Characterization and Assessment of Land Capability and Suitability for Some Soils at Al Jabal Al-Akhdar Region, Libya

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ABSTRACT

The characterization and evaluation of land are essential tools for proper planning and sustainable agriculture development. Al Jabal Al Akhader region at the north east of Libya has a considerable potential for agriculture activity. The current work was carried out to characterize the main soil properties and evaluate the land capability and suitability for some crops in Aluiseata area at the middle of Al Jabal Al Akhader region.

The data showed that the area is characterized by absence of diagnostic horizons except ochric or plaggen epipedon and argillic horizon. Considerable area has clayey followed by clay loam texture. The chemical analysis revealed that the soil is non saline and non alkaline with low $CaCO_3$ content (< 2 %) in most of the area. Concerning the nutritional properties, the soil has relative low organic matter content (1.7 – 2.92 %) and low available N, while available P and K differ in wide range. The soils are classified as Haploxeralfs, Rhodoxeralfs, and Xerochrepts.

Regarding to land capability and suitability assessment, data showed that the area lies in class 2 (good) and class 3 (fair) with erosion risk and / or soil properties as limiting factors. Data exhibited also that most of the area (83.5 to 86.4 %) are marginally suitable (S3) for Wheat, Alfalfa and Sunflower. Also, significant areas (47.6 – 62 %) are marginally suitable for Corn, Melon, Potato and Cotton, while considerable areas (21.5 – 44.6 %) are moderately suitable (S2) for these crops. Accordingly, these crops are recommended to be cultivated in this area. In contrast, most of the area is either conditionally suitable (S4) or potentially suitable (S5) for peach, citrus and olive. The limitation factors are mainly clayey texture in most of the area in addition to profile depth; carbonate content and alkalinity in some areas. Suitability classes based on data of weighted average of soil profile have almost same trend as those explained from the upper horizon data only.

Key words: Al Jabal Al-Akhdar, mapping units, land capability, land suitability,

INTRODUCTION

The rapid increase in the population in the last few decades represents a serious problem and needs to keep balance between food production and population projection. Therefore, much attention must be paid to evaluate land resources and provide the decision makers with essential data which help in the proper planning of land use and sustainable agriculture development. Land evaluation refers to the assessment of land performance when used for specified purposes (Sys *et al,* 1991).The term land capability is widely used to indicate the inherent potentiality of land to perform at a given level for a general use. On the other hand, land suitability is the fitness of a given type of land for a defined use. It indicates the adaptability of a given area for a specific kind of land use (FAO, 1976)

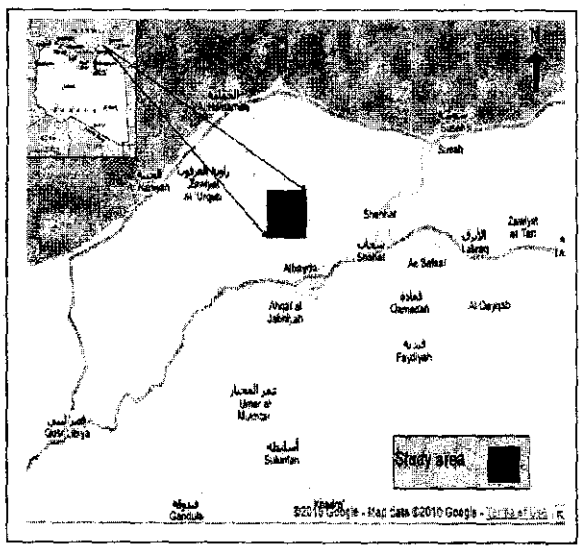
There are many models for the computing the land capability and suitability classes. However, Micro LEIS (De la Rosa, 2000) is one of the most widely used models in the assessment of land in the Mediterranean region.

Al Jabal Al Akhdar region at the north east of Libya has considerable potential for agricultural activities since the natural resources are promising. The available studies about this area are relatively limited. Thus, more investigation should be done to help in the sustainable development of this area. In this concern, land evaluation is very helpful.

Hamed (2002) applied Micro LEIS to evaluate some Libyan soils around Benghazi city and reported that the soils belong to capability classes C2 and C3 with erosion risk and soil as limiting factors. Suitability classes were also calculated for six crops, namely wheat, melon, corn, olive, citrus and alfalfa. He found that depth, texture, carbonate content and drainage are the main limiting factors.

This study aims to characterize the main soil properties and evaluate the land capability and suitability for some crops in Aluiseata area at the middle of Al Jabal Al Akhdar region, Libya (Map-1).

The studied area occupies about 25 km^2; and lies between latitudes 32°-48' and 32° 51' N, and longitudes 21° 41' and 21°44' E. The elevation ranges between 285 and 400m ASL.



Map 1: Location of the studied area.

The soils of the studied area were derived from limestone (Hey, 1956). The main climatological data are illustrated in Table (1)

Materials and methods

Twenty-eight soil profiles were dug and described morphologically according to FAO (2006). Soil samples were collected from the subsequent horizons according to morphological variations for laboratory analysis.

The collected soil samples were air dried and gently ground, then sieved through a 2 mm sieve to separate the fine fraction. The following analyses were carried out:

- Mechanical analyses to determine soil texture using Pipette method (Page *et al.* 1982).
- Saturated soil paste was prepared and extracted using a suction pump. Electrical conductivity (EC) was measured in the extracted solution.
- Total calcium carbonate ($CaCO_3$%) was determined by calcimeter (Page *et al.* 1982).
- Organic carbon was determined according to Walkley and Black rapid titration method (Jackson, 1973).
- Exchangeable calcium, magnesium, potassium, and sodium were determined by ammonium acetate (FAO, 1970). Exchangeable Sodium percent (ESP) was also calculated.
- Available nitrogen was extracted using 2 M KCl, and then determined by micro-Kjeldahl (FAO, 1970).
- Available phosphorus were extracted by ammonium bicarbonate - DTPA solution according to Soltanpour and Schwab (1977) and then determined colorimetrically with ammonium molybdate (Jackson, 1973).
- Descriptive statistical analyses were carried out for the different soil properties using SYSTAT12 program.
- Land capability and suitability assessment for some field crops (wheat, corn, cotton, sunflower), fruit trees (peach, citrus, olive), vegetables (potato, melon) and fodder crops (alfalfa) were carried out using MicroL EIS program (De la Rosa, 2000) to determine the classes and the limitation factors. The rating range and their indices were identified according to Storie (1964) and followed the criteria of FAO (1983). The crop requirement based on the data introduced by Sys *et al.* (1991).
- Maps for the distribution of the different Land capability and suitability classes of the some crops as well as their area were created using ArcGIS 9.3.

RESLUTS AND DISCUSSION

Soil characterization

The morphological description of soil profiles indicated that the soil is characterized generally by the absence of diagnostic horizons except ochric or plaggen epipedon and argillic horizon at subsurface. Presence of rock fragments was observed either at the surface or at different depths. The profile depth in most of the area ranged between 55 and 65 cm. The texture is clayey followed by clay loam, silty clay loam and silty clay. Sand, silt and clay content differ largely from about 9.30 to 48, 16.50 to 42.20, and 24.6 to 55.7, respectively (Table 2). Data in Table (2) showed that the soil is generally non saline and non alkaline since EC dose not exceed 0.78 dS/m and ESP<15%.$CaCO_3$ content is <2% except very small scattered areas with maximum 14 %.

Data revealed also that the exchangeable cations followed the sequence: $Ca^{++} > Mg^{++} > Na^{+} > K^{+}$ with ESP ranged between 5.44 and 14.94%.

Regarding the nutritional status, the data exhibited that organic matter as well as available N are generally low and ranged from 1.7 to 2.92 % and from 22.4 to 74.6 ppm, respectively. On the other hand, available P and K differ in wide range between 8.6 to 84.8, and 312 to 624 ppm, respectively.

Soil classification:

Depending on the morphological, physical, and chemical soil properties and based on the Key of Soil Taxonomy (Soil Survey Staff, 2006), the soils are classified at great group level as Haplxeralfs, Rhodoxeralfs, and Xerochrepts as illustrated in (Map -2).

Table-1: Mean Annual climatological data*

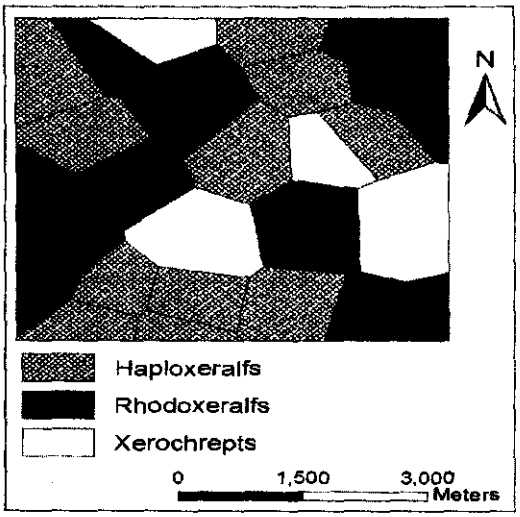
Precipitation (mm)	air temperature (C)	Evaporation (mm)	air humidity %	wind speed (km/ha)	sun light hr/day
556.98	17.15	5.51	70.02	8.67	8.34

*Source: shahaat meteorological station, average of the period 1970- 2003.

Table 2: Statistical parameters of the studied soil properties for the upper horizons.

Properties \ parameters	Min*	Max	SD	CV
Sand %	9.30	48.00	11.07	0.41
Silt %	16.50	42.20	7.53	0.25
Clay %	24.60	55.70	7.03	0.16
PH	6.19	7.65	0.36	0.05
EC ds/m	0.24	0.78	0.14	0.30
CaCO3 %	0.04	14.09	3.67	2.19
Ca meq/100g Soil	11.10	19.50	2.25	0.15
Mg meq/100g Soil	1.80	4.20	0.70	0.23
Na meq/100g Soil	1.30	2.60	0.35	0.20
CEC meq/100g Soil	17.20	25.60	2.52	0.12
OM %	1.70	2.92	0.32	0.13
N ppm	22.40	74.60	13.52	0.28
P ppm	8.60	84.80	26.35	0.61
K ppm	312	624	0.24	0.20
ESP	5.44	14.94	2.13	0.25

*Min: Minimum, Max: Maximum, SD: Standard Deviation, CV: Coefficient of Variation



Map 2: Soil classification of study area.

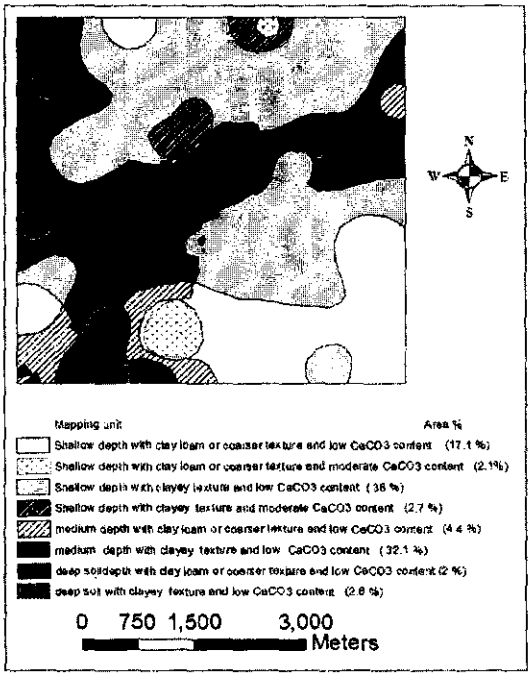
Soil mapping units

The soil mapping units of the studied area were created by overlying the geospatial distribution of profile depth, texture, and $CaCO_3$ content using ArcGIS software version 9.3.The resulted map show that the area under investigation could be grouped into 8 mapping units as shown in map 3.

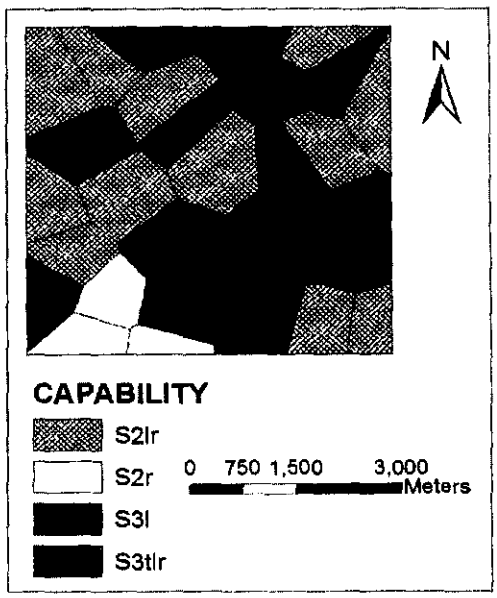
However,the following three units are the most frequent units and occupy more than 87% of the studied area:

1. Shallow depth with clayey texture and low $CaCO_3$ content: This unit occupies 38% of the total area and characterized by profile depth < 60 cm, clayey texture and $CaCO_3$ content < 5%.
2. Medium depth with clayey texture and low $CaCO_3$ content: This unit occupies 32.1% of the total area and similar to the above mentioned unit except that the profile depth ranges between 60 and 90 cm.
3. Shallow depth with clay loam or coarser texture and low $CaCO_3$ content: This unit occupies 17.1% of the total area and similar to the first unit but it has clay loam texture or coarser.

In contrast, the deep soil (>90 cm) represents only 4.5% of the area.The data indicate also that the soils which characterized by relatively moderate Ca CO_3 content (5-14%) occupies about 5% of the area.



Map 3: Soil mapping units of the studied area.



Map 4: Geo-spatial distribution of Capability subclasses (based on data of upper horizon).

Land capability

The determination of the capability classes based on soil properties of the upper horizon revealed that 47.6 of the total area lie in class C2 which reflect good capability for the major kinds of land use (FAO, 1993) while the rest of the area have relatively lower capability and belong to class C3 (fair) as illustrated in map 4. Each class has two subclasses according the dominant limitation factors. Data show that soil properties and erosion risk are the main limiting factors as shown in Table (3) and map (4).

Table 3: Area of Land capability subclass.

Land capability subclass	Hectares	Area%
C2lr	1091.842	40.8
C2r	181.811	6.8
C3l	1326.356	49.6
C3tlr	73.578	2.8

Land Capability Classes: Class C1 = Excellent, Class C2 = Good, Class C3 = fair
Limitation Factor: t = Slope, l = Soil, r = Erosion risks, b = Bioclimatic deficit

Land suitability:

The results of land suitability assessment for the tested crops are illustrated in Tables (4 & 5)and maps (5&6). The data revealed that most of the area (83.5-86.4%) is marginally suitable (S3) for wheat, sunflower, and alfalfa, while considerable areas (21.5-44.6%) are moderately suitable (S2) for corn, melon, potato and cotton. Significant areas (47-62%) are also marginally suitable for corn, melon, potato, and cotton (Table 4 and map 5). On the other hand, most of the area is either conditionally suitable (S4) or potentially suitable (S5) for peach, citrus and olive (Table 4 and map 6).

Table 4: Area percent of land suitability class for some crops*

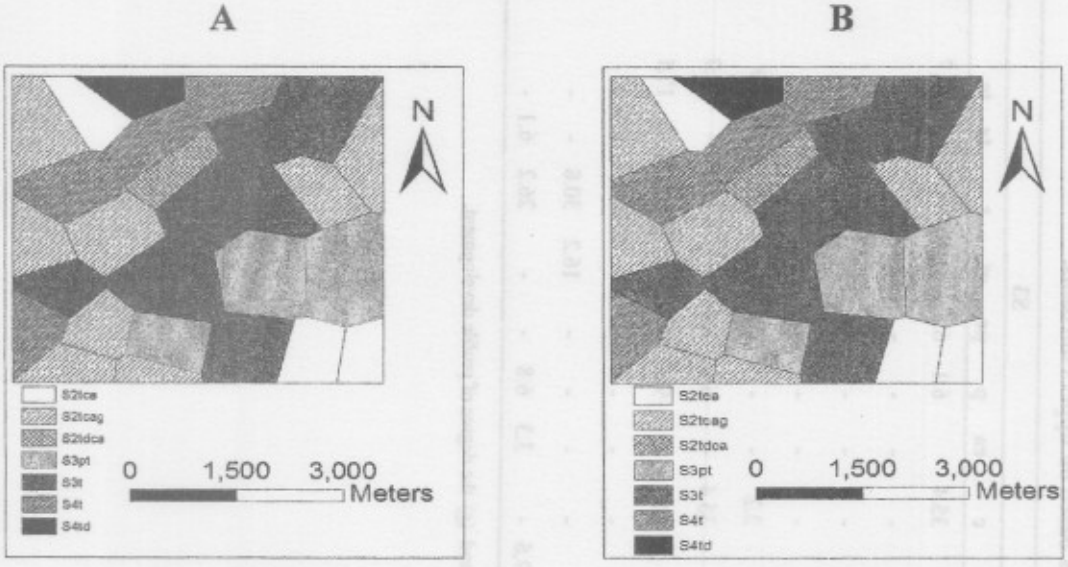
Crop \ Suitability class	S2	S3	S4	S5
Wheat	0	83.5	16.5	0
Peach	2.2	4.7	56.1	37
Citrus	2.2	4.7	56.1	37
Melon	36.4	47	16.6	0
Cotton	30.6	52.8	16.6	0
Alfalfa	0	83.5	16.5	0
Sunflower	0	86.4	13.6	0
Olive	2.2	0	55	42.8
Potato	44.6	47	16.6	0
Corn	21.5	62	16.5	0

*based on data of upper horizon.
S1: Highly suitable S2: Moderately Suitable
S3: Marginally suitable S4: Conditially suitable
S5: Potentially suitable

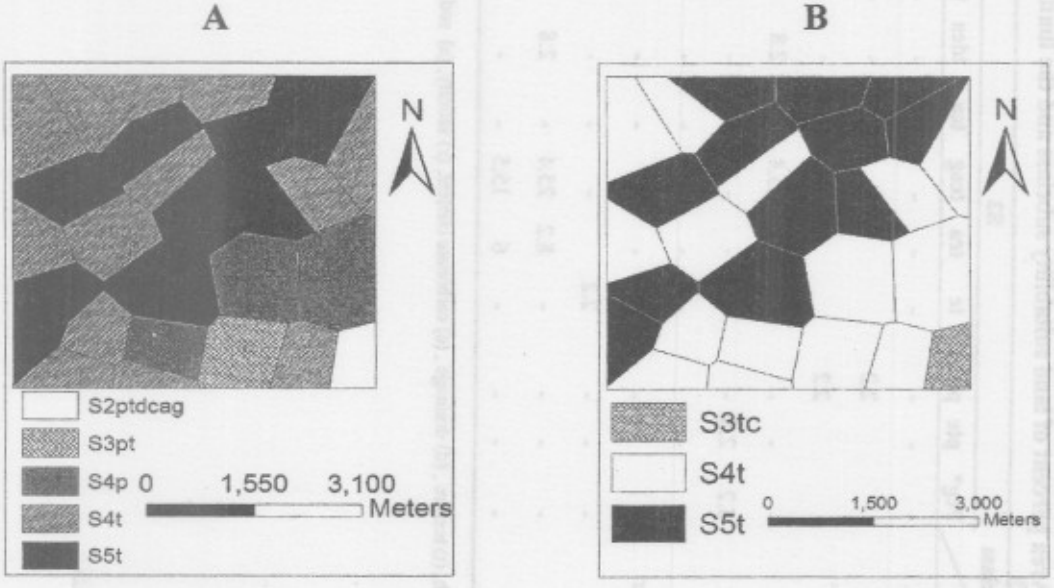
Regarding the limitation factors, the results showed that texture is the main limiting factor for most of the studied crops. In addition, profile depth, carbonate content and alkalinity are limiting factors in some areas (Table 5).

Determination of land suitability classes based on the weighted average has almost the same trend as the results of the upper horizon. Data exhibited that most of the area (83.5%) is marginally suitable (S3) for wheat, sunflower, and alfalfa, while considerable areas (21.6-37.2%) are moderately suitable (S2) for corn, melon, potato and cotton. Significant areas (43.3-59%) are also marginally suitable for corn, melon, potato, and cotton. In contrast, most of the area is either conditionally suitable (S4) or non suitable (S5) for peach, citrus and olive. Data currently show that the limiting factors are same as those determined in the land suitability studies based on the upper horizon.

According to the above mentioned data of sutability, it is recommended to enhance the cultivation of potato, cotton, corn and melon in the study area. In contrast, the citrus, peach and olive cultivation is not recommended.



Map 5: Geospatial distribution of suitability subclass for A-Melon and B-Potato.



Map 6: Geospatial distribution of suitability subclass for A-Peach and B-Olive.

Table 5: Area percent of land suitability subclass and the limitation factors based on uppers horizons.

Sui-class / Crop	S2									S3										S4					S5
	Pcg*	ptc	ptdcag	tc	tca	tcag	tcg	tdca	tdg	a	c	ca	p	pc	pt	t	ta	tc	d	c	p	t	td	t
Wheat	-	-	-	-	-	-	-	-	-	-	35.4		6.1	6.8	-	18.5	-	16.7	2.8	2.9	10.8	-	-	-
Peach			2.2			-	-	-	-	-	-	-	-	-	4.7	-	-	-	-	-	16.2	39.9	-	37
Citrus			2.2			-	-	-	-	-	-	-	-	-	4.7	-	-	-	-	-	16.2	39.9	-	37
Melon	-	-	-	-	8.2	25.4	_	2.8	-	-	-	-	-	-	16.2	30.8	-	-	-	-	-	13.8	2.8	-
Cotton	3.2	2.8	-	-	-	-	17.1	-	7.5	-	2.2	-	-	-	16.2	28.7	-	2.9	2.8	-	-	13.8	2.8	-
Alfalfa	-	-		-	-	-	-	-	-	-	35.4	-	6.1	6.8	-	18.5	-	16.7	2.8	2.9	10.8	-	-	-
Sunflower			-	-	-	-	-	-	-	-	41.1	-	9.4	6.8	-	12	-	17.1	2.8	-	-	10.8	-	_
Olive	-	-	-	2.2		-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	55	-	42.8
Potato	-	-	-	-	8.2	25.4	-	2.8	-	-	-	-	-	-	16.2	30.8	-	-	-	-	-	13.8	2.8	-
Corn	-	-	-	-	6	15.5	-	-	-	19.6	-	3.3	6.8	-	-	26.2	6.1	-	2.8	2.9	-	10.8	-	-

*(p) depth, (t) texture , (d) drainage , (c) carbonate content, (s) salinity, (a) sodium saturation and (g) the degree of profile development.

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الملخص العربى

خصائص وتقييم القدرة الإنتاجية والصلاحية لبعض أراضى الجبل الأخضر- ليبيا

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دراسة خصائص وتقييم الأراضي من العوامل الأساسية المساعدة على التخطيط المناسب وتطوير الزراعة المستدامة. وقد تمت هذه الدراسة بهدف معرفة خصائص الأرض الرئيسية وتقييم الأراضي لتحديد قدرتها الإنتاجية ومدى ملائمتها وصلاحيتها للمحاصيل الزراعية وتحديد المعوقات المحددة للقدرة الإنتاجية ولقد اتضح من النتائج:

- غياب الأفاق التشخيصية ماعدا أفق ochric أوافق plaggen السطحيين والأفق argillic الطيني التحت سطحي.
- معظم المساحة يسود بها القوام الطيني ويليه الطيني اللومي.
- أوضحت الخصائص الكيميائية أن الأراضي غير ملحية وغير قلوية وتحتوي على أقل من ٢% من كربونات الكالسيوم في معظم المساحة،كما وأن محتواها من المادة العضوية منخفض حيث يتراوح بين ١,٧ و ٢,٩٢%.
- تتميز الأرض بانخفاض نسبة النيتروجين الميسر بينما هناك مدى واسع لمحتوى الأرض من البوتاسيوم والفسفور المتيسر.
- بالاستعانة بخواص التربة المورفولوجية والفيزيائية والكيميائية أمكن تقسيم التربة تبعاً للتقسيم الأمريكي في المجموعات العظمى: Xerochrepts - Haploxeralfs - Rhodoxeralfs
- أظهرت نتائج خريطة الوحدات الأرضية من خلال عملية Overlay لخرائط توزيع عمق القطاعات الأرضية، القوام، نسبة

كربونات الكالسيوم انه يمكن تقسيم منطقة الدراسة إلى ٨ وحدات أرضية وكانت أكثر الوحدات انتشارا هي: الأراضى الضحلة الطينية ذات المحتوى المنخفض من كربونات الكالسيوم، الأراضى المتوسطة العمق الطينية ذات المحتوى المنخفض من كربونات الكالسيوم ، الأراضى الضحلة الطينية اللومية ذات المحتوى المنخفض من كربونات الكالسيوم.

- تبين من نتائج تقييم أراضي منطقة الدراسة لمعرفة قدرتها الإنتاجية Land capability باستخدام برنامج Micro LEIS بأنها ذات قدرة إنتاجية C2 (جيدة) و C3 (متوسطة) وإن المعوقات الأكثر سيادة هي التعرية وخصائص التربة.
- أظهرت نتائج الملائمة Land suitability باستخدام برنامج MicroLEIS إن ٨٣,٥- ٨٦,٤% من المساحة المدروسة S3 (حدية الملائمة) بالنسبة لمحاصيل القمح، البرسيم وعباد الشمس. بينما ٢١,٥- ٦, ٤٤ % من المساحة S2 (متوسطة الملائمة) بالنسبة لمحاصيل الذرة، البطيخ، البطاطا والقطن ، بالإضافة إلى ٤٧,٦-٦٢% من المساحة حدية الملائمة لهذه المحاصيل ومعظم المساحة (٩٣,١-٩٧,٨ %) S4 منخفضة الملائمة أوS5 (غير ملائمة حاليا) لكل من الخوخ، الموالح والزيتون، وكانت العوامل المحددة للملائمة هي القوام الثقيل في معظم المساحة ، عمق القطاع، كربونات الكالسيوم والقاعدية في بعض المساحات.
- تبين أن تقدير الملائمة باستخدام قيم المتوسط الموزون للقطاع الأرضى أوالأفق السطحي تعطي نفس النتائج لقدرة الأرض على الإنتاجية ومدى ملائمتها للمحاصيل المختلفة.