals,

These results were in the same direction with El-Shesheny *et al.* (2014) who carried out investigation during the period extended from spring 2011 to autumn 2012 at Sidi-Barrani in the North Western Coast of Egypt. Their results showed that there were thirty-eight plant species belonging to 16 families were found; the highest number of plant families, number of plant species and palatable plant species were obtained under *Artemisia herba-alba* community.

Table 3. Plant composition, palatability and plant duration of three different altitude levels at East Sidi Barani study area, Egypt.

N.	Studied sites at the different elevation levels (level 1 from 0 – 50, level 2 from 51 – 100, level 3 from 101 – 200m).					Level 3	Level 2	Level 1
	Du	P	Vernacular name	Scientific name	Family			
1		*Anacyclus alexandrines*	Sorret el-kabsh	P	An	×	√	×
2		*Filago desertorum*	-	Up	An	×	√	×
3	Asteraceae	*Scorzonera alexandrina*	Dabbaah	Up	An	√	×	×
4		*Silybum marianum*	Shoak el-gamal	Up	Pr	√	×	×
5		*Centaurea aegyptiaca*	Moraar	Up	An	√	×	×
6	Apiaceae	*Deverra tortuosa*	Qazzah	P	Pr	√	√	×
7	Brassicaceae	*Maresia pygmaea*	Shigara	P	An	×	√	×
8		*Cardaria draba*	Lislis	P	An	×	√	×
9	Caryophyllaceae	*Gymnocarpos decandrum*	Gurad	P	Pr	√	×	√
10		*Haloxylon salicormicum*	Rimth	Up	Pr	√	√	√
11	Chenopodiaceae	*Noaea mucronata*	Shoak el-hanash	P	Pr	√	×	√
12		*Suaeda vermiculata*	Sewaid	Up	Pr	√	×	×
13		*Salsola tetrandra*	Domrran	P	Pr	√	×	×
14		*Atriplex halimus*	Kataf	P	Pr	√	×	×
15	Fabaceae	*Trigonella stellate*	Gargas	P	An	√	×	×
16		*Medicago polymorpha*	Oqqeil	P	An	√	×	×
17	Geraniaceae	*Erodium hirtum*	Timmeir	P	An	×	√	×
18	Liliaceae	*Asphodelus microcarpus*	Basal el-onsal	Up	Pr	×	√	×
19	Plantaginaceae	*Plantago cylindrical*	Yanam	P	An	√	√	×
20		*Stipa capensis*	Abo father	P	Pr	×	×	√
21		*Aegilops kotschyi*	Shaeer el-faar	P	An	√	√	×
22	Poaceae	*Hordeum leporinum*	Abu shtirt	P	An	√	√	×
23		*Lygeum spartum*	Halfa	P	Pr	√	×	×
24		*Cutandia memphitica*	Khaafoor	P	An	×	×	√
25	Primulaceae	*Anagallis arvensis*	Ain elgoot	P	An	√	×	×
26	Ranunculaceae	*Adonis dentate*	Naab elgoot	P	Anm	×	√	×
27	Salvadoraceae	*Salvia aegyptiaca*	Thalaba	Up	An	√	√	×
28	Solanaceae	*Lycium shawii*	Awsag	P	Pr	√	√	×
29	Thymelaeaceae	*Thymelaea hirsuta*	Methinan	Up	Pr	√	×	√
30	Zygophyllaceae	*Peganum harmala*	Harmal	Up	Pr	×	√	√

P = palatability; Up = Unpalatability; Pr = Perennial; An = annual; Du = duration; √ = Presence; x = Absence of which 12 were palatable and 4 were unpalatable.

Effect of the altitude levels on vegetation attributes

Vegetation attributes including plant density, plant cover, frequency, and abundance of the three different altitude levels at West Matrouh study area is presented in table (4). The highest plant cover value registered in the first altitude level of 0 to 50m of 8.7% was achieved by *Gymnocarpos decandrum*. From analyzing rangeland vegetation measurements in this site, the plant community which was common could be named as *Gymnocarpos decandrum* plant community associated with 10 plant species. The highest plant coverage recorded in the second altitude level (51 to 100m) of 9.8% was achieved by *Lycium shawii* followed by *Haloxylon salicormicum* with plant cover of 8.4%.

From analyzing rangeland vegetation measurements in this site, the plant community which was common could be named as *Lycium shawii* - *Haloxylon salicormicum* plant community associated with 16 plant species. The least number of plant species (10 species) was recorded in the third altitude level of 101 – 200m, and the highest plant coverage recorded for a plant species in the third altitude level of 14% was achieved by *Haloxylon salicormicum* followed by *Asphodelus microcarpus* with plant cover of 4.1%. From analyzing rangeland vegetation measurements in this site, the plant community which was common could be named as *Haloxylon salicormicum* plant community associated with 9 plant species.

Vegetation attributes including plant density, plant cover, frequency, and abundance of the three different altitude levels at East Sidi Barani study area is presented in table (5). In general rangeland vegetation cover and other attributes were higher in this study area compared with West Matrouh study area. The highest plant cover for a plant species registered in the first altitude level of 0 to 50m was 13% and achieved by *Suaeda vermiculata,* followed by *Haloxylon salicormicum* with plant cover of 9.2. From analyzing rangeland vegetation attributes in this site, the plant community which was common could be named as *Suaeda vermiculata* plant community associated with 19 plant species. The highest plant coverage recorded in the second altitude level of 51 to 100 m was 14.8% and achieved by *Haloxylon salicormicum* followed by *Asphodelus microcarpus* with plant cover of 9.3%.

Table 4. Vegetation attributes of the three different altitude levels at West Matrouh study area, Egypt.

N.	Plant species	Elevation: 0 – 50 m				Elevation: 51 – 100 m				Elevation: 101 – 200 m			
		P.D.	P.C.	F.	A.	P.D.	P.C.	F.	A.	P.D.	P.C.	F.	A.
1	*Aegilops kotschyi*	0.75	0.3	33.3	34.9	0.1	0.1	33.3	1.0	0.65	0.35	66.7	10.9
2	*Anacyclus alexandrines*	--	--	--	--	0.2	0.1	33.3	1.1	--	--	--	--
3	*Aristida caerulescens*	0.85	1.4	100	74.6	--	--	--	--	--	--	--	--
4	*Asphodelus microcarpus*	0.95	2.7	66.7	45.7	2.25	5.1	66.7	16.2	0.55	4.1	66.7	9.7
5	*Cardaria draba*	0.05	0.2	33.3	2.4	--	--	--	--	--	--	--	--
6	*Carrichtera annua*	--	--	--	--	--	--	--	--	11.8	3.4	100	159
7	*Cutandia memphitica*	--	--	--	--	4.75	1.8	66.7	53.6	--	--	--	--
8	*Deverra tortuosa*	0.15	2.1	66.7	7.2	0.05	1.0	33.3	0.5	--	--	--	--
9	*Erodium hirtum*	--	--	--	--	0.4	0.3	33.3	4.1	0.5	0.33	66.7	9.0
10	*Gymnocarpos decandrum*	0.95	8.7	100	58.8	0.1	3.6	33.3	1.0	--	--	--	--
11	*Haloxylon salicormicum*	0.05	0.1	33.3	2.1	0.6	8.4	66.7	5.5	1.25	14.0	100	18.8
12	*Hordeum leporinum*	--	--	--	--	3.0	1.85	100	31.3	2.5	0.5	33.3	27.0
13	*Lycium shawii*	--	--	--	--	1.35	9.8	100	13.8	0.4	4.0	33.3	5.8
14	*Maresia pygmaea*	0.1	0.4	66.7	4.7	0.1	0.15	33.3	0.1	--	--	--	--
15	*Medicago polymorpha*	--	--	--	--	1.15	0.6	100	8.6	0.6	0.4	66.7	10.4
16	*Noaea mucronata*	0.75	3.8	100	40.7	--	--	--	--	0.05	0.1	33.3	0.7
17	*Phalaris minor*	--	--	--	--	11.25	3.3	66.7	2.7	2.85	0.55	66.7	49.0
18	*Plantago cylindrical*	--	--	--	--	4.25	1.7	66.7	35.5	--	--	--	--
19	*Salvia aegyptiaca*	--	--	--	--	0.65	0.5	100	6.2	--	--	--	--
20	*Scorzonera alexandrina*	--	--	--	--	2.25	5.1	66.7	26.8	--	--	--	--
21	*Silybum marianum*	0.25	0.25	66.7	11.9	0.3	0.35	66.7	2.7	--	--	--	--
22	*Sonchus oleraceus*	0.05	0.1	33.3	2.1	--	--	--	--	--	--	--	--
23	*Trigonella stellate*	--	--	--	--	3.1	0.8	100	21.6	--	--	--	--

P.D. = plant density (plant/m^2); P.C. = plant cover%; F. = frequency; A. = abundance

From analyzing rangeland vegetation measurements in this site, the plant community which was common could be named as *Haloxylon salicormicum* plant community associated with 15 plant species. The least number of plant species (7 species) was recorded in the third altitude level of 101 – 200m, the highest plant coverage recorded for a plant species in the third altitude level of 16.3% was achieved by *Haloxylon salicormicum* followed by *Thymelaea hirsuta* with plant cover of 16%. From analyzing rangeland vegetation measurements in this site, the plant community which was common could be named as *Haloxylon salicormicum- Thymelaea hirsuta* plant community associated with 5 plant species.

Table 5. Vegetation attributes of the three different altitude levels at East Sidi Barani study area, Egypt.

N.	Plant species	Elevation: 0 – 50 m				Elevation: 51 – 100 m				Elevation: 101 – 200 m			
		P.D.	P.C.	F.	A.	P.D.	P.C.	F.	A.	P.D.	P.C.	F.	A.
1	*Adonis dentate*	--	--	--	--	0.6	0.1	33.3	3.5	--	--	--	--
2	*Aegilops kotschyi*	4.5	0.85	100	41.3	0.75	0.4	100	7.0	--	--	--	--
3	*Anacyclus alexandrines*	--	--	--	--	7.5	0.75	100	29.5	--	--	--	--
4	*Anagallis arvensis*	0.1	0.13	33.3	1.0	--	--	--	--	--	--	--	--
5	*Asphodelus microcarpus*	--	--	--	--	1.4	9.3	100	6.4	--	--	--	--
6	*Atriplex halimus*	0.1	2.4	33.3	0.6	--	--	--	--	--	--	--	--
7	*Cardaria draba*	--	--	--	--	0.1	0.15	33.3	0.3	--	--	--	--
8	*Centaurea aegyptiaca*	0.15	0.2	33.3	0.5	--	--	--	--	--	--	--	--
9	*Cutandia memphitica*	--	--	--	--	--	--	--	--	5.5	1.0	100	164
10	*Deverra tortuosa*	0.1	1.9	33.3	0.6	0.05	2.2	33.3	0.2	--	--	--	--
11	*Erodium hirtum*	--	--	--	--	0.15	0.1	33.3	0.5	--	--	--	--
12	*Filago desertorum*	--	--	--	--	12.75	1.4	66.7	44.3	--	--	--	--
13	*Gymnocarpos decandrum*	0.1	2.6	33.3	1.3	--	--	--	--	0.4	5.0	100	13.5
14	*Haloxylon salicormicum*	0.55	9.2	100	5.3	2.25	14.8	100	10.7	1.1	16.3	100	36.7
15	*Hordeum leporinum*	0.9	0.25	66.7	8.1	0.85	0.25	66.7	4.3	--	--	--	--
16	*Lycium shawii*	0.2	3.2	33.3	1.4	0.1	2.2	33.3	0.6	--	--	--	--
17	*Lygeum spartum*	0.1	0.25	33.3	1.0	--	--	--	--	--	--	--	--
18	*Maresia pygmaea*	--	--	--	--	2.2	0.45	66.7	10.2	--	--	--	--
19	*Medicago polymorpha*	6.0	0.8	33.3	75.0	--	--	--	--	--	--	--	--
2	*Noaea mucronata*	0.1	2.5	33.3	0.7	0.3	2.0	66.7	1.2	--	--	--	--
21	*Peganum harmala*	--	--	--	--	0.05	0.1	33.3	0.3	1.25	6.5	100	42.1
22	*Plantago cylindrical*	13.3	1.25	66.7	99.1	43.5	4.3	100	180	--	--	--	--
23	*Salsola tetrandra*	0.05	3.0	33.3	0.5	--	--	--	--	--	--	--	--
24	*Salvia aegyptiaca*	0.05	0.13	33.3	0.5	0.2	0.15	33.3	1.2	--	--	--	--
25	*Scorzonera alexandrina*	3.75	0.6	33.3	37.3	--	--	--	--	--	--	--	--
26	*Silybum marianum*	0.55	0.35	100	5.4	--	--	--	--	--	--	--	--
27	*Stipa capensis*	--	--	--	--	--	--	--	--	0.7	0.65	66.7	21.1
28	*Suaeda vermiculata*	0.4	13.0	100	4.3	--	--	--	--	--	--	--	--
29	*Thymelaea hirsuta*	0.3	6.2	66.7	3.2	--	--	--	--	0.5	16.0	100	14.0
30	*Trigonella stellate*	1.25	0.3	33.3	12.4	--	--	--	--	0.25	0.15	33.3	8.6

P.D. = plant density (plant/m²); P.C. = plant cover%; F. = frequency; A. = abundance.

Data presented in table (6) show the effect of the different altitude levels and locations on the average plant density (plant/m2) and the average plant cover (%) in West Matrouh and East Sidi Barani study areas during spring of 2014. Plant density was significantly higher in East Sidi Barani study area at the first (0 – 51m) and the second (51 – 100m) altitude level by 10.83 and 24.60 plant/m², respectively compared with West Matrouh study area. However, there was non-significant difference between plant density at the third altitude level at East Sidi Barani and West Matrouh study areas. The highest plant density of 24.6 plant/m² was recorded at the second altitude level of 51 – 100m at East Sidi Barani study area, followed by the second altitude level at West Matrouh study area of 11.95 plant/m². There were significant differences in the plant cover percentage among the first and the third altitude level at both of the study areas and plant cover % were higher in East Sidi Barani study area compared to West Matrouh study area. The highest plant cover percentage of 16.54 was recorded at the first altitude level of 51 – 100m at East Sidi Barani study area, followed by 15.20% which was recorded at the third altitude level at East Sidi Barani study area. Khalifa (2015) 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 Umm Ashtan, Matrouh declined from about 24% in 2004 to 15% in 2015. The author also stated that the Matrouh area has faced

more land use changes where several farmers started to use subservice water to establish and irrigate small field of vegetable crops. This new land use type leads to increase the tillage activity in the area and resulted in more rangeland vegetation degradation.

Table 6. Effect of the different altitude levels and locations on plant density (plant/m²) and plant cover (%) in West Matrouh and East Sidi Barani study areas, Egypt.

Altitude levels / Locations	Elevation: 0-50m	Elevation: 51-100m	Elevation: 101-200m	Mean
Plant Density (Plant/m²)				
West Matrouh	1.63[a]	11.95[b]	7.03[b]	6.87[b]
East Sidi Barani	10.83[b]	24.60[a]	3.23[b]	12.89[a]
Mean	6.23[b]	18.28[a]	5.13[b]	
Plant Cover (%)				
West Matrouh	8.75[b]	13.98[ab]	9.24[b]	10.66[a]
East Sidi Barani	16.54[a]	13.82[ab]	15.20[a]	15.18[a]
Mean	12.65[a]	13.90[a]	12.22[a]	

Normalized Difference Vegetation Index (NDVI)

NDVI was calculated from a Landsat 8 OLI image acquired for the study area on March 27, 2014; then West Matrouh and East Sidi Barani study areas were extracted as presented in fig. (3). In West Matrouh study area, NDVI values ranged from -0.73 to 0.417 and in East Sidi Barani study area, NDVI values ranged from 0.075 to 0.382. These NDVI values considered being low as the study areas located on an arid environments; however, NDVI values were in accordance with vegetation and land cover types dominated in the study areas and it were also verified by the field survey data. In general NDVI values were higher in West Matrouh study area in comparison with East Sidi Barani study area due to cultivated barley and wheat areas were larger in West Matrouh study area. Vegetation cover was lower in the northern part of the study areas and ten to increase as we move to the south, then it was decreasing aging as precipitations were lower in the south compared with the Mediterranean costal belt.

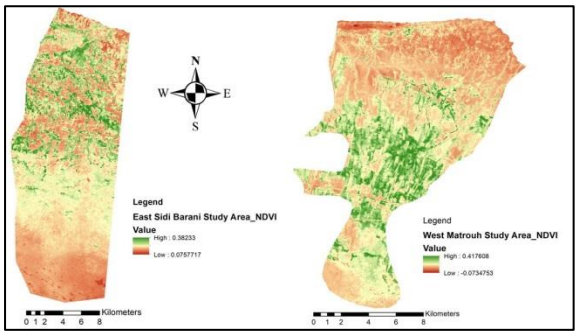

Fig. 3. NDVI calculated from Landsat 8 satellite image at spring of 2014 of West Matrouh and East Sidi Barani study areas, Egypt.

Rangelands vegetation maps

Maximum likelihood supervised classification was used to classify the Landsat 8 satellite images to the primary land cover types dominated in the study areas which were identified from the field survey. These land cover types included bare ground soils, sparse rangeland vegetation whereas plant cover was less than 10%, dense rangeland vegetation whereas plant cover was more than 10%, and cultivated areas. Rangeland vegetation condition based on the percentage of dense rangeland vegetation cover in East Sidi Barani study area was higher than rangeland vegetation condition in West Matrouh study area.

This can be due to the high human activities in West Matrouh study area including urban development and encroachment, more cultivation, and the area has been facing higher grazing pressure. These finding was in agreement with Islem *et al.* (2018) who used time series Landsat images from 1987 to 2016 to study the vegetation dynamics of Algerian's steppe ecosystem.

They stated that sparse vegetation classes were correlated with the agriculture class, demonstrating that the human action contributes to the degradation of the plant cover in the area. Image classification wasn't accurate in distinguish between the plant communities common on the study areas; however, rangeland field survey conducted in the areas indicated the there are six plant communities in the study areas including, *Gymnocarpos decandrum* plant community in the first elevation level, *Lycium shawii - Haloxylon salicormicum* plant community in the second elevation level, and *Haloxylon salicormicum* plant community in the third elevation level at West Matrouh study area. For East Sidi Barani study area, the plant communities identified in this area included, *Suaeda vermiculata, Haloxylon salicormicum, Haloxylon salicormicum- Thymelaea hirsute* plant community for the first, the second, and the third altitude levels, respectively.

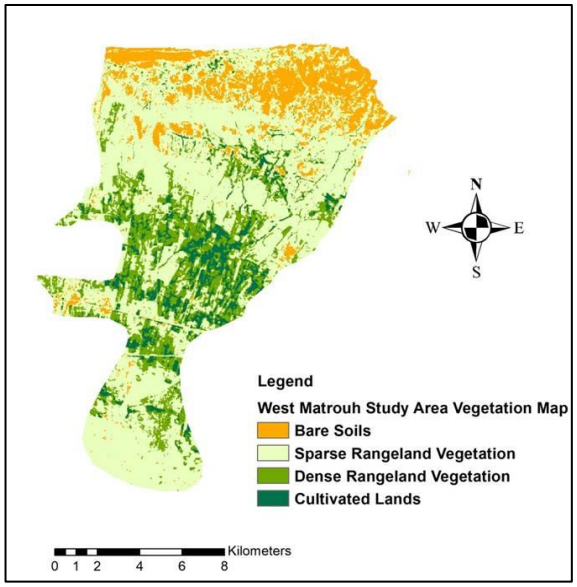

Fig. 4. Classified vegetation map produced from analyses of Landsat 8 satellite image and ground survey at spring of 2014 of West Matrouh study area, Egypt.

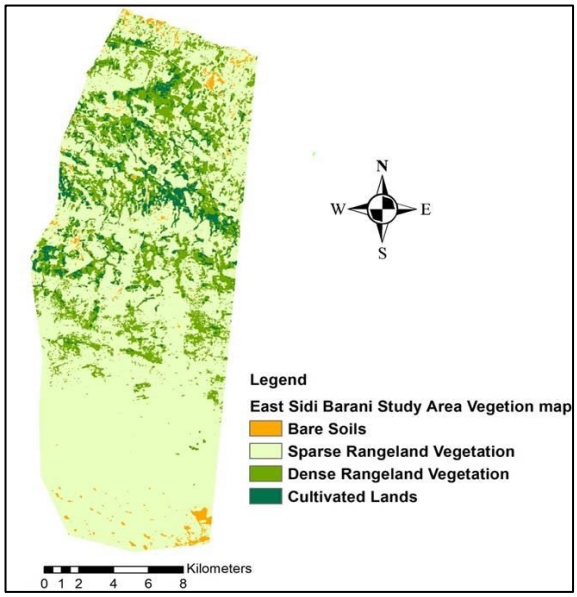

Fig. 5. Classified vegetation map produced from analyses of Landsat 8 satellite image and ground survey at spring of 2014 of East Sidi Barani study area, Egypt.

Conclusion

Characterization and mapping native plant communities at the two study areas (West Matrouh and East Sidi Barani) in the north western coast of Egypt indicated that there are six plant communities associated with several plants species with multipurpose usage including animal feed and medicinal use. Plant density was significantly higher in East Sidi Barani study area at the first and the second altitude level in comparison with West Matrouh study area. There were six plant communities surveyed and identified on the study areas. In general, rangeland vegetation condition based on the percentage of dense rangeland vegetation cover derived from satellite image analysis in East Sidi Barani study area was higher than rangeland vegetation condition in West Matrouh study area. Efforts to improve the degraded rangeland and conservation of native plants species including collecting of natural seeds of some valuable forage shrubs, propagation of native plants though seedling production, and using simple low cost water harvesting techniques for the reproduction of the native plant species with implementing conservation program to reduce the grazing stocking rates in the region would resulted in positive improvement in the rangeland at the north western coast of Egypt.

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