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Change Detection in Land Degradation and Environmental Hazards Sensitivity in Some Soils of Siwa Oasis

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SOME selected soils of Siwa Oasis were characterized, classified and evaluated for land degradation. Soil samples from pedogenic horizons were analyzed. The total investigated area is 126166.7 (529.9 km^2). The study revealed seven major physiographic units in the area: sand sheets, hummocks, alkali flats, overflow basins, decantation basins, mountain footslopes and hill footslopes. One soil profile was taken from each of the physiographic units. Since cultivation started in Siwa, several problems have arisen including wind erosion, soil salinity, sodicity, drought, water-logging and expansion of the water bodies. Wind erosion hazard status ranged from none to very severe hazards. Salinity hazard ranged from slight to very severe hazards, 85.70 % of the total area showed increased salinity (27610.01 ha). Sodicity hazards ranged from slight to very severe, 71.31 % of the total area showed increased sodicity (22970.05 ha). Waterlogging hazards ranged from moderate to severe; 70.60 % of the total area showed a rise in water table level (22740.05 ha). There are changes between land cover feature in between 1999 and year 2014. The increment of agricultural area with 14616 ha. Enlargement of area of lakes and ponds increased by 3190 ha. The soils which altered to salinity in area 94 ha and the area of wetlands decreased 187 ha.

Keywords: Siwa Oasis, Land degradation, Salinity, Water logging, Wind erosion

Land is a terrestrial ecosystem that includes not only soil resources, but also vegetation, water, other biota, landscape setting, climate attributes, and ecological processes (Scherr &Yadav, 1996; Moyo, 2000; MEA, 2005 and Vlek *et al.,* 2008) that operate within the system, ensuring its functions and services. Land meets three needs of the human being essential to survival and development: food, clothing, and shelter. Agricultural land is not only the essential land resource that supplies materials for humans but also a complex system that combines natural ecology and social economy. Rapidly developing economy and growing population accelerate degradation of land and endanger food efficiency (Brouwer, 2004 and Wiebe, 2003). Since soil is the most important component of land resource, soil evaluation is crucial for land evaluation (Rossiter, 1996). Land is central to development in Africa since the livelihoods of about 60% of the population are dependent on agriculture (Moyo, 2000). However, the future health of land in Africa is in question due to increasing population pressures and low investments on land conservation (Vlek, 2005). The development and survival or disappearance of civilizations has been based on the performance of land to provide food, fiber, and further essential goods for humans (Mueller *et al.,* 2010). Therefore, assessing the health of agricultural land takes into account the quality and productivity of land as well as the soil environment. Separating human-induced land degradation from that caused by natural processes is a challenging task, but important for developing mitigation strategies (Le *et al.*, 2012).

According to UNCCD (2004) and MEA (2005), land degradation is defined as the persistent reduction or loss of land ecosystem services (Adeel *et al.,* 2005; Safriel, 2007 and Vogt *et al.,* 2011). This definition focuses on the ecological services of the land (Safriel, 2007 and Vu *et al.,* 2014). Land degradation is a major global environmental issue. Eswaran *et al.* (2001) stated that about 1360 million ha of global land are moderately to severely degrade. More than half of the dry areas worldwide are affected by land degradation (Dregne and Chou, 1994). Land degradation is a serious problem for food security and development of society (FAO, 2010 and Vlek *et al.,* 2010). Degradation involves the combination of many interrelated processes such as soil erosion, and long-term loss of natural vegetation that reduces land performance. Degradation of ecosystems sets in when the system services, are persistently reduced or lost (Katyal & Vlek, 2000; Reynolds & Smith, 2002; MEA, 2005; Safriel, 2007 and Vogt *et al.,* 2011). Once land degradation sets in it tends to induce further degradation and other environmental problems as the population in Africa have few options of coping other than resorting to the use of more fragile lands. Explicit, quantitative assessment of land degradation can help to design informed interventions and policy development of resources (Randolph, 2004 and Vlek *et al.,* 2008).

Desert reclamation is one of the priorities to compensate for the loss of agricultural land in Egypt (Aldabaa *et al.,* 2010). Siwa represents the smallest oasis located in the Egyptian part of the extensive Libyan Desert and depends on ground water and drainage water reuse. Farmers experience a challenging rising water level together with the groundwater salinity and soil salinization, especially in the low lands (DRC, 1988 and Abdulaziz & Faid, 2013). This water flows from a large number of old springs, or from many wells, dug by the farmers. The misuse of water in irrigation produced lakes. Enlargements of lakes arise water table level and threaten the agricultural lands (Metwaly, 2003). Most of these wells, especially the shallow and the hand-dug ones, are poorly designed to control water flow (Wang & Anderson, 1982; and Abdulaziz & Faid, 2013). Large-scale land development is associate with problems, such as waterlogging (Masoud and Koike, 2006), rapid falling water level and groundwater depletion (Nour, 1996; Konikow & Kendy, 2005 and Venot & Molle, 2008), salt water intrusion (Kashef, 1983 and Werner Simmons, 2009), and disturbance to groundwater system (Vrba & Pêkný, 1991; Abdulaziz, 2007 and Ahmed *et al.*, 2012). Water management is a decisive action that may be partly conflicting to maintain and improve water resources (Pahl-Wostl, 2007). The principle objective of water resource management is to grant water demands for different uses in a most environmentally effective manner (Biswas, 2004).

The main goal of the current study is to identify places with different environmental sensitivity to land degradation in Siwa Oasis (Egypt) according to FAO/UNEP provisional methodology for the common degradation process.

Materials and Methods

Site description

The Western Desert of Egypt comprises the main Oases of Egypt. Siwa Oasis represents the smallest one, which covers an area attaining 0.15% (1175 km^2) of the area of the Western Desert. It has an irregular elongate shape narrowing westward. The selected sites are located between longitudes 25° 16'- 26° 7' E and latitudes 29° 7' - 29° 21' N. The Siwa depression is bordered from the north by the Marmarica Plateau, which extends as far as the Mediterranean Sea, while towards the south by the dunes of the Great Sand Sea. Figure 1 shows the location of the studied area. The total investigated area is 126166.7 feddans (529.9 km^2).

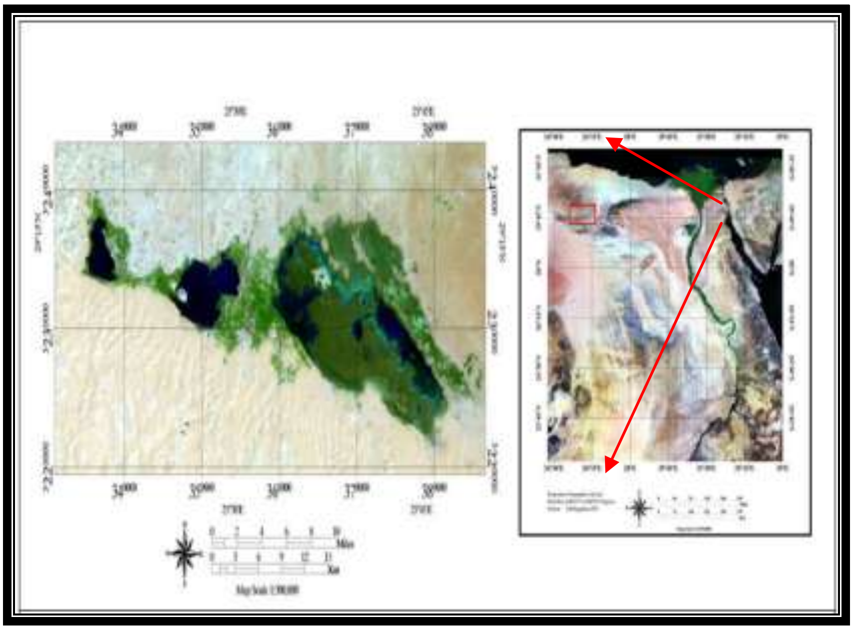

Fig. 1. Location map of the studied area

Topographically, five local depressions are easily recognized in Siwa Oasis, the area lying below zero elevation, and altitudes between -1 and -18 m above the mean sea level (a.m.s.l.) (Fig. 2). These depressions host the important lakes recognized from west to east as Maraqi, Siwa, Aghourmy and Zeitoun lakes. The climate is arid to semi-arid with a negligible rainfall, high evaporation, and moderate to high humidity (Parsons, 1963). Siwa was populated in historic times and has increased from 3000 in 1840 to approximately 23000 in 2009. hot in summer and mild in winter with average maximum–minimum temperature between 20 and −5 °C in January and 38 and 21 °C in July (EMA, 2012). Rainfall is scarce with an average annual rainfall of 13 mm, but humidity is a relatively high range from 22 % in May to 45 % in December depending on the associating daily evaporation rate (average 17 mm in June, and 5.2 mm in December). There are two main types of water resources: surface water resources and ground water resources. The role of climatic conditions on the fluctuation of the surface water resources will be presented.

Soil survey

Detailed soil survey (Rigid grid) was carried out on each of the seven sites after which the major soil of the area was picked as largest coverage area for Siwa Oasis. One profile pit was dug at each of the major soil types, since these soils have been identified as benchmark soils. The morphological properties were described in the field using the criteria of the soil survey manual of Soil Survey Staff (USDA, 2003) and the guidelines for soil profile description (FAO, 1990). Soil samples were taken from pedogenic horizons or layers of the profiles for laboratory analysis.

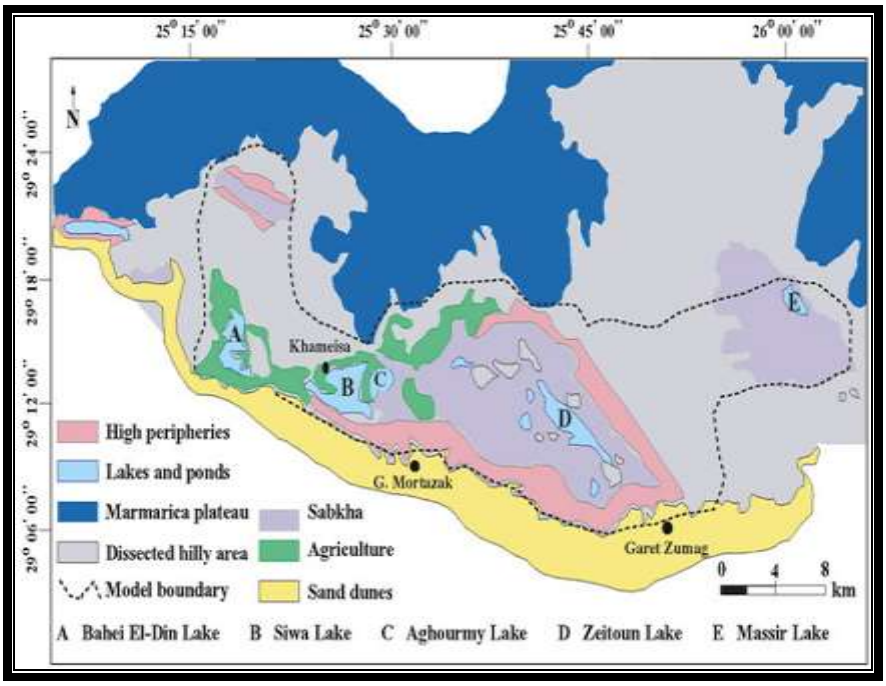

Fig. 2. Map of the important features developed in Siwa Oasis area

Geology

In Siwa Oasis, the Middle Eocene chalky limestone 75 m is exposed and overlain by quartzitic gravel and silisified wood west of Timeira. In subsurface (at Qattara, well located in the west of Qattara depression close to Siwa Oasis), the Moghra Formation, a clastic fluviomarine delta-front sequence of Early Miocene that grades laterally to marine fancies (Said, 1990), uncomfortably overlies the Upper Eocene (Fig. 3). At the depression, a 94-m- thick Marmarica Formation of the Middle Miocene forms the greater part of Siwa Oasis and comprises mainly limestone, dolomite, and shale. It mainly forms the northern scarp (78 m height) and many of the hills at Gebel El-Dakrour, Mortazak, Zomag, El-Mawta, and Khameisa (Fig. 2) (Gindy and El-Askary, 1969). Tertiary rocks are covered by the Quaternary alluvium and aeolian deposits that constitute 2–3 m soil zone that is replaced by salt or sabkha at the proximity of the lakes. Siwa occupies a regional NNW–SSE synclinal fold (El-Shazly *et al.*, 1978) and is characterized by well-developed NW–SE and ENE–WSW structural lineaments.

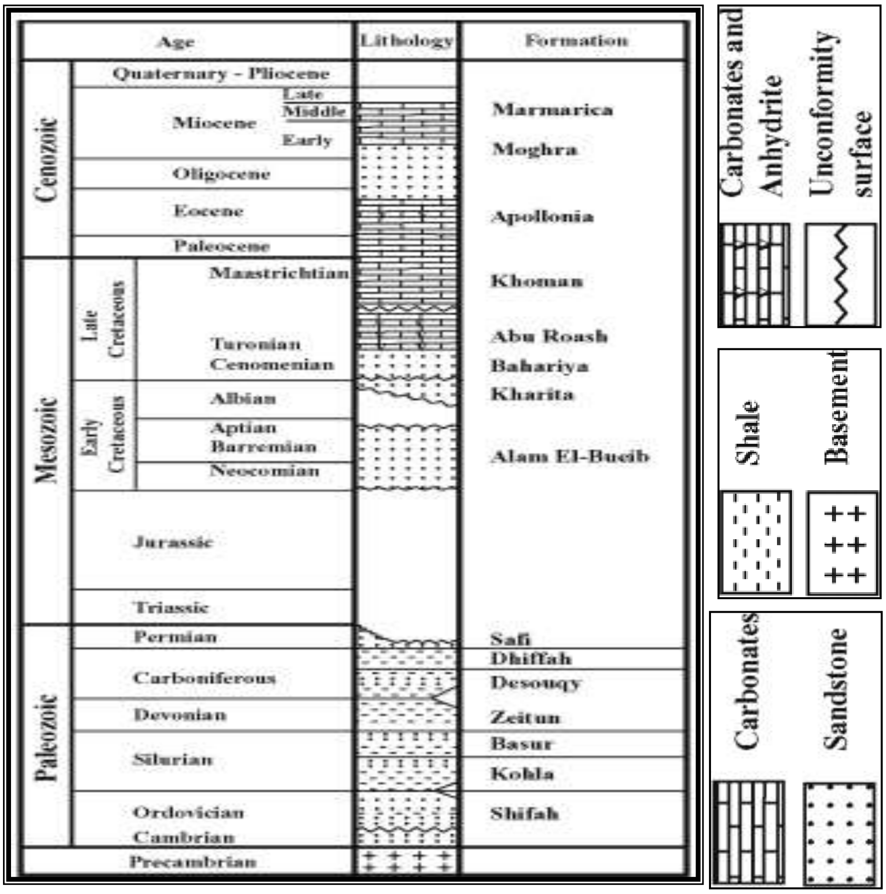

Fig. 3. Composite stratigraphic section in Siwa basin (modified from EGPC, 1992)

Geomorphologic features

According to Metwaly (2003), based on the interpretation of satellite image, the study revealed seven major physiographic units in the area: sand sheet, hummock, alkali flat, overflow basin, decantation basin, mountain footslope and hill footslope. Seven soil profiles were taken from each of the physiographic units. The soil profiles represented by 19 soil samples were characterized in Siwa Oasis.

Soil laboratory analyses

Soil samples were air-dried in the laboratory ground and sieved through a 2 mm sieve.

Physical analysis

-Particle size distribution of soil was done by the method described by Rowell (1995).

-Soil color was determined with the aid of Munssel Soil Color Charts (Anon., 1975).

Chemical analyses

-The electrical conductivity (EC) was estimated in the extracted soil paste by Conduct-meter. Exchangeable sodium percentage was calculated as the relative amount of exchangeable sodium and cation exchange capacity according to Rowell (1995).

FAO/UNEP criteria of hazards

FAO/UNEP (1978) criteria are used to determine the degree, class and rate different types belonging to land degradation as shown in Table 1.

TABLE 1. Criteria used to determine the degree of different types of hazards

Criteria/degradation type	**Indicator**	**Unit**	**1**	**2**	**3**	**4**	**5**
Wind erosion	Observed erosion	Class	None	Slight	Moderate	Severe	Very severe
Salinization	EC	dS/m	<4	4-8	8-16	16-32	>32
		Class	None	Slight	Moderate	Severe	Very severe
Sodicity	ESP	%	<10	10-15	15-30	30-50	>50
		Class	None	Slight	Moderate	Severe	Very severe
Waterlogging	Water logging	Cm	>150	150-100	100-50	50-30	<30
		Class	None	Slight	Moderate	Severe	Very severe

Note: 1-5 means degrees of hazard. Source: After FAO/UNEP (1978).

Results and Discussion

Soil morphological properties

The soil morphological properties are shown in Table 2. The soil of sand sheet was characterized by bright yellowish brown (10 YR 6/6) sand on top coming down to sand yellowish brown (10 YR 5/6) sub soil. There are some few brown mottles between 20 to 60 cm depth. The soil of hummok is characterized by dull yellow orange (10 YR 7/4) sandy loam on top coming down to loamy sand bright yellowish brown (10 YR 7/6) in the middle depth and finally to loamy sand bright yellowish brown (10 YR 5/8) at the subsoil. The profile at alkaliflat was characterized by dull yellow orange (10 YR 6/4) silty loam on top coming down to silty loam bright yellowish brown (10 YR 6/6) in the middle depth and finally to loamy sand dull yellowish brown (10 YR 5/3) at the subsoil. The overflow basin was characterized by grayish brown (10 YR 5/2) loamy sand topsoil coming down to loamy sand brownish gray (10 YR 5/1) in the middle depth and finally to sand yellowish brown (10 YR 6/6) at the subsoil. There are some few reddish brown in sub soil and few yellowish brown mottles between 25 to 75 cm depth. The decantation basin was characterized by bright yellowish brown (10 YR 6/6) sandy loam topsoil coming down to sandy loam dull yellow orange (10 YR 6/4) coming down to loamy sand yellowish brown (10 YR 5/6) and finally to loam yellowish brown (10 YR 5/3) at the subsoil. The soil of mountain footslope was characterized by brownish yellow (10 YR 6/8) sand on top coming down to sand bright yellowish brown (10 YR 6/6) sub soil. The soil of hill footslope was characterized by bright yellowish brown (10 YR 6/6) sand on top coming down to sand bright yellowish brown (10 YR 6/6) sub soil.

Soil Classification

Done using the Soil Taxonomy System (USDA, 2006) was applied up to the level of the sub-great group for mapping units, while to family level for the profile description (Table 2).

Environmental hazards

Environmental hazard' is a generic term for any situation or state of events which poses a threat to the surrounding environment. Hazards in the area are widespread causing increasingly serious problems. Large areas are being undermined through improper land use and poor management. The area is exposed to different hazards; the first hazard group relates to wind erosion, the second hazard group deals with hazards in situ: chemical or physical, and the third group involves natural hazards such as: enlargement of lakes because of uncontrolled irrigation water and over-irrigation practices which led to raising the water table level and causing salinization and encroachment of sands dunes, which are creeping from the south (great Sand Sea) threatening the cultivated lands and neighboring villages, *i.e.* Khamisa village.

According to the FAO/UNEP methodology the most common process of land degradation in Siwa Oasis are salinity and wind erosion (Afifi *et al.,* 2014).

TABLE 2. Soil classification and field morphological description of mapping unit of Siwa oasis.

Geographic unit	Profile number and coordinate	Classification	Colour (dry)	Mottles	Texture	Structure	Consistence	Boundary	Drainage class	Concretions	Gravels
Sand sheets (SS)	**P1**: Long.25°25' 05" E Lat. 29°11' 48" N	**Typic Torripsamments**	0-55 (10YR 6/6) 55-80 (10 YR 5/6) 80+ Water table	F, brown F, brown	S S	C,sg C,sg	D,l D,l	w s	IV IV	P, Ca-Cs P, Ca-Cs	a a
Hummocks (HA)	**P2**: Long. 25°35' 44" E Lat. 29°09' 47" N	**Typic Torripsamments**	0-15 (10YR 7/4) 15-45 (10YR 7/6) 45-90 (10YR 5/8) 90+ Water table	- - -	SL LS LS	M,g M,g M,cr	D,sh D,sh D,sh	w w s	IV IV IV	P, Ca P, Ca P, Ca	a a a
Alkali flats (AF)	**P3**: Long. 25°29' 12 "E Lat.29°15' 08" N	**Calcic Aquisalids**	0-10 (10YR 6/4) 10-20 (10YR 6/6) 20-35 (10YR 5/3) 35+ Water table	- - -	SiL SiL LS	F,sb F,sb M,sab	D,h D,h D,sh	s s s	I I I	P, Ca P, Ca P, Ca	a a a
Overflow basins (OB)	**P4**: Long. 25°25' 33" E Lat. 29°12' 28" N	**Typic Torripsamments**	0-25 (10YR 5/2) 25-50 (10YR 5/1) 50-85 (10YR 6/6) 85+ Water table	F, reddish brown F, yellowish brown F, yellowish brown	LS LS S	M,sab M,sab C,sg	D,sh D,sh D,l	gs s s	III III III	P, cc P, cc P, cc	a a a
Decantation basins (DB)	**P5**: Long. 25°30' 11" E Lat. 29°13' 49" N	**Typic Torripsamments**	0-5 (10YR 6/6) 5-15 (10YR 6/4) 15-50 (10YR 5/6) 50-90 (10YR 5/3) 90+ Water table	- - - -	SL SL LS L	F,sab M,sab M,sab F,sb	D,sh D,sh D,sh D,h	w w w s	III III III III	P,n P,n P,n P,n	a a a
Mountain footslopes (MF)	**P6**: Long. 25°21' 50 "E Lat.29°14' 03"N	**Typic Haplocalcids**	0-8 (10 YR 6/8) 8-30 (10YR 6/6) 30+ Limestone hardpan	- -	S S	C,sg C,sg	D,l D,l	gw s	IV IV	P,n P,n	P,m P,m
Hill footslopes (HF)	**P7**: Long. 25°23' 37" E Lat.29°13' 44 "N	**Duric Haplosalids**	0-5 (10 YR 5/6) 5-40 (10 YR 6/6) 40+ Limestone duripan	- -	S S	C,sg C,sg	D,l D,l	gw s	IV IV	P,n P,n	P,n P,m

Long.: Longitude **Lat.**:- Latitude.
Texture: SL = Sandy Loam, LS = Loamy sand, SC = Sandy Clay, C = Clay Loam, SiL = Silty loam, S = Sand, SCl = Sandy clay loam, and C = clay.
Mottles: M = many, F = few.
Structure: M = medium, C = coarse, F= fine, sg= single grain, g= granular, cr = crumb, ab = angular blocky, sab = sub angular blocky.
Consistence: D = dry, M = moist, W = wet, l= loose, fr = friable, fi = firm, sh = slightly hard, h = hard, s = sticky.
Boundary : w = wavy, s = smooth, gs = gradual and smooth, gw = gradual and wavy, i = irregular.
Drainage: I = poorly drained, III = moderately drained, IV = well drained.
Concretions: a = absent, p = present, Fe-Mn = Iron and Manganese concretion – Cc = calcium carbonate – Cs = gypsum, n = numerous.
Gravels: a = absent, p = present, n = numerous, f = few, m = moderate.

Wind erosion hazards

Wind erosion is nearly always caused by a decrease of the vegetation cover of the soil, either due to overgrazing or to the removal of vegetation for domestic use or agricultural purposes. It is widespread in arid and semi arid climates. Course textured soils are vulnerable to wind erosion more than fine textured soils. Three types of wind erosion are recognized in Siwa. They are: 1) Loss of topsoil by wind erosion, causing uniform displacement of the topsoil, 2) Terrain deformation, causing uneven displacement of soil material, leading to deflation hollows and barchans, transverse dunes and 3) Encroachment of sands dunes.

Chemical (salinization and sodification) and physical (water logging) hazards

Siwa suffers many environmental problems related to water use, management and overall water balance leading to; water logging; soil salinization; increase the saltwater lakes, marshes and a rise of water table levels by 4.5 cm/year (Abo-Ragab, 2008). The results of these problems are deterioration in land productivity and which in turn results in lowering agriculture income.

Type, degree, and class, of hazards in the study area

Table 3 shows data on salinity, sodicity, and waterlogging hazards and Table 1 shows hazard classification according to FAO/UNEP (1978). The type of hazard refers to the causative factor, and the degree refers to the class level of hazard. The 5-degree classes are: none, slight, moderate, severe, and very severe having 5 respective degree classes of 1, 2, 3, 4, and 5.

TABLE 3. Soil characteristics and environmental hazards evidence of the Siwa Oasis area

Land form	**Wind erosion hazards Degree**	**Salinity Ece past extract (dS/m) in upper horizon**	**sodicity ESP in upper horizon**	**Water-logging (cm)**
SS	Severe	11.15	12.93	80
HA	Severe	37.93	16.44	90
AF	None	53.12	60.61	35
OB	Slight	4.62	7.54	85
DB	Slight	8.74	17.52	90
MF	Very Severe	151.25	16.24	30
HF	Very Severe	135.67	55.61	40

Wind erosion hazards are from none to very severe, Table 3 shows that soil of AF belongs to class 1 (no hazard). Soils of OB and DB belong to class 2 (slight hazards). Soils of SS and HA belong to class 4 (severe hazards). Soils of MF and HF belong to class 5 (very severe hazards).

Salinity hazard has a range from slight to very severe hazards. Table 3 shows that soil of OB belongs to class 2 (slight hazards). Soils of SS and DB Soils belong to class 3 (moderate hazards). Soils of HA, AF, MF and HF belong to class 5 (very severe hazards).

Sodicity hazards have a range from slight to very severe, except for soils of SS and OB (no hazards), Table 3 shows that soil of SS belongs to class 2 (slight hazard). Soils of HA, DB and MF belong to class 3 (moderate hazards). Soil of AF belongs to class 4 (severe hazards). Soils of AF and HF belong to class 5 (very severe hazards).

Water logging hazards have a range from moderate to severe. Soils of SS, HA, OB and DB belong to class 3 (moderate hazards), soils of AF, MF and HF belong to class 4 (severe hazards).

Change detection in degradation variables from 2003 to 2014

A comparison was held between 2003 given by an early study by the authoress (Metwaly, 2003) and 2014 of the current study. Salinity, sodicity, compaction and water-logging were investigated. Changes in such properties were detected during the period between 2003 and 2014. Table 4 shows these variables for each landform in the two dates.

TABLE 4. Properties of soils of the different landforms of Siwa Oasis study are recorded in the year 2003 and 2014

Landform	2003 (data after Metwaly, 2003)			2014 (data of the current study)		
	Chemical degradation		Physical degradation	Chemical degradation		Physical degradation
	Salinity (as EC dS/m)	Sodacity (as ESP)	Water logging (as Depth to water table cm)	Salinity (as EC dS/m)	Sodacity (as ESP)	Water logging (as Depth to water table cm)
SS	7.35	13.10	110	9.61	11.27	80
HA	28.66	19.10	110	36.89	23.03	90
AF	29.25	40.20	65	48.03	55.37	35
OB	5.47	8.87	98	3.44	9.05	85
DB	16.91	25.58	95	7.46	13.93	90
MF	98.00	8.90	25	103.16	12.83	30
HF	77.5	40.90	40	94.84	45.85	40

Note: Values are grand mean of weighed means of profile for each landform.

Soil salinity, sodicity, compaction and water logging

Salinity

Soil salinity is a major problem in Siwa. Soil salinity is expressed in terms of EC of soil paste extract weighed means for the profile. An area of 27610.01 ha (85.70 % of the total) showed an increase in EC. They are of soils of SS, HA, AF, MF and HF landforms. The remaining area of 4600.04 ha (14.30 % of the total area) showed a decrease in EC. They are of soils of OB and DB landforms. Increased salinity is due to the use of ground and drainage waters in irrigation.

Recently, farmers started to experience the challenging rising water level in the soil zone together with the groundwater salinity and the escorted soil salinization and natural lakes causing severe soil salinization. Leaching enhancing the drainage system indicates an improvement in land management. Table 5 and Figure 4 show EC change during the period of 2003-2014.

TABLE 5. Change detection in salinity during the period of 2003-2014 in soils of Siwa Oasis study area

EC: Soils which showed…	of landforms	with an area of (ha)	and a proportion (%) of the total area
An increase	**SS, HA, AF, MF, HF**	**27610.01**	**85.70**
A decrease	**DB, OB**	**4600.04**	**14.30**
No change	**None**	**0.00**	**0.00**
Total		**32210.05**	**100.00**

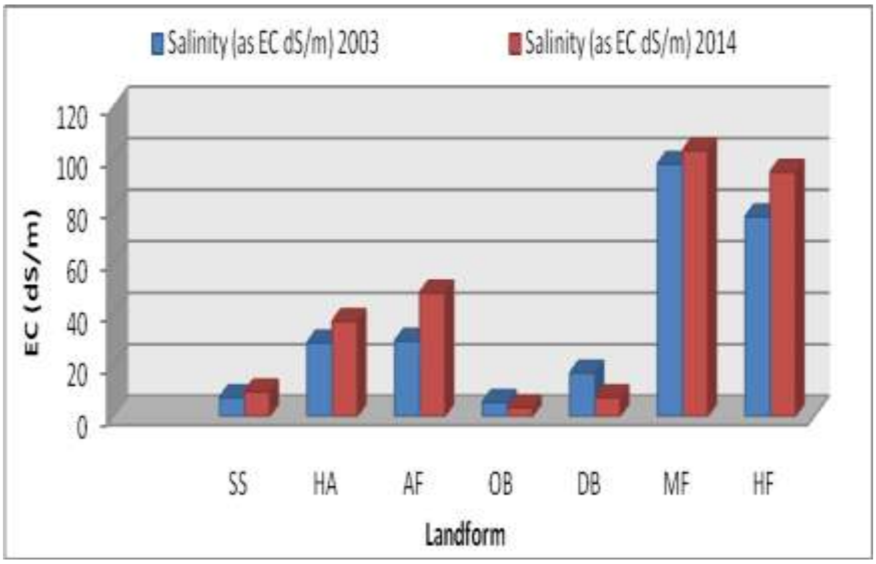

Fig. 4. Soil EC in 2003 and 2014

Sodicity

Sodicity is expressed in terms of exchangeable sodium percent (ESP). An area of 22970.06 ha (71.31% of the total) showed an increase in sodicity. They are of soils of HA, AF, OB, MF and HF landforms. The remaining area of 9240 ha (28.69% of the total area) showed a decrease in sodicity. They are of soils of SS and DB landforms. Increased sodicity is due to using ground water and saline water of lakes of relatively high soluble Na. Decreased sodicity may be due to the use of gypsum amendment and/or ordinary Ca-superphosphate. Table 6 and Figure 5 show ESP change during the period of 2003-2014.

TABLE 6. Change detection in ESP during the period of 2003-2014 in soils of Siwa Oasis study area

ESP soils which showed…	of landforms	with an area of (ha)	and a proportion (%) of the total area
An increase	HA, AF, OB, MF, HF	22970.05	71.31
A decrease	SS, DB	9240.00	28.69
No change	None	0.00	0.00
Total		32210.05	100.00

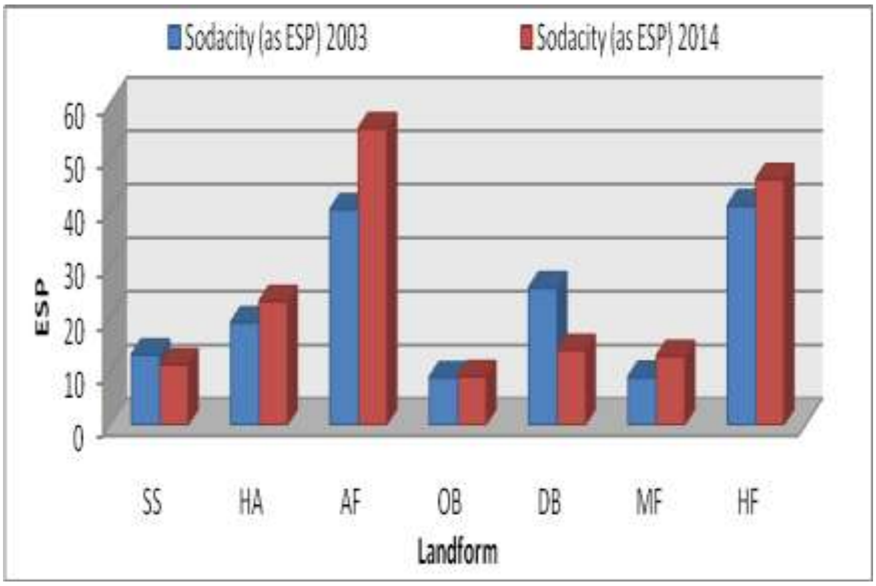

Fig. 5. Soil ESP in 2003 and 2014

Water logging

Water logging is another physical hazard where aeration is insufficient for root growth of crops due to water being present permanently or nearly permanently in the root zone of the soil profile. An area of 2160.00 ha (6.70 % of the total) showed a decrease in waterlogging. They are in soils of MF landform. An area of 22740.05 ha (70.60 % of the total) showed an increase in waterlogging, they are of soils of SS, HA, AF, OB and DB landforms. The remaining area of 7310.00 ha (22.70 % of the total area) showed no change in waterlogging. They are of soils of HF landforms. Decreased waterlogging may be due to enlargement of the area of lakes because of uncontrolled irrigation water and over-irrigation which led to raising the water table level. The increase may be due to improvement land management. Table 7 and Figure 6 show waterlogging change during the period of 2003-2014.

TABLE 7. Change detection in waterlogging during the period of 2003-2014 in soils of Siwa Oasis study area

Waterlogging (cm): Soils which showed…	of landforms	with an area of (ha)	and a proportion (%) of the total area
An increase	MF	2160.00	6.70
A decrease	SS, HA, AF, OB, DB	22740.05	70.60
No change	HF	7310.00	22.70
Total		32210.05	100.00

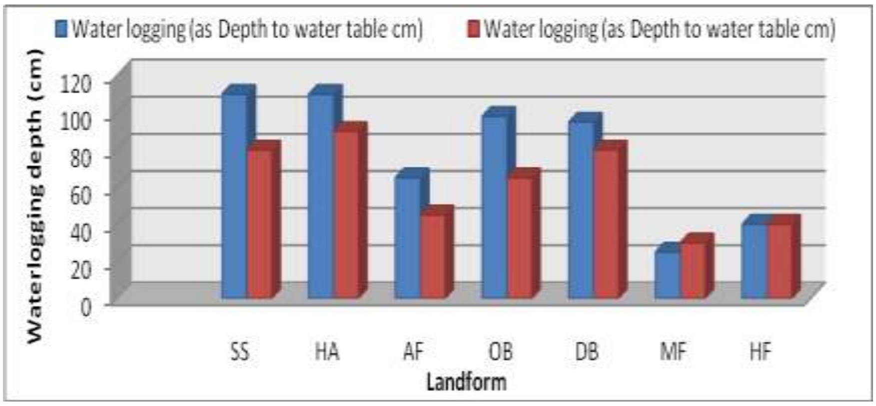

Fig. 6. Water logging depth in 2003 and 2014

Change detection in some features in the investigated area from 1999 to 2014.

Detection of changes is the process of identifying differences in the state of an object or phenomenon by observing the changes of its radiance at different times. A comparison was held between 1999 and 2014. Table 8 and Figure 7 show the changes in the two dates.

TABLE 8. Change in the area of land cover features of Siwa oasis between (1999 and 2014)

Feature	Sum area in 1999 (ha)	Sum area in 2014 (ha)	Exchang e (ha)
Increment of agricultural area	4438	19054	14616
Enlargement of area of lakes and ponds	3905	7095	3190
Soils altered to salt affected soils	89	183	94
Wetland	22174	21987	187

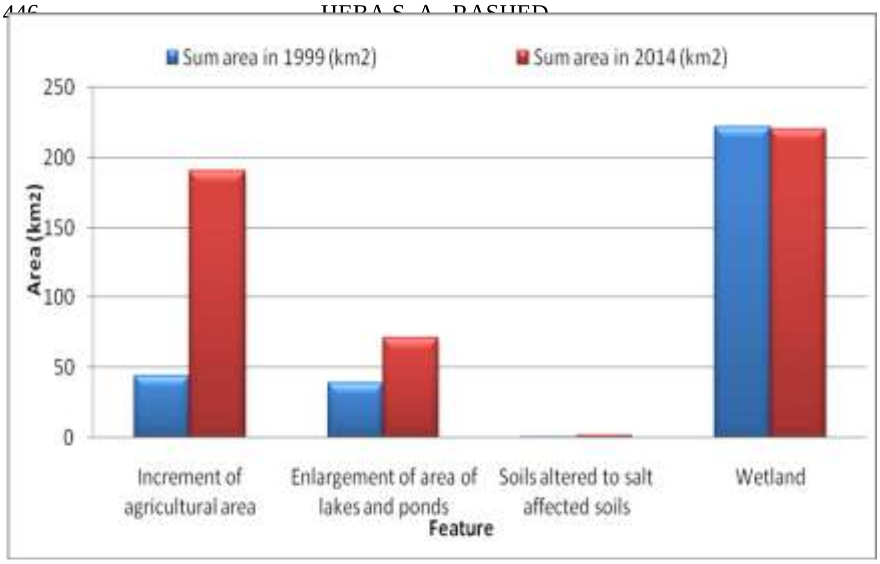

Fig. 7. Change detection between land cover features during the period of 1999 – 2014 in Siwa area

There are changes in land cover in Siwa between 1999, 4438 ha became 19054 ha in 2014 increasing 14616 ha. The area of enlargement of lakes and ponds is 3905 ha for 1999 and became 7095 ha for 2014 with increasing about 3190 ha also the sum area of soil which became salt affected soils is 89 ha for 1999 and 183 ha for 2014 increasing by an area of 94 ha and the sum area of wetlands 22174 ha for 1999 and became 21987 ha for 2014 with a decrease of 187 ha, Fig. 7 shows the change detection between land cover during the period of 1999 – 2014 in Siwa.

Conclusion

In the investigated area, ground water is flowing, at high amounts, through natural springs and the uncontrolled man-made wells. The water quality from these natural springs and wells is not suitable for drinking purposes because of its high salinity. Part of this water is used in irrigation and the rest is diverted directly to the drainage network and finally to the natural lakes causing severe water logging and soil salinization. Enlargement of the lakes because of uncontrolled irrigation water and over-irrigation caused rising of the water table level causing salinization. Reclamation of these soils depends on three major factors: soil property, quantity and quality of irrigation water and construction of adequate drainage system.

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كشف التغيرات الزمنية الحادثة فى تدهور التربة والحساسية للاخطار البيئية فى بعض اراضى واحة سيوة

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يهدف هذا البحث إلى تقييم خصائص التربة فى بعض الاراضى المختارة فى واحة سيوة و تقييم تدهور التربة. المساحة الكلية المدروسة 52990 هكتار والدراسة كشفت عن وجود سبع وحدات فيزيوجرافية هى: الفرشات الرملية – الكراديد – المسطحات القلوية – الاحواض الترسيبية و التجميعية – اقدام المنحدرات الجبلية و التلالية. تم حفر قطاع واحد فى كل وحدة فيزيوجرافية. منذ البدء فى زراعة سيوة ظهرت العديد من المشاكل التى تتضمن النحر الريحى و ملوحة التربة وقلونتها و الجفاف ارتفاع منسوب الماء الارضى وتمدد الاجسام المائية. واخطار النحر تكون من عديمة الى شديدة جدا واخطار الملوحة ما بين قليلة الى شديدة جدا. واظهرت النتائج ان ملوحة التربة ارتفعت بمقدار 85.7% من المساحة الكلية للمنطقة المدروسة والتى تمثل حوالى 27610 هكتار. واخطار الصودية تكون ما بين قليلة الى شديدة جدا وارتفعت الصودية فى منطقة الدراسة بنسبة 71.3% من المساحة الكلية والتى تمثل حوالى 22970 هكتار. واخطار ارتفاع مستوى الماء الارضى تتراوح ما بين متوسطة الى شديدة وارتفع مستوى الماء الارضى بنسبة 70.6% من مساحة الارض الكلية والتى تمثل 22740 هكتار. والتغيرات الزمنية الحادثة بين عام 1999 وعام 2014 اظهرت زيادة فى المساحات الزراعية بمقدار 14616 هكتار والتمدد فى مساحات البحيرات والاجسام المائية بمقدار 31900 هكتار والزيادة فى الاراضى الملحية بقدار 94 هكتار وقلت مساحات الاراضى المبتلة بمقدار 187 هكتار.