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LAND EVALUATION FOR COTTON CULTIVATION IN THE SOUTH AL_JEZIRA IRRIGATION PROJECT - IRAQ BY USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS

Uzaktan Algılama ve Coğrafi Bilgi Sistemleri Kullanılarak Güney Cezire Sulama Projesi'nde Pamuk Üretimi için Arazinin Değerlendirimesi

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ABSTRACT

The research aims to assess the suitability of cotton cultivation in South Al_Jezira Irrigation Project Nineveh - Iraq at the actual and in the potential after major improvements possible. By using remote sensing to classify land use and land cover, also using geographic information systems for input and storing the data to building data bank of land resources and land characteristics relate to the land evaluation, also the requirements and limitations for the cultivation of cotton in the study area, also in the processing, analysis and building computer model for the evaluated and classification of land suitability actual and potential for the cotton cultivation in the study area, to find out and display the results which showed that the actual land suitability classification for cotton cultivation in the study area Is moderate suitability S2, marginal suitability S3, which occupies area 82% and 18% respectively for each class, it is possible improvements and reclamation some of the limitation for the cultivation of cotton in the future to change the land index and land suitability classification.

Key Word: *Cotton, Remote sense, South Al_Jezira Irrigation Project.*

ÖZET

Bu çalışmanın amacı, Ninova'da (Irak) Güney El Cezire Sulama Projesi kapsamında pamuk ekiminin uygunluğunun mevcut durumumunu ve proje sonrasındaki muhtemel potansiyeli tespit etmek ve değerlendirmektir. Uzaktan Algılama metodları ile arazi kullanımı ve arazi örtüsü sınıflandırılmaları yapılabilmekte ve bu veriler coğrafi bilgi sistemleri teknolojisi kullanılarak da daha kolay saklanabilmekte, veri girişi, modelleme ve analizler yapılabilmektedir. Bu kapsamda bu çalışmada çalışma alanı

içerisinde mevcut pamuk ekim alanları ve potansiyel ekim alanları modelleme yapılarak tespit edilmiştir. Buna göre ortalama uygunluk (S2) % 82 ve marjinal uygunluk % 18 (S3) olarak tespit edilmiştir. Bunun yanında pamuk ekimindeki muhtemel gelişme ve iyileştirmeler sonucunda gelecekte arazi indekslerinde ve arazi uygunluk sınflamasındaki değişimler de tespit edilmiştir.

Anahtar Kelimler: *Pamuk, Uzaktan algılama, Güney El Cezire Sulama Projesi.*

1. INTRODUCTİON

The ability of the natural resources to provide the needs of its growing population is a fundamental issue for the international community. Limits to the productive capacity of land resources are set by climate, soil and landform conditions, and by the use and management applied to the land. Sustainable management of the land resources requires sound policies and planning based on knowledge of these resources, the demands of the use to which the resources are put, and the interactions between land and land use. Undoubtedly one of the ways to provide food for people being is to increase production in area nit with respect to its potentiality in an appropriate way. Therefore to know the land production and to allocate the land to the best and to most profitable showed be cared. The basic problem is increasing pressure on natural resources, limits to the productive capacity of land resources are set by climate, hydrology, landform, soil, and by the produce and management applied to the land.

Land valuation is to assessment the of land performance when used for a particular purpose. Cooperating the land characteristics and or land qualities of specific area, with all requirement and limitation of such use. Provides a rational basis for taking land use decisions based on analysis of relations between land use and land resources (Vink, 1975), which provides a comprehensive framework for the appraisal and planning of land resources.

The research aims to identify major land cover and land use in the South Al_Jezira Irrigation Project Nainavah governorate - Iraq using remote sensing and supplemental information. Evaluated land suitability for cotton cultivation in the study area by using computer model to comparing the cotton requirement and land characteristics, in the present

condition (actual) and in the future (potential) after major improvements using geographic information system.

The main research problem and questions are as major kinds of land use in the study, physical and human land use resources in study area, cotton requirements and land characteristics limited cotton cultivation in the study area, land evaluation improve land use and the study area. To responding about the questions above research apply remote sensing to interpretation and classification land use land cover, using Andorson and others land use land cover classification system (Anderson, & others, 1976). Depending on the Sys and others method for land evaluation ((Sys, Van Rants, Debareye1991, Sys, & Others, 1993), FAO framework for land evaluation (FAO, 1976), FAO land evaluation for rainfed agriculture (FAO, 1983) and FAO land evaluation for irrigated agriculture (FAO, 1985), Apply geographic information system to enter and storage spatial and attribute data to make data bank ready for processing and building the computer model for actual land suitability and potential land suitability for cotton cultivation in study area, display and present the results to the users.

2. Location and extent

The southern Al-Jazira irrigation project is situated in the north - west part of Iraq, in Nineveh Governorate on the right side of the Tigris River and to the south of Sinjar Mountain, it's about 70 km far from the south-west of Mosul city and to the south of Tel-Afar and Sinjar cities. Geographically it lies between latitudes of $35^{o}\ 50^{\backslash}$ N to $36^{o}\ 15^{\backslash}$ N and longitudes of $41^{o}\ 50^{\backslash}$ E to $42^{o}\ 10^{\backslash}$ E. The study area extent to 197.950 ha. Figure (2-1) and (2-2) show the location of the study area.

Figure (2-1) Location map of the study area in Iraq

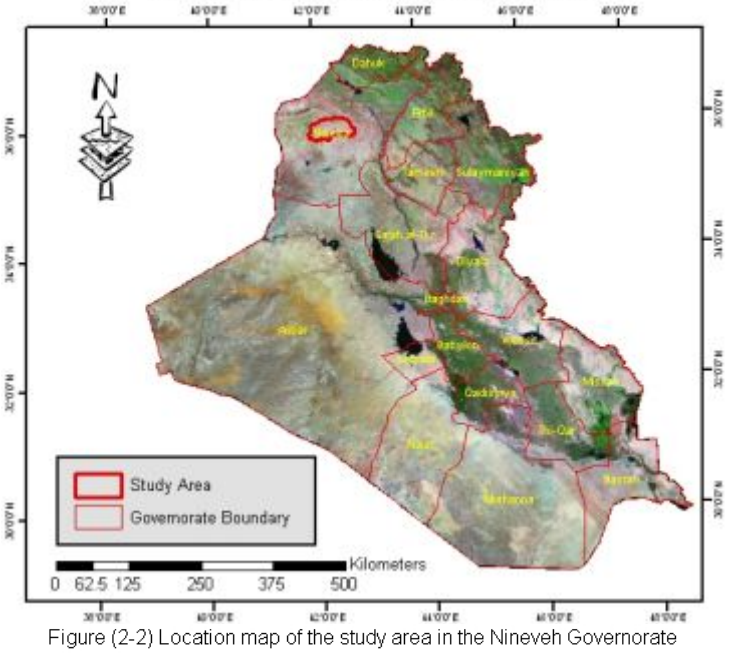
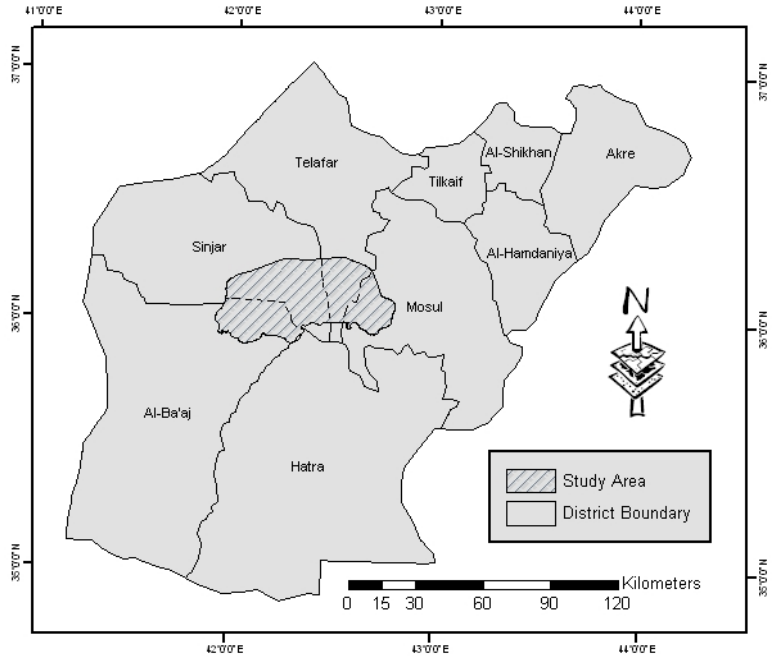


Figure (2-2) Location map of the study area in the Nineveh Governorate



3. Climatic Characteristics

The climate of study area is semi-arid subtropical Mediterranean climate which characterized by cold winter with rains and a hot dry summer. From December to March Winter, from April to spring, from June to September Summer and from October to November Autumn ((Al-Kishtaini, 1985)

There is no meteorological station in the study area, there for used three near by stations located near the study area (Snjar, Telafar, Mosul) belong to the Iraqi Meteorological Organization for the period of 1971-2002, The Meteorological data including temperature, rainfall, relative humidity, evapo-transpiration, are used for climate requirements of cotton cultivation.

3. 1 Temperature

Table (3-1) shows that the mean monthly temperature in the study area, is ranging from 20.4^{o}c Telafar to 20.2^{o}c at Mosul station, the mean maximum temperature is ranging from 27.6 ^{o} c Mosul to 24.6^{o}c Sinjar, The mean minimum temperature is ranging from 15.9^{o}c Sinjar 12.6 ^{o}c Mosul. The hottest month is July, while the coldest month is January. Figure (3-1) monthly means, maximum and minimum temperature in the study area, figure (3-2) shows temperature distribution map in the study area,

Table (3-1) *means monthly temperature*

Station		Jun.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	annual
Sinjar	Mean	6.6	8.4	12.1	17.9	24.7	30.6	34.4	33.7	29.8	22.7	14.4	8.7	20.3
	Max.	10.1	12.2	16.1	22.3	29.4	35.3	39.2	38.5	34.5	27.7	18.7	11.7	24.6
	Min.	3.6	4.7	8	13.4	19.3	25.2	29.1	28.7	24.8	18.1	10.7	5.5	15.9
Telafar	Mean	7.1	7.9	12	18.2	25	31.1	34.8	34	30	22.7	13.4	8.9	20.4
	Max.	11.4	12.6	17.3	24.1	31.9	37.9	42.1	41.3	36.9	27.7	19.9	13.3	26.4
	Min.	3.6	3.8	6.5	11.9	18.4	23.5	27.4	26.9	22.8	16.6	9.8	5	14.7
Mosul	Mean	6.6	8.5	12.5	18	27.2	30.9	34.4	33.3	28.5	21.1	13.2	8.1	20.2
	Max.	12.4	14.6	18.8	25	32.7	39	43	42.3	38.2	30.5	20.9	13.9	27.6
	Min.	2.2	3.2	6.4	10.8	16	21.1	24.9	24.1	18.8	13.1	7.1	3.6	12.6

Figure (3-1) *means monthly temperature*

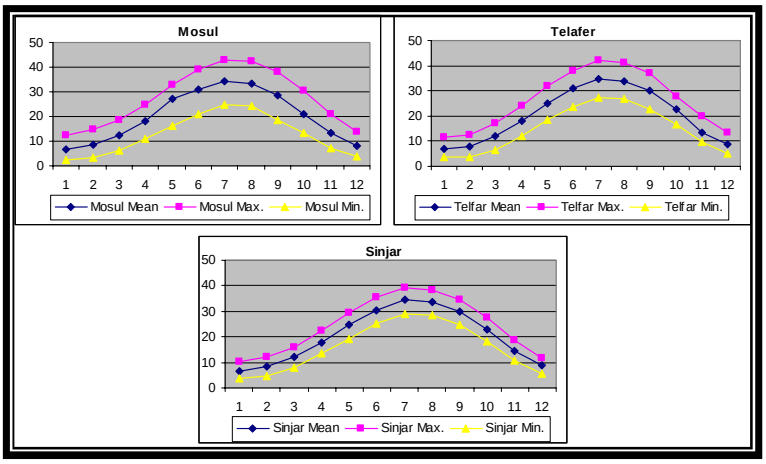
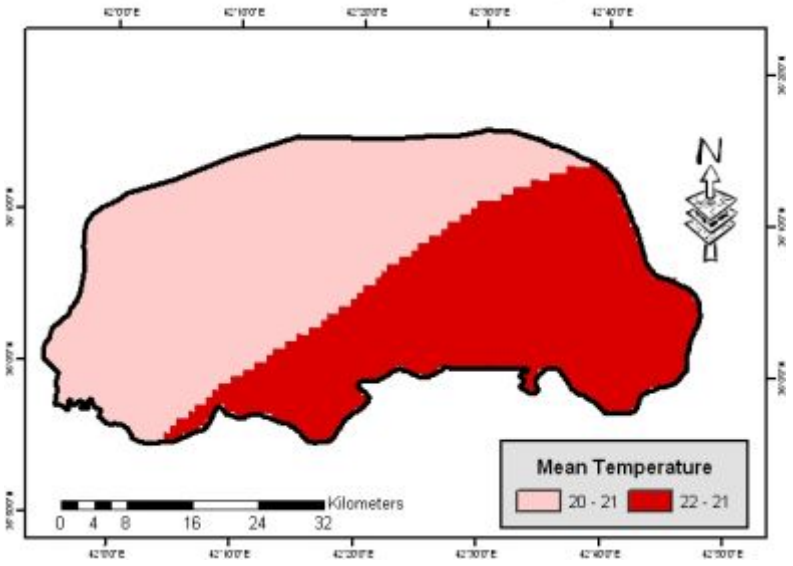


Figure (3-2) Distribution of annual Temperature



3. 2 Rain fall

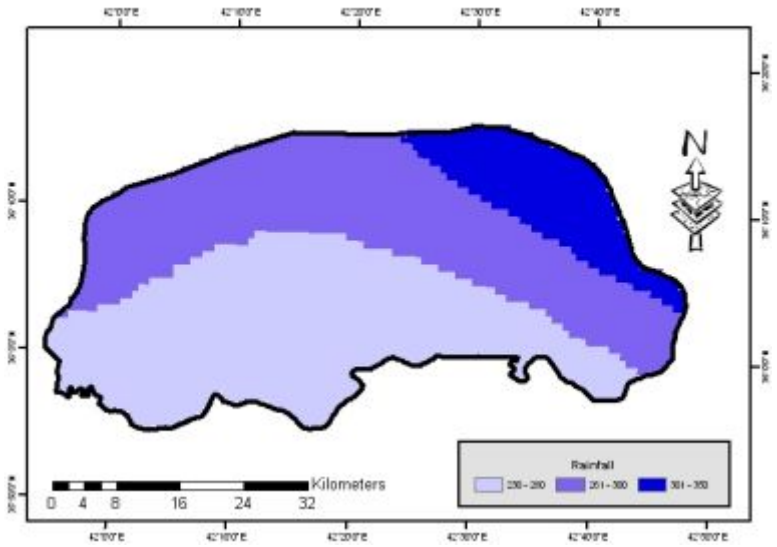
Table (3-2) show that the total annual rainfall is ranging from 380.9mm Sinjar to 331.6 Telafar. The rainfall occurs from October till

May, more than 90% rainfall is received during the November to April, The maximum monthly rainfall occurs in December and January; figure (3-3) showing rain distribution in the study area.

Table (3-2) *means monthly Ranifall*

Month / Station	Jun.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	annual
Sinjar	67.9	64.4	66.5	40.9	20.6	0.9	0	0	0.4	13	37.3	69	380.9
Telafar	59.5	52.8	62.8	39.2	14.6	0.7	0.1	0	0.7	10.8	37.5	52.9	331.6
Mosul	63.2	62.2	67.8	43.2	17	1.3	0.2	0	0.6	11.4	45.1	60.4	372.4

Figure (3-3) Distribution of annual rainfall



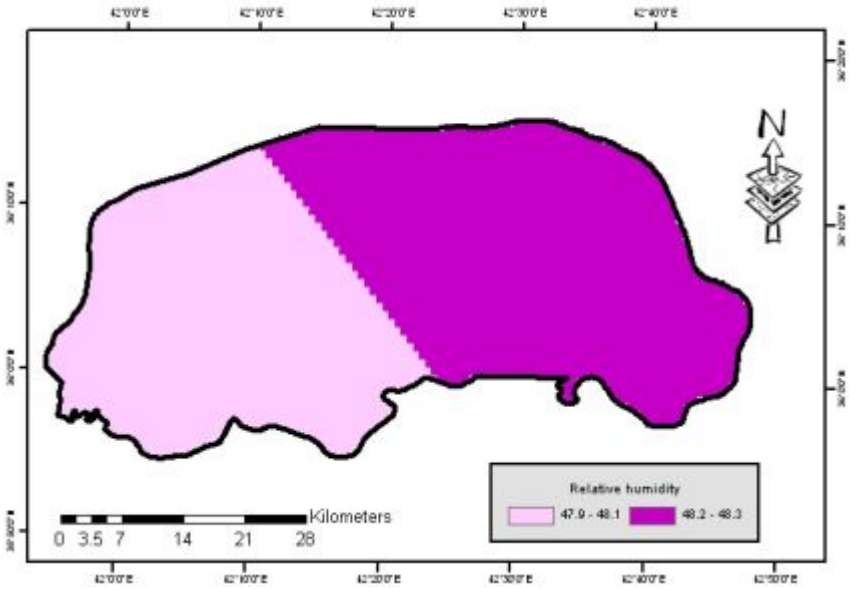
3. 3 Relative Humidity

Table (3-3) show that the mean annual relative humidity is ranging from 52% Mosul to 42 % Sinjar station. The average of relative humidity during November to April more than 60 %, while during May to October the relative humidity average is less than 30 % at both Sinjar, Telafar station, while 33% to Mosul station. Figure (3-4) showing the relative humidity distribution in the study area.

Table (3-3) *Mean monthly relative humidity*

Month / Station	Jun.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	annual
Sinjar	68	61	56	47	33	22	19	21	23	35	51	68	42
Telafar	76	70	62	52	35	24	23	24	25	38	57	72	47
Mosul	80	74	68	62	44	28	24	26	31	46	66	80	52

Figure (3-4) Distribution of annual relative humidity



3. 4 Evapo-transpiration

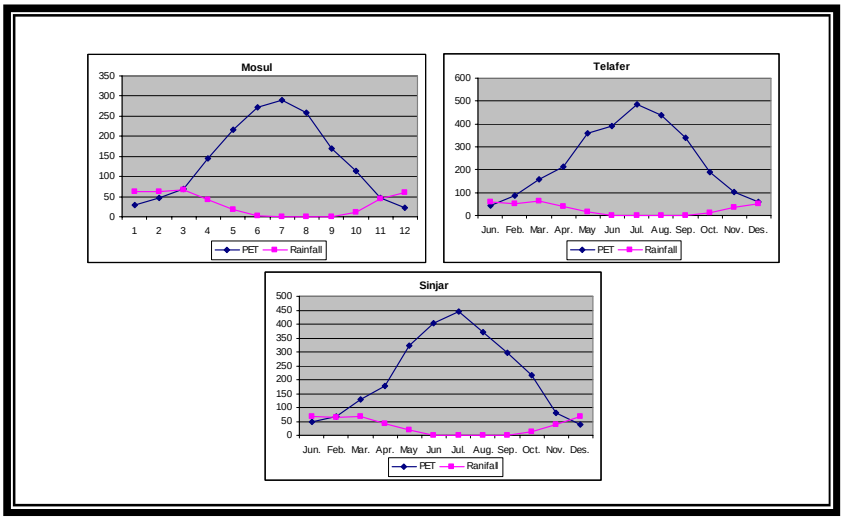
Table (3-4) shows that the mean annual evapo-traspiration (Doorenbos, and Pruitt, 1977) is ranging from 2875mm Tel afar station to 1676mm Mosul station. The average of evapo-traspiration during May to October more than 75%, while during November to April less than 25%. In order to determine the length of growing period of the study area based average monthly rainfall and evapo-traspiration (FAO 1993a) show Figure…

..

Table (3-3) *Mean monthly evapo-transpiration of the study area*

Month / Station	Jun.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	annual
Sinjar	50	67	130	177	321	403	445	370	296	216	80	39	2594
Telafar	42	87	158	215	361	392	487	440	338	191	104	60	2875
Mosul	28	47	69	145	216	272	290	258	169	113	46	23	1676

Figure (3-5) *mean monthly rainfall and evapo-transpiration*



4. Geology and Geomorphology

Geological formations to the study area belong to Lower Fars in Miocene age of Tertiary period in the northern periphery. The Upper Fars formation comprises of Sand stone with interblended silt and mudstone. The rocks in the study area generally sedimentary type formed by the process of sedimentation in the inland sea, which include Mudstone, marine lime stone, Gypsum salt and shale. The sedimentary irregular in nature and indicate different cycle of deposition, The Aeolian deposits are also common in the study area.

The stratigraphical it is seem the present material of the soils and underground stratum have a predominance of both Calcium and Gypsum salts (Mohi, 1977).

The name of Al-Jazira depending on the Iraqi broad physiographic region of Buring (Buring 37).

Figure (4-1) shows the category of the digital elevate model to the study area is ranging from 350m to 210m, reclass (ESRI…)into three classes (350-301)m, (300-251)m, (250-210)m occupies 20%, 51%, 29% respectively. The southern part is consisted of a cut up land with small valleys confined to drainage courses mostly developed due to erosional process. Undulating land with local depressions are mostly toward the northern periphery.

Figure (4-2) shows the slope map, which extracted from DEM, then reclassify into two classes depending to the USDA classify system, The first class (flat or almost flat) slope percent < 2% it covers 95.5 %, the second class (undulating) slope percent (2-8) % it covers 4.5 %.

Figure (4-1) Digital elevation Model

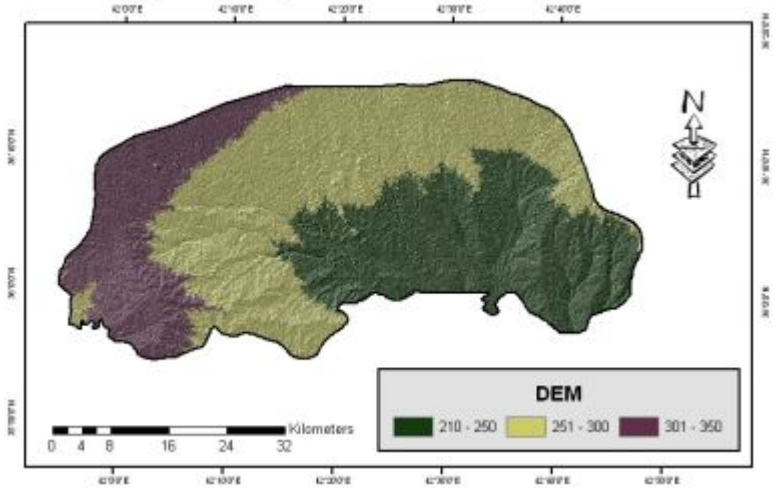
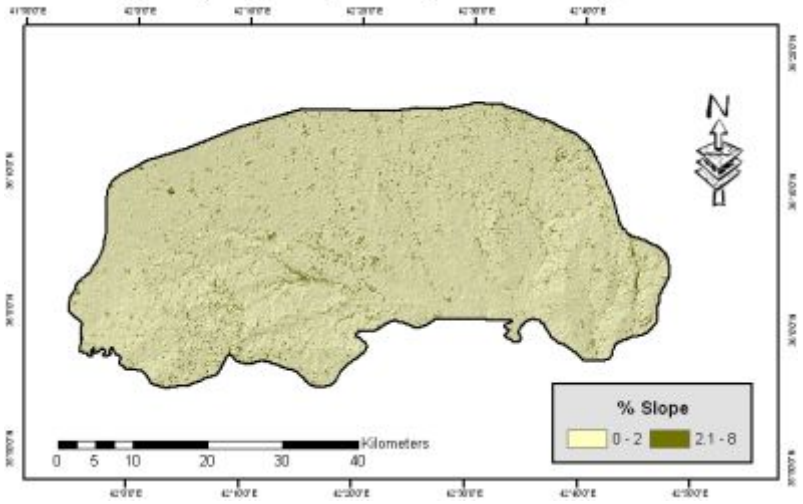


Figure (4-2) Slope map of the study area



5. Soil

Adopted to soil taxonomy USDA 1975 (USDA, 1975) for classification of soils in the study area. The basis of the profile characteristics, aridic moisture regime and thermic soil temperature, the soils of study area are placed under Order Aridisols. The presence of pedogenic horizons and Aridic moisture regime in the study area sub order Orthids. Depending upon the presence of diagnostic horizons such as calcic, gypsic and cambic in control section of soils anew encountered, three great groups represented by Gypsiorthids, Calciorthids and Cambiorthids. Depending upon the dominance of individual soil characteristics such as soil texture minerology and temperature classes, great 5 groups, soil families and soil series (Ata Aziz, 1982). Show Table (5-1) and figure (5-1) soil map in the study area.

Table (5-1) *Soil classification of the study area*

Order	Sub Order	Great Group	Sub Group	Family	Series	%
Aridisols	Orthids	Gypsiorthids	Typic Gypsiorthids	Coarese loamy over loamy gypsiferous material, gypsic, thermic	Al-Jazira	5

			Clacic Gypsiorthids	Fine over coarse, loamy, mixed, thermic	Hedhial Al-Wosta	34
		Cambiorthids	Cambic Gypsiorthids	Fine Silty, mixed, thermic	Al-Mukhtari	10
		Calciorthids	Typic Calciorthids	Fine loamy, mixed, thermic	Al-Theban	6
					Ghuzaiyl	3
				Fine silty, mixed, thermic	Al-Mahalbia	23
				Fine, mixed, thermic	Balaij	16
				Fine, carbonatic, thermic	Youstappa	3

A1.1 Series of Al-Jazira: Coarse loamy over loamy gypsiferous material, gypsic, thermic family of Typic Gypsiorthids. Typically has Brown to dark Brown color, Silt Loam surface soil. Brown to dark Brown and reddish Brown, Silt Loam, subsoil. Well drained soil, depth is shallow. Occupied 5% of the total area.

A1-2 Series of Hedhial Al-Wosta: Fine over coarse, loamy, mixed, thermic family of calcic Gypsiorthids. Typically has Dark yellowish Brown, Silt Loam surface soil. Dark yellowish Brown, Silt Clay, subsoil. Well drained soil, depth is very deep. Occupied 34% of the total area.

A1.3 Series of Al-Mukhtari: Fine silty, mixed, thermic family of cambic Gypsiorthids. Typically has Dark Brown, Silt Loam surface soil. Brown to dark brown, Silt Clay, subsoil. Well drained soil, depth is moderately deep. Occupied 10% of the total area.

A2.1 Series of Al-Theban: Fine loamy, mixed, thermic family of Typic Calciorthids. Dark yellowish Brown, Silt Loam surface soil. Brown to dark brown, Silt Loam, subsoil. Well drained soil, depth is deep. Occupied 6% of the total area.

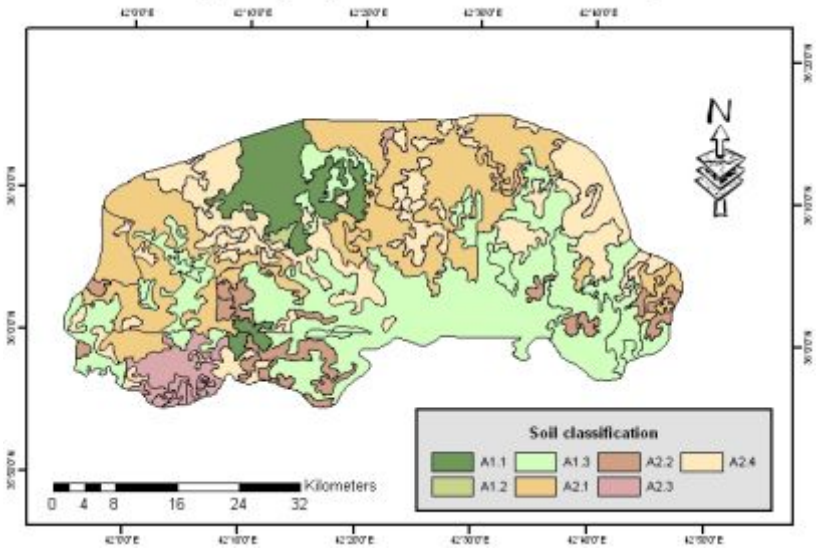
A2.1 Series Ghuzaiyl: Fine loamy, mixed, thermic family of Typic Calciorthid. Dark yellowish brown, Silt Loam surface soil. Yellowish Brown, Silt Loam to Silt Clay Loam, subsoil. Well drained soil, depth is deep. Occupied 3% of the total area.

A2.2 Series of Al-Mahalbia: Fine silty, mixed, thermic family of Typic Calciorthids. Dark yellowish brown, Silt Loam surface soil. Brown to dark brown, Silt Clay Loam, subsoil. Well drained soil, depth is very deep. Occupied 23% of the total area.

A2-3 Series Balaij: Fine, mixed, thermic family of Typic Calciorthids. Brown to dark brown, Silt Loam surface soil. Brown to dark brown, Silt Clay Loam, subsoil. Well drained soil, depth is very deep. Occupied 16% of the total area.

A2.4 Series Youstappa: Fine, carbonatic, thermic family of Typic Calciorthids. Dark yellowish brown, Silt Loam surface soil. Yellowish brown, Silt Clay Loam and Silt Loam, subsoil. Well drained soil, depth is very deep. Occupied 3% of the total area.

Figure (5-1) Soil classification map



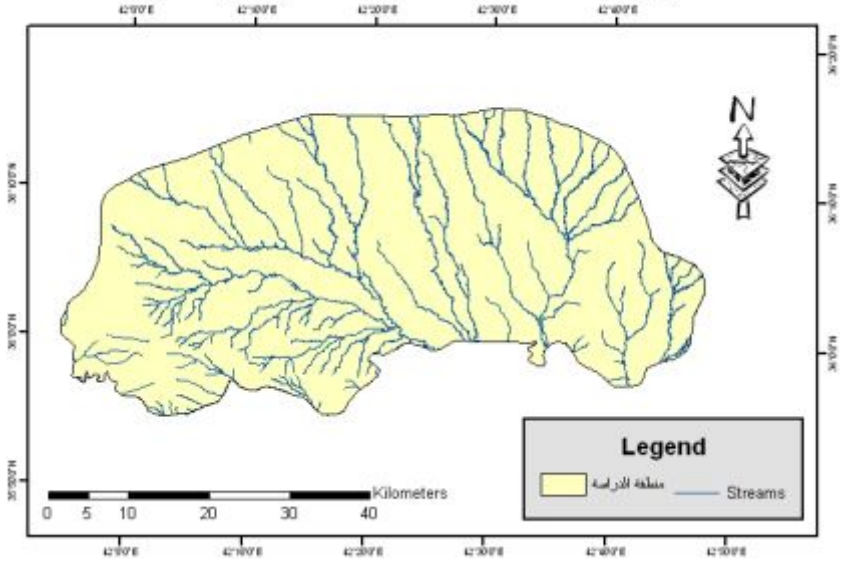
6. Hydrology

The rain is the main resource of the agriculture in winter season (winter and spring), and it is the main resource for the surface water which gather in the valleys. The study area occupied the upper part of Al-Thurthar valley (stream), the area cuts by many of valleys. The most important of them is AL-thurthar valley occupies the eastern parts and Abadan valley occupies central parts, and Abrah valley occupies western

parts of the study area. The general pattern of the drainage is the dendritic reflects the homogeneous of the rocks and the soil, Show Figure (6-1).

The ground water is the main resource of the water when the surface water is unavailable for agriculture in the summer season. The water table ranges from 2.5m to more than 5m.The wells differ from each other by it is deepness, the power of production and the amount of salt. The manual and the mechanical wells are deeper in the western parts than the other parts, the depth average is about 7.4m and 128m sequence. The production average is about 6 liters / Sec. The amount of salt dissolved in the ground water especially Sulfate and Calcium carbonate is about 4084 mg/ liter (Araim, 1983).

Figure (6-1) Streams map of the study area



7. Natural vegetation

Depending on the climate characteristics, topography, soil …etc. the prevailing for zerophytic type of vegetation which commonly occurred in the study area. The density of vegetation varies from slight to moderate. The undergrowth is consisted of some bushy shrubs and grasses which have profuse growth during winter rainy season while they

disappear during dry summer. The influence of human activities including that of sheep and goat on the natural vegetation is also noticed in the area. The main species that are observed in the area along with their local and botanical names are given below (Guest, 1966), show table (7-1).

Table (7-1) *Local and botanical names of the Natural vegetation*

Local Name	Nafial	Ziwan	Rasob	Agol	Shoke	Shofan	Middad	Thayel	Kaab
Botanical Name	Trifolium compestre	Cephalaril syriaca	Centallea pallecess	Alhagi maurorum	Leganychium faretum	Avena fatua	Covolvulus arvensis	Silybum marianum	Compositea cundelia

8. Land use and land cover

Knowledge of land use and land cover is important for many planning and management activities and considered an essential element for land evaluation.

In this research used landsat 7 ETM+ images of April 2002 present winter cultivation and September 2002 present summer cultivation that covered the study area. Depending to the USGS land use and land cover classification system (Anderson) by using image processing techniques including radiometric and geometric correction, spectral and spatial enhancement, then visual and digital multispectral image classification that integrated in expert classification.

8. 1. Image restoration

These operations aim to create amore faithful representation of the original scene. The radiometric and geometric correction was done.

8. 1. 1. Radiometric correction: To study the changes in the reflectance of ground features at different times, in such application it is usually to apply a sun elevation correction and an earth – sun distance correction, by using radiometric correction model for each image, show Figure(8-1) for winter season, Figure(8-2) for summer season.

Figure (8-1) Radiometric correction April 2002

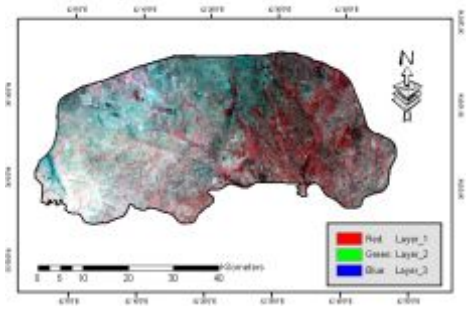
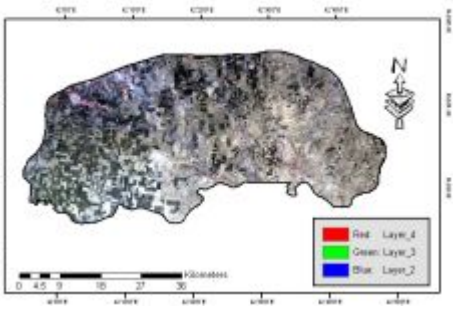


Figure (8-2) Radiometric correction September 2002



8. 1. 2. Geometric correction: Usually raw digital image contain geometric distortion that they cannot be used directly as a map base without subsequent processing. Applied to the reproject images according to the WGS 84 Universal Transverse Mercator Projection (UTM) zone 38 N by using nearest neighbor resampling approach, for each season and for all bands.

8. 2. Image enhancement

The objectives of image enhancement are to create new images from the original image that for particular application, in order to increase the amount of information that can be visually interpreted from the data (Gonzalez and Wintz, 1977). Image spectral and spatial enhancement technique is done, to improve its quality and its visual impact for human eye.

8. 2. 1. Normalized Difference Vegetation Index

Vegetated areas have a relatively high reflection in the near infrared and allow reflection in the visible range of the spectrum by NIR/Red ratio, the flowing. Normalized Difference Vegetation Index (NDVI) is based on the reflectance properties of vegetated area as compared to the other ground cover types. Simple formula was used to generate NDVI map for identification of vegetation cover:

NDVI = (NIR band – R band) / (NIR band + R band)

Where NIR band is ETM spectral band 4 and R band is ETM spectral band 3 (Jensen, 2000).

Show Figure (8-3) NDVI for winter season and Figure (8-4) NDVI for summer season. An after determination of NDVI, the density

slicing classification was applied for differentiating between covers with varying vegetation densities.

Figure (8-3) NDVI April 2002

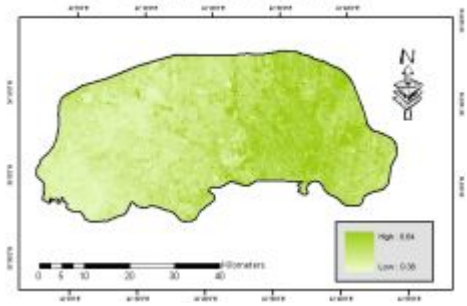
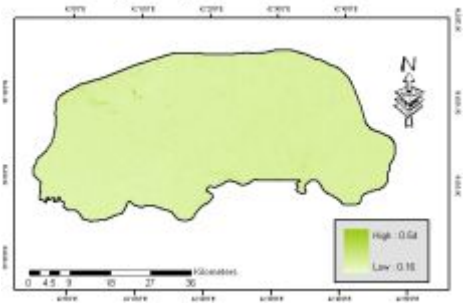


Figure (8-4) NDVI September 2002



8. 2. 2. Resolution Merge

These techniques are often used to produce high resolution, multispectral imagery. This improves the interpretability of the data by having high resolution information which is also in color. Resolution merge technique is done to make a raw image better interpretable, multispectral imagery has the lower spatial resolutions for Landsat TM 30m, with higher spatial resolution for Landsat TM 10m imagery, principal component method, nearest neighbor resampling technique. Show figure (8-5) for winter season, and figure (8-6) for summer season.

Figure (8-5) Resolution Merge April 2002

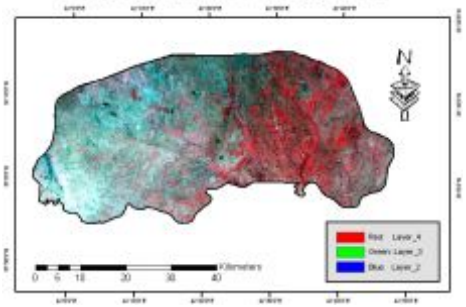
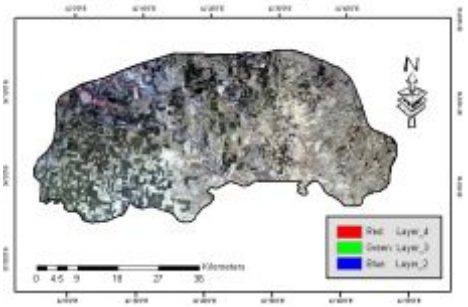


Figure (8-6) Resolution Merge September 2002



8.3. Image Classification

The objective of this operation is to automating the identification of feature in the scene. This generally involves the analysis of multispectral image data and the application of statistically based decision rules for determining the land cover identity for each pixel in an image.

8.3.1. Unsupervised Classification: In the unsupervised approach the image data are classified then determines the land cover identity (Lillesand, and other 2004). Classification is done automatically using digital image data. Figure (8-7) show unsupervised classification map for winter season about 83% of the winter 2002. Most of area was occupied by agriculture land; there remaining area was under range land. Figure (8-8) show unsupervised classification summer 2002, about 52% of the total area was occupied by agriculture land; the remaining area was under fallow land.

Figure (8-7) Unsupervised classification April 2002

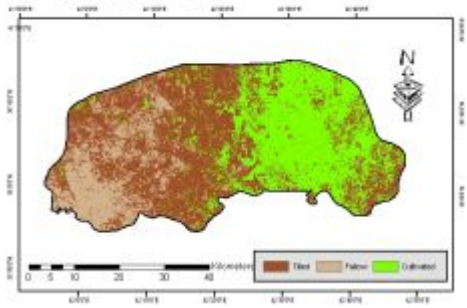
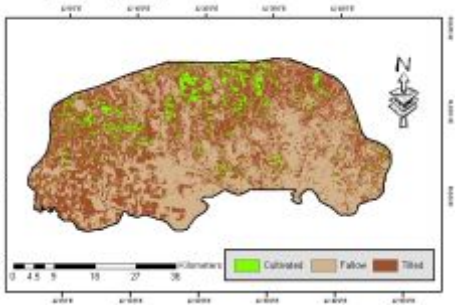


Figure (8-8) Unsupervised classification Sept. 2002



8.3.2. Supervised Classification: Supervised classification involves a training step followed by a classification step (Campel, 1996). Supervised classification is the procedure that user predefines spectral classes, training areas were done based on field observation knowledge, after construction of the training areas, the image was classified using maximum likelihood classifier.

Figure (8-9) show supervised classification map winter 2002, about 79 % of the most area was occupied by agriculture land, the remaining area was under rangeland. Figure (8-10) show supervised

classification summer 2002, about 46 % of the most area was occupied by agriculture land, the remaining area was under fallow land.

Figure (8-9) Supervised classification April 2002

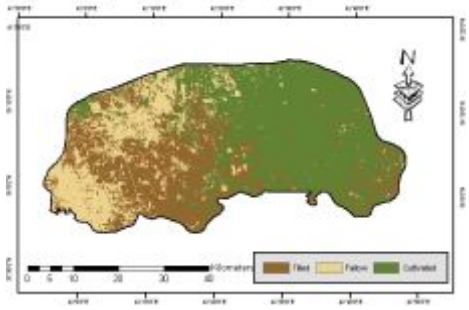
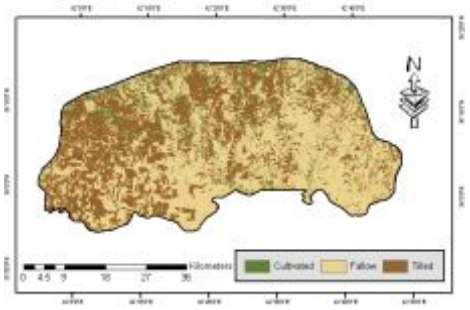


Figure (8-10) Supervised classification Sept. 2002



8.3.3. Knowledge Engineer Classification: The knowledge engineer provides the interface for an expert with first land knowledge of the data and the application to identify the variables, rules and output classes of interest and create the hierarchical decision tree (ERDAS, 2005ab), depending to the visual interpretation then convert the vector land cover land use classes to the raster by using ArcGIS. Building land use land cover classes model by using ERDAS imagine.

To classification accuracy assessment by using error matrix, which compare the land use classes and their area, over all accuracy 90% average accuracy 91% average reliability 89%. Fig (8-11) shows distribution land use classes map, table (8-1) shows land use classes as follows:

1- Urban or Built-up Land: Built up land included towns, villages, transportation routes, occupied 4% of total area.

2- Agriculture land: Agriculture land included winter crops wheat and barley grown in a system of dry land farming occupied 32% of the total area, summer crops cotton... etc, with the mixed crops under well irrigation occupied 0.02% of the total area, and fallow land occupied 42% of the total area.

3- Range land: Range land consisted of some bushy shrubs and grasses which growth during winter season occupied 20% of the total area.

4- Water: Water included streams and seasonal valleys occupied 2% of the total area.

Figure (8-11) Knowledge Engineer land use map 2002

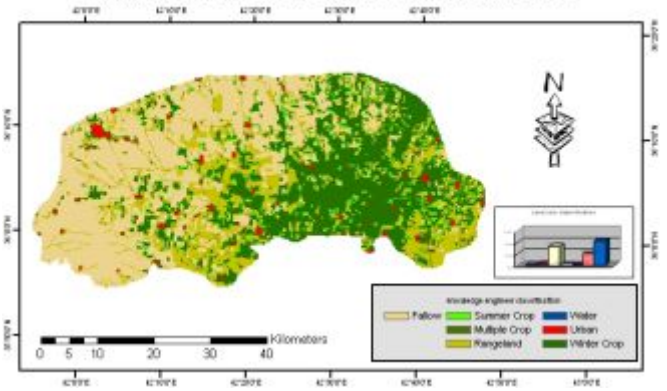


Table (8-1) *Land use classification of the study area*

Level I		Level II		Level III	
Class No.	**Class Name**	**Class No.**	**Class Name**	**Class No.**	**Class Name**
1	Urban or built-up land	**14**	Built-up land	**112**	Town and villages
			Transportation	**141**	Paved routes
				142	Unpaved routes
2	Agriculture land	**21**	Cropland	**211**	Winter crops
				212	Summer crops
				213	Multiple crops
				214	Fallow
5	Water	**51**	Streams and canals		

9. Cotton Requirements

Tropical and subtropical herbaceous plant belonging to the mallow family, (Genus Gossypium, family Malvaceae). Although the actual origin of cotton is still unknown, archaeological findings indicate its use in cloth 3000 BC in India. Cotton is an important textile fiber by which a unique and comfortable fabric is made (Gordon, and Hsieh, 2007). Cotton enrolled the most portions in the textile market. Cotton fibers are seed hairs from plants of the Malvaceae family, the tribe Gossypieae, and the genus Gossypium.

Cotton grown in the study area, but it is extent is few cultivated as summer crop under well irrigation. Cotton requirement of climate, the air temperature range for cotton growing is (15 - 40) ^{o} c; the optimum air temperature is (24 – 34) ^{o}c. An air temperature of > 40 ^{o}c may cause damage, depending on the moisture availability. The minimum temperature for germination is 15^{o}c (Marani, and Amirar, 1970). Cotton is not tolerant to frost. The required mean annual precipitation is (500-1000) mm; the optimum annual precipitation range is (900- 1200) mm, the rainfall should be well distributed during the growing cycle. A modrate relative air humidity < 65% is desirable at the ripening stage (Jassim, 1981). The land form should be flat if optimal conditions are considered. Cotton dose not tolerate flood, well drained soil are preferred on other drainage classes a moderate soil moisture about 45% is desirable at the establishment period (Mali, Varade and Musande, 1977). Cotton grows on soils with large variety of texture, though preference is given to silt loam to clay soil. The available soil depth should be at least 25 cm; optimal conditions are reached as the soil depth exceeds 100 cm. Cotton is moderately tolerant to calcium carbonate and gypsum. Cotton develops well on moderately fertile soils the optimal pH range from 6 to 7.5, and marginal range from 5 to 8 (Sys, and Riquire, 1979) Cotton is considered as tolerant to salinity (Sexton and Gerard, 1982).

10. Land suitability for cotton

The relative suitability of land for cotton is given in the table (10-1), figure (10-1) and (10-2) show distribution of actual and potential land suitability for cotton in the study area.

The climate characteristics, temperature and relative humidity compare with the cotton growing cycle requirements. There are not important limitations, only slight limitation of the mean day and night temperature of flowering stage.

Slope is the most important topographical factor. The slope of study area is flat or almost flat, there for these are not important limitation, only one land unit A2-1 Chuzaiyl has slight limitation for cotton cultivate.

The wetness situation of land units in the study area for cotton cultivation, there are not flooding or drainage limitations in the study area.

The texture evaluated of the profiles is subdivided into sections, and depth correlations are used. There is not much textural variation in the soils; silt loam and silt clay loam, there are not important limitation in the study area.

The soil depth in the study area, the soils are continuous and some have more or less consolidated gypsiferous layer containing more than 25% gypsum and minimum thickness is more than 30cm. there are not important limitation in the study area, accept A1.3 Al-Mukhtarin and Al-Jezira land units have slight to severe depth limitation.

The calcium carbonate affects both the physical and the chemical characteristics of the soil. In this study area, the soils are calcareous in nature and have slight to severe limitation for cotton cultivate.

The gypsum indirectly affects soil physical properties; none to moderate gypsum limitation in the soils are common in the study area for cotton cultivate.

The apparent cation exchange capacity of the clay fraction in arid and semi-arid areas most soils are calcareous and have an appreciable reserve in weatherable minerals. Their apparent CEC is always more than 24cmol (+) kg^{-1} clay, there for these are not limitation for cotton cultivate.

The organic carbon content is often good expressions of the natural fertility of the soil, slight to moderate limitation are common for cotton cultivate.

The salinity in the study area, the soils are almost free from salinity, the soils have mostly less than 4 (mmhos/cm) electrical conductivity, there for these are not limitation for cotton cultivate.

The alkalinity exchange sodium percentage in the study area, the soils are almost free from ESP, the soils have mostly less than 3%, there for these are not limitation for cotton cultivate.

The degree of limitation and rating for above characteristics for all the land units in the study area have been worked out and ratings are

computed by comparing the land characteristics with the requirements of cotton, the land class can be determine in the parametric method a numeral rating to each characteristics the land indices done square root method (Khiddir, 1986), by using computer model builder in ArcGIS.

The land suitability for cotton cultivation in the study area given in above table (10-1). It is seen that two land suitability classes are common in the study area:

- Moderate suitability class (S2);

The land unit have slight to moderate limitation in the climate, topography, physical soil condition and fertility. This class included A1.2, A2.1, A2.2 and A2.3 land unites, which occupied 82% of the total area at the present situation. Potential suitability after major improvements for cotton cultivation in the study area, to raised land indices, but not change land class.

- Marginal suitability class (S3)

The land unit have slight, moderate and sever limitation in the climate, topography, physical soil condition and fertility. This class included A1.1, A1.3 and A2.4 land unites, which occupied 18% of the total area at the present situation. Potential suitability after major improvements for cotton cultivation in the study area, to raised land indices, but not change land class.

Table (10-1) *Actual and potential land suitability for cotton*

LC / LMU	Actual Suitability		Potential Suitability	
	Land Index	**Land Class**	**Land Index**	**Land Class**
A 2.2	55	S2csf	59	S2cs
A 2.1	69	S2cs	69	S2cs
A 2.4	36	S3csf	38	S3cs
A 1.2	53	S2csf	58	S2cs
A 1.3	44	S3csf	46	S3cs
A 1.1	43	S3csf	47	S3cs
A 2.1	57	S2cts	60	S2cts
A 2.3	51	S2csf	53	S2cs

Figure (10-1) Actual land suitability map for cotton

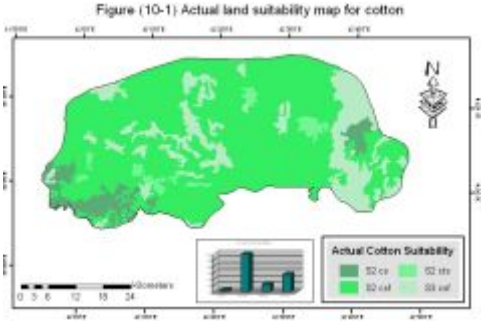
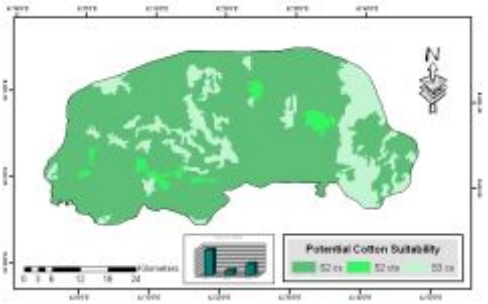


Figure (10-2) Potential land suitability map for cotton



11. CONCLUSON

The study area situation in the North-West part of Iraq, in the Nineveh Governorate. Semiarid with hot summer and cold winter with rains. The study area is consisted of old alluvial plain, with flat or almost flat topography. The rain is the main resource of the surface water in the winter; the water table ranges from 2.5 m to more than 5 m. Natural vegetations are present in the study area. The soils are well drained with loamy texture. Containing both calcium carbonate and gypsum, soil depth over gypsum is not uniform and varying considerably, three great groups represented by Gypsiorthids, Calciorthids and Camborthids are met with the study area.

Wheat and barley the main crops in the study area in the winter season, under rained condition, cotton and other crops with vegetables are also grown through wells are source of irrigation.

Depending to the landsat -7 ETM+ images of the April 2002 and September 2002 to identify major land use and land cover in the study area: the built up land, agriculture, range land and water occupied 4%, 74%, 20%, and 2% respectively of the total area.

Land evaluation and land suitability classification for cotton cultivation in the study area by using computer model (model builder) in ArcGIS is moderate suitability S2 occupied 82% and marginal suitability S3 occupied 18% of the total area, because the land unit have slight, moderate and sever limitation in the climate, topography, physical soil condition and the fertility in present situation, the improvement in the future raised land indices.

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