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Land Evaluation and Assessment of Land Cover Change Using Geospatial Techniques: A Case Study in West Samlout Area, Egypt

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THE POPULATION surge in Egypt has led to the conversion of agricultural land into urban areas, necessitating urgent agricultural expansion into new areas, particularly in the interference zone between the Nile valley and desert regions. To address this issue, this research study aims at assess the temporal and spatial land cover changes in West Samlout area, El-Minia government, Egypt using remote sensing data and to evaluate land capability and suitability for some agricultural crops. The study area, located in the Western Desert of Egypt, was analyzed using multi-temporal Landsat imagery (2011, 2016 and 2021) and Digital Elevation Models. The Soil Adjusted Vegetation Index (SAVI) was utilized to determine the spatial distribution and temporal changes of vegetation. Soil samples were collected and analyzed to determine soil attributes like depth, salinity, pH, calcium carbonate, and texture. Results showed that the vegetation areas were increased with 18.96 % during the period from 2011 to 2021. The annual rate of vegetation change was increased by 910.42 ha year-1 through the same period. Land capability evaluation results showed that the study area was grouped into three grades; Grade 3 (1105.96 ha), grade 4 (20682.83 ha) and grade 5 (967.38 ha) represented 4.61%, 86.14% and 4.03 % of the examined area, respectively. The results of land suitability analysis illustrated that mango, citrus, and olives were the most appropriate fruit crops for the investigated area, where 83.8 5 %, 74.7 %, and 71.8 % of the total area were moderately suitable (S2), respectively. Moreover, barley and wheat were found to be highly suitable field crops. The highly suitable (S1) for barley and wheat covered 77.6% and 55% of the total area were, respectively. While, onion was the most suitable vegetable crop in the study area occupied an area of 2768.4 ha (11.5 %) and 19987.7 ha (83.2 %) as highly suitable (S1) and moderately suitable (S2), respectively. With regarding to the oil crops, the finding conducted that sunflower was the highest suitable crop in investigated area occupied 1914.2 ha and 20842.0 ha as highly suitable (S1) and moderately suitable (S2), respectively. Finally, sorghum and millets, as feed crops, were the most suitable crops occupied 82.1 % and 9.2 % of the total area as high suitable (S1), respectively. Furthermore, results indicated that the soil salinity, slope, depth, and coarse texture were the most limiting criteria for suitability. Overall, this research study provides valuable information for land use planning, agricultural development, and sustainable resource management in the West Samlout area, Egypt. The results emphasize the importance of remote sensing and spatial analysis techniques in understanding land cover changes and making informed decisions for agricultural expansion and development projects.

Key words: Geospatial techniques; change detection; SAVI; land suitability; spatial distribution.

1. Introduction

Rapid population increase has led to agriculture being replaced by new buildings, roads and highways. Competition for different uses on the same parcel of land is mainly caused by changing human needs and rising population stress. Since Egypt's population has grown dramatically over the past century, primarily in the Nile valley and Delta regions, successive administrations have given careful consideration to the issue of overpopulation and how it is related to the country's ongoing need for the agricultural sector, which is growing in productivity. From this point of view, Egypt changed its focus to the expansion of numerous new agricultural areas such as the interferences zone of the Nile valley and delta with the western and eastern desert (Elimy et al., 2020; Fadl & Sayed, 2020). In order to increase the productivity of the current agricultural land and expand agricultural regions, Egypt has supported development programs. Consequently, there is an insistent need to assess the

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change of land cover as well as the land capability and suitability for the sustainable land use planning. Changes in land use and cover (LULC) are regarded as one of the most significant ecological issues that should be of global concern (Halmy et al., 2015). Change detection is regarded as an effective method for characterizing the changes seen in each land cover category as well as for environmental and agricultural planning at various scales. It is very effective tool in various applications relevant to land use and land cover (LULC) changes (Abd El-Kawy et al., 2011; Huang et al., 2019; Yousif & Ahmed, 2019). Effective assessment and monitoring of these changes can be achieved through extracting updated land cover information at a low cost and with high efficiency from data collected via remote sensing. As a result, due to the vast library of regularly occurring, high-quality images with short intervals, remote sensing is currently a prominent tool for change detection research (Farrag & Mostafa, 2006). It is crucial for improved management to have timely and reliable information on LULC change detection of the earth's surface (Abowaly et al., 2018; Elzahaby et al., 2015). Agriculture constitutes an essential component of the societal structure and economy of Egypt, serving as the foundation for many sustainable development initiatives within the country. An estimated 3.5 million hectares (3.5% of Egypt's total area) are used for agriculture and the remaining area is desert (Khalil et al., 2014). The government's priority during the previous 20 years consisted of expanding the agricultural area to improve agricultural production and quality (Khalil et al., 2014; Shalaby & Ali, 2010). Therefore, many research studies were implemented in Egypt to evaluate the change detection of land use/land cover along many areas (Abd El-Kawy et al., 2011; Bakr et al., 2010; Dewidar, 2004; El-Zeiny & Effat, 2017; Elagouz et al., 2020; Elimy et al., 2020; Elnaggar, 2013; Elzahaby et al., 2015; Ezzeldin et al., 2016; Halmy et al., 2015; Kamel, 2020; Morsy & Aboelkhair, 2021; Radwan, 2019; Yousif & Ahmed, 2019). This extracted information from change detection studies is very essential for planning and achieving policies to improve the use of natural resources whilst decreasing the impact on the environment. Many land evaluation studies stated that the Egyptian western desert has many promising areas for land reclamation and agricultural development (Abd El-Aziz et al., 2024; Elkhouly et al., 2021; Hegab, 2019; Moghazy & Kaluarachchi, 2020; Negm et al., 2021; Sawy et al., 2013; Yousif, 2018; Yousif et al., 2020; Yousif, 2019, 2024). In response to government initiatives, several of massive projects have been started to bridge the gap between the scarcity of water resources and the growing population. Recently, the largest and biggest project lunched by the Egyptian government is a new reclamation enterprise for 1.5 million acres (Feddans). The examined area which is located in west of El-Minia region is an area of a natural extension for agricultural, manufacturing, and civil activity and can be viewed as a component of this huge undertaking. The most promising desert region in Egypt's western desert that is undergoing land reclamation is thought to be West El-Minia (Rashed, 2020; Yossif & Taher, 2020; Zakarya et al., 2021) predominating in the extraction of groundwater through drilled wells (Moneim et al., 2016; Yousif et al., 2018). In this context, the primary goals of the research were; 1) To delineate the temporal and spatial land cover changes in west Samlout area, El-Minia government, Egypt using new remote sensing data, 2) to assess land capability and land suitability for some agricultural crops.

2. Materials and Methods

2.1 General description of the investigated area

The research area is situated within the western desert of Egypt and is positioned to the west of the Nile River. The study area is an extended stretch of the Samlout area, El-Minia governorate that is found west of the River Nile between longitudes 30° 26' 26" to 30° 33' 40" E and latitudes 28° 16' 20" to 28° 28' 12" N (Figure. 1). The investigated area covers an area of 24011.28 Hectares. The terrain of the research area varies significantly, with elevations ranging from 46 to 197 meters above sea level (Figure 1).

Climatologically, the researched area mainly suffers from hot, dry summers and cold winters, rainless summers, and mild winters with infrequent precipitation. The temperature in January ranges between 4.0 ˚C and 20.5 ˚C with a mean annual temperature of 12.3 ˚C. While the temperature in August ranges between 20.5˚C and 36.6˚C with mean annual temperature of 36.3 ˚C. The relative humidity fluctuates between 42% in May and over 67% in December. The average yearly precipitation varied from 23.05 to 33.15 mm, and the average daily evaporation was 4.17 ml in January to 12.2 ml in June.

Geologically, the Tertiary and Quaternary alluvial sediments that cover the study area include sand sheets, Nile silt, proto-nil, pre-nil deposits, fanglomerate, and gravel (El-Sayed, 2007; Moneim et al., 2016; Yousif et al., 2018) as described by (Conoco, 1987).

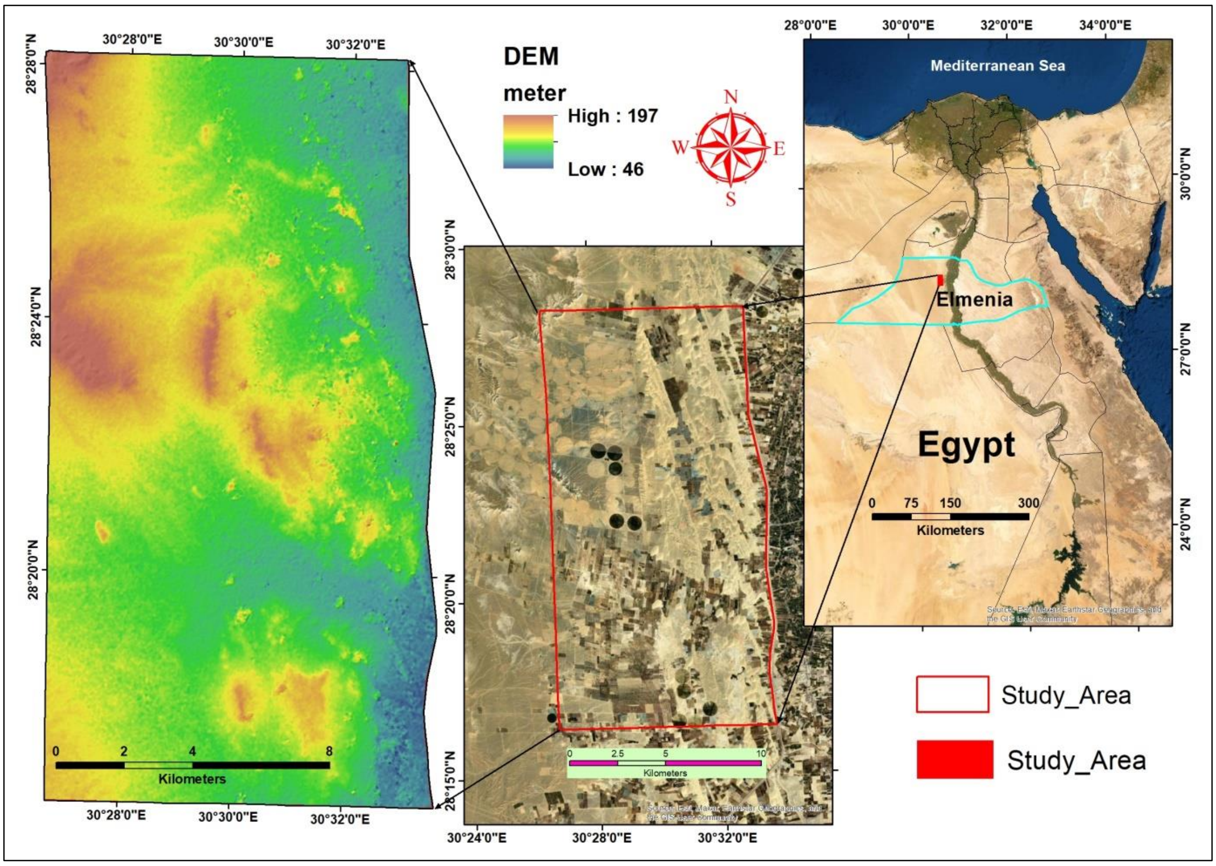

Fig. 1. Location map and digital elevation model of the studied area.

2.2 Remote Sensing Data processing

A digital elevation model (DEM) with a spatial resolution of 30 meters and multi-temporal Landsat 5, 7, and 8 images were downloaded from the Shuttle Radar Topographic Mission (SRTM) at https://earthexplorer.usgs.gov as shown in Table (1). Digital image post processing involved data subsetting, image enhancement (RGB composite and Pseudo colour display), and change detection technique was used to the statistical aspects and information. Also digital elevation model (DEM) was utilized to extract topographical data about the study area such as slope and aspect maps. All the previously mentioned methods were applied to the satellite images and DEM to characterize the investigated area using ArcGIS 10.8 and ENVI 5.2 software.

Table 1. Attributes of remote sensing data of the study area.

Source	Sensor type	Identifier
Landsat 5	TM “Thematic Mapper”	"LT05_L2SP_177040_20110415_20200823_02_T1"
Landsat-8	OLI / TIRS “Operational Land Imager /Thermal Infrared Sensor”	"LC08_L2SP_177040_20160412_20200907_02_T1"
Landsat-8	OLI / TIRS “Operational Land Imager /Thermal Infrared Sensor”	"LC08_L2SP_177040_20210410_20210416_02_T1"
DEM	SRTM 1 Arc (30x30 meter)	SRTM1N30E030V3

2.3 Vegetation cover

The Soil Adjusted Vegetation Index (SAVI), which detects the amount of chlorophyll found in leaves, was utilized to determine the density and spatial distribution of vegetation (Qi et al., 1994). The SAVI is an NDVI modification that uses a correction factor (L) to correct the impact of soil brightness in areas with little vegetation cover.

The SAVI is computed using the subsequent formula:

$$\mathrm{SAVI} = \frac{(\mathrm{NIR}-\mathrm{RED})(1+\mathrm{L})}{(\mathrm{NIR}+\mathrm{RED}+\mathrm{L})} \qquad \text{where } (0<\mathrm{SAVI}>1)$$

Where (L) is the correction factor and (NIR) is a near infrared band. Depending on the density of the vegetation cover, it varies from zero to one. L takes on a value of one at the areas with no vegetation, while takes avalue of 0.5 at the moderate vaegetation cover areas, and a value of zero at very high plant densities (Huete, 1988). According to (Xu, 2008), SAVI performs better than the NDVI in areas with less than 15% plant cover, whereas the NDVI performs well in areas with more than 30% plant cover. Therefore, SAVI index is more suitable for the study area.

2.4 Changes detection

To calculate the changes in land cover within the research area, the binary images produced from the investigated index for two consecutive years were subtracted. A comparison between each pair of the final raster images acquired from the vegetation index was done in order to determine the changes in the research area between the specified time series of 2011-2016, 2016-2021, and 2011-2021. To assess the expansion of vegetation inside the research region over the last 10 years, changes in the two specified land cover categories (bare land and vegetation) were determined for the classed maps.

2.5 Soils Samples

Two hundred soil profiles were chosen and dug to represent the investigated area (Figure 2). Different soil samples (n=428) were collected from the horizons of representative soil profiles in December 2021. Physical and chemical soil analyses were performed in accordance with the soil survey laboratory methods manual (USDA, 2014).

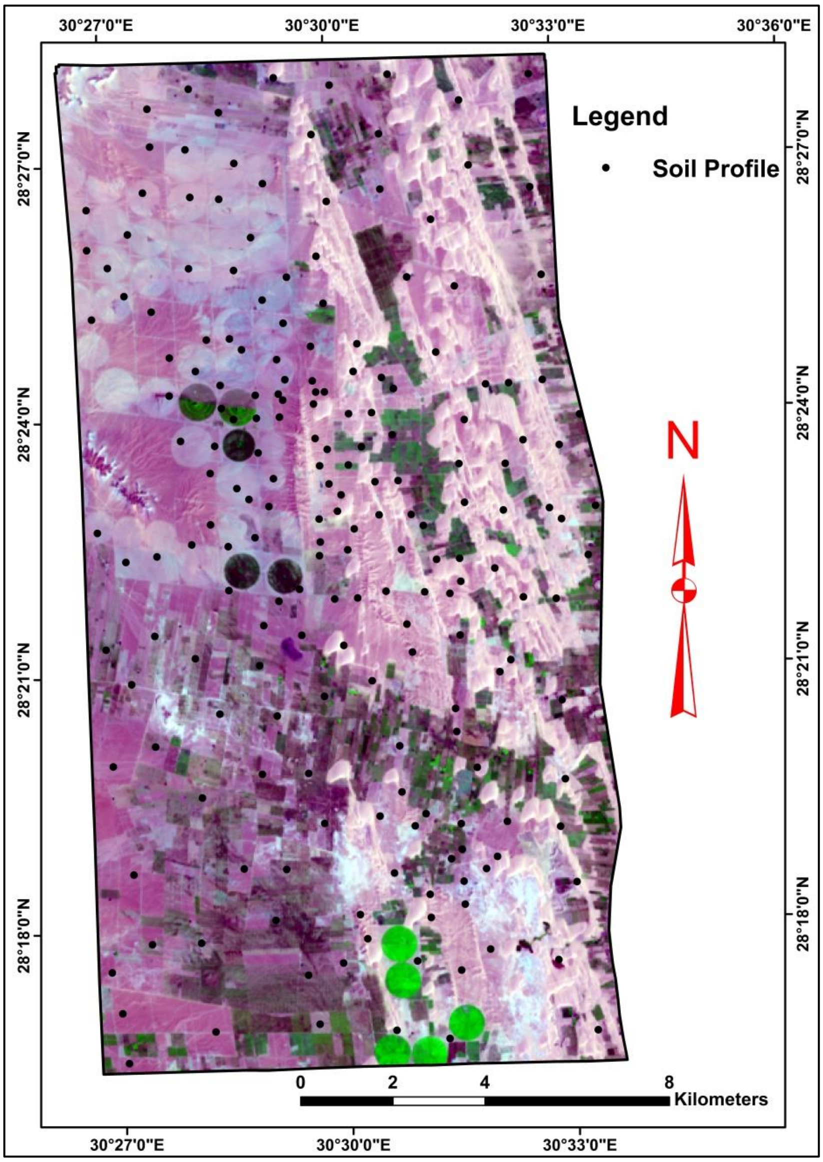

Fig. 2. Landsat-8 Image of the studied area and soil profiles site.

2.6 Land Capability Evaluation

A modified Storie Index was used to determine the land capabilities based on the soil analysis (O'geen, 2008). The computation was performed and VisualBasic was employed to code the software for Microsoft Excel (Aldbaa, 2012).

Rating of the Storie index = [(Factor A/100)*(Factor B/100)*(Factor C/100)*(Factor X/100)] *100

Where; A: total depth (cm), B: soil texture, C: Slope gradient, and X: includes; Drainage, Microrelief, Fertility, Alkalinity
Capability classes; Grade 1 (Excellent): Storie index rate between 100-80%, Grade 2 (Good): Storie index rate between 79-60%, Grade 3 (Fair): Storie index rate between 59-40%, Grade 4 (poor): Storie index rate between 39-20% and Grade 5 (nonagricultural): Storie index rate < 20%.

2.7 Land Suitability Evaluation

Depending on the crop requirement and soil analysis The computer-based tool Land Use Suitability Evaluation Tool (LUSET) was used to determine land suitability (Yen et al., 2006). This application's procedure is based on the framework for land evaluation produced by the Food and Agriculture Organization (FAO, 1976). The requirement needs are given by (Sys et al., 1993) for most of the commonly produced crops in the examined area.

2.8 Map production using geostatistical analyses

Geostatistical analysis is concerned with the description of patterns in spatial data; each known data point has a geographic location and a value, and the connection between them is exploited to help predict values at the unknown locations. Histogram, Normalization of Interpolation by Inverse Distance Weighting (IDW) interpolation estimates unknown values with specifying search distance, closest points, power settings and barriers technique. Soil maps and maps predicting soil characteristics can be produced using geostatistical approaches (Aldabaa & Yousif, 2020; Yousif, 2017). As recommended by (Ahmed, 2019; Elsayed et al., 2019; Zakarya, 2009), inverse distance weighted (IDW) interpolation was utilized to create thematic maps of the research area. The inverse distance weighting (IDW) technique was used to construct the land capability map (ZARE-MEHRJARD et al., 2010). Normalization of soil data is a very important step when IDW method is used to produce a quantile map. Data that do not follow the normal distribution should be transformed to achieve normality (Abramowitz & Stegun, 1964). According to (Tunçay et al., 2016),. The IDW interpolation approach employed the following equation, which was thoroughly explored by (Alhammadi & Glenn, 2008).

$$Z^*(xo) = \sum_{i=1}^{n} wiZ(xi) \qquad (1)$$

Where the Z(xi) data value of locations is used to construct the variable Z value of X0 the not sampled location; the Z(xi) value is assigned by the weight wi, n is the number of the closest neighboring data points used for estimation.

$$w_i = \frac{1/d_i^2}{\sum_{i=1}^{n} 1/d_i^2} \qquad (2)$$

where di is the distance between the estimated point and the observed point.

3. Results

3.1 Change detection

The results of change detection for vegetation land cover were achieved using SAVI as illustrated in Figure 3, Figure 4 and Table 2. The spatial distribution of vegetation cover which based on SAVI illustrated that vegetated areas represented 7.51 % with an area of (1803.96 ha), 8.49 % (2038.68 ha), and 26.47 % (6356.07 ha) for 2011, 2016, and 2021, respectively.

Table 2. Land cover areas from 2011 to 2021 based on the vegetation index.

	Area	Bare Soil	Vegetation	Total
2011	Hectare	22207.48	1803.96	24011.44
	%	92.49	7.51	100.00
2016	Hectare	21972.76	2038.68	24011.44
	%	91.51	8.49	100.00
2021	Hectare	17655.37	6356.07	24011.44
	%	73.53	26.47	100.00

The obtained results demonstrated that the vegetation areas were expanded with 0.98%, which occupied an area of (234.72 ha), 17.98 % (4317.39 ha), and 18.96 % (4552.11 ha) during three periods (2011 to 2016), (2016 to 2021), and (2011 to 2021), respectively. The yearly rate of vegetation change were increased by 46.94 ha year^{-1} (0.20 %), 863.48 ha year^{-1} (3.60 %), and 910.42 ha year^{-1} (3.79 %) through three periods from 2011 to 2016, 2016 to 2021, and 2011 to 2021, respectively.

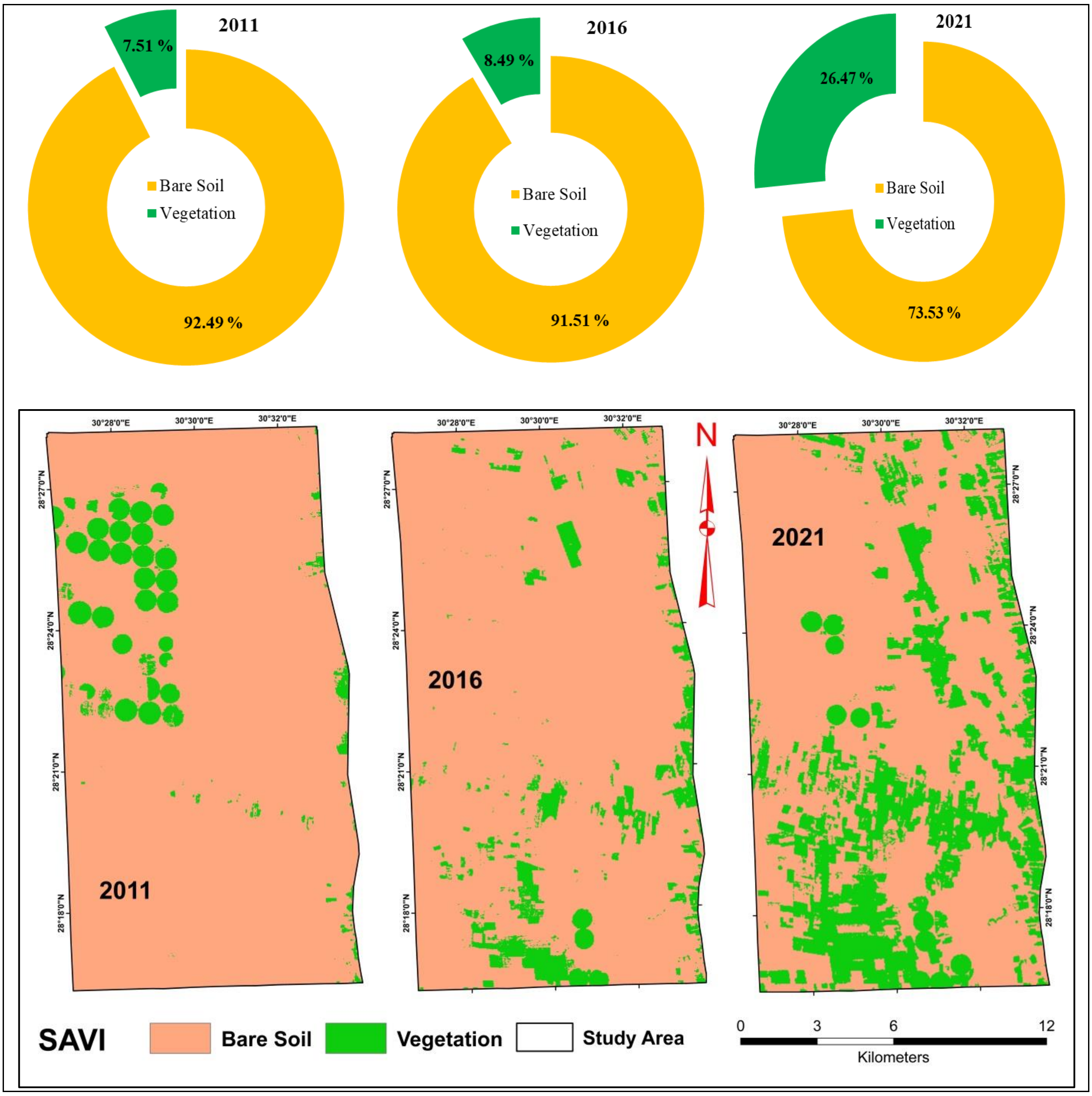

Fig. 3. Soil Adjusted Vegetation Index (SAVI).

Table 3. Rate of Chang for three periods; 2011 - 2016, 2016-2021, and 2011-2021.

Year	**First time 2011-2016**		**Second time 2016-2021**		**Third period (Total time) 2011-2021**	
	Total change	Rate of change / year	Total change	Rate of change / year	Total change	Rate of change / year
Class	Vegetation		Vegetation		Vegetation	
Area (ha)	234.72	46.94	4317.39	863.48	4552.11	910.42
%	0.98	0.20	17.98	3.60	18.96	3.79

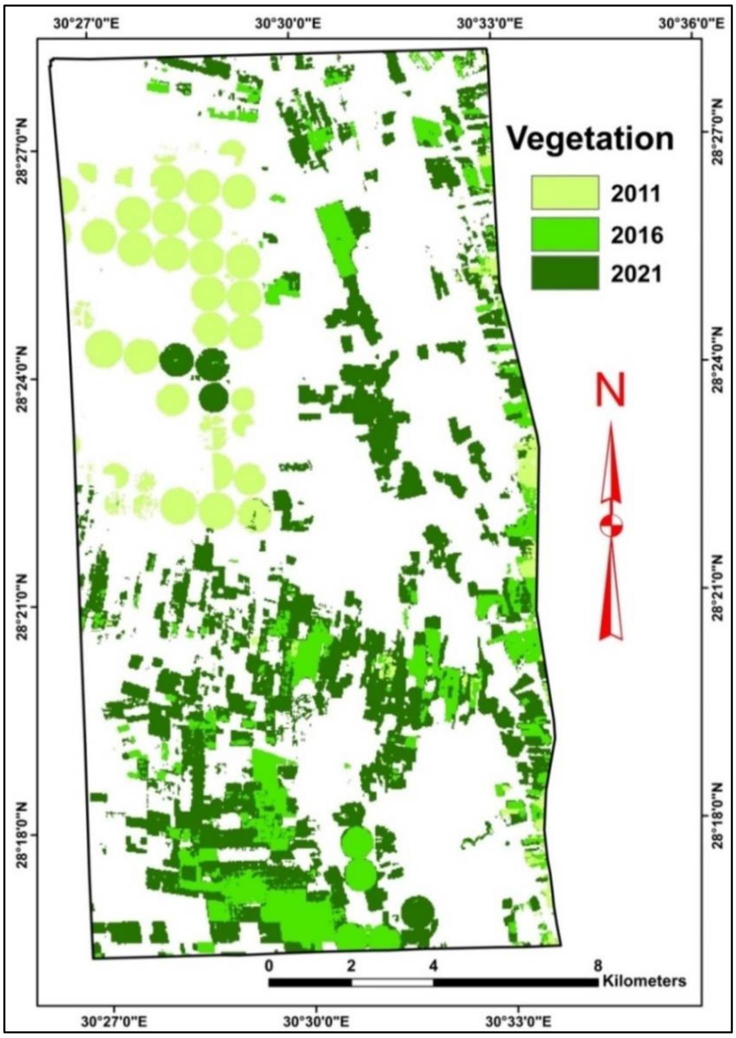

Fig. 4. Spatial distribution of vegetation change from 2011 to 2121.

3.2 Descriptive statistics of soil properties

Descriptive statistics of soil attributes were analyzed using SPSS software (Table 5). The effective soil depth varies between 30 and 150 cm, having a mean of 75.73 cm as presented in Table 4. Soil salinity ranges between 0.16 dSm^{-1} and 20.51 dSm^{-1} with mean value of 3.93 dSm^{-1}. While Soil pH varies between 7.36 and 8.82 with mean value of 7.84. EC and pH had the lowest and the highest coefficient variation with values 52.67 and 2.17%, respectively

Table 4. Descriptive statistics of some soil properties.

Soil attribute	unit	Range	Min	Max	Mean	Std. Dev.	CV %	Variance	Skewness
Depth	cm	120	30	150	75.73	32.10	42.39	1030.25	0.87
pH	-log [H+]	1.46	7.36	8.82	7.84	0.17	2.17	0.03	1.36
$CaCO_3$	%	35.77	1.50	37.27	11.51	4.71	40.92	22.23	2.27
EC	dSm^{-1}	20.35	0.16	20.51	3.93	2.07	52.67	4.29	3.64
Clay	%	23.56	3.15	26.71	6.46	2.80	43.34	7.85	4.79
Sand	%	51.49	41.95	93.44	84.28	5.95	7.06	35.40	-3.18
Silt	%	18.82	4.08	22.90	8.88	3.02	34.01	9.13	1.40
CEC	cmol/kg	47.13	6.29	53.42	12.91	5.60	43.38	31.39	4.79
ESP	%	11.54	7.50	19.04	11.10	1.02	9.19	1.04	3.18
SAR	%	10.62	5.97	16.59	8.89	0.98	11.02	0.96	3.35
Gravel	%	5	4	9	6.97	1.20	17.22	1.45	-0.38

3.3 Spatial variation of physical and chemical criteria

The soil depth's spatial variability: Soil depth refers to the specified measurement in centimetres where root growth faces no physical or chemical barriers, such as impermeable or toxic layers, allowing unrestricted development. In the study area, there are three categories for soil depth: shallow soils (30–50 cm) represent 1916.57 ha (7.98%), moderately deep soils (50–100 cm) represent 17795.82 ha (74.11%) and deep soils (100–150 cm) represent 3043.78 ha (12.68%). The spatial variability distribution of soil depth illustrated that moderately deep are the most common soils in the study area as shown in Table 5 and Figure 5.

The soil salinity's spatial variability: Table 5 and Figure 6 display the regional distribution pattern of soil salinity in the research area. Within the study area, the slightly and moderately saline soils made up approximately 13711.36 ha (57.10%) and 8722.34 ha (36.33%), respectively. The highly saline and the non-saline soils are very rare and scattered around the study area.

The total calcium carbonate's ($CaCO_3$) spatial variability: As indicated by Figure 7 and Table 5, the calcium carbonate content of the soils under investigation could be divided into two classes.
The geographical variability distribution of calcium carbonate illustrated that 22.54% (5412.86 ha) and 71.65% (17203.09) of the studied area ware, moderately and strongly calcareous, respectively.

Spatial variability of the soil pH: The pH of the soil gives information about the nutrients' solubility, which in turn indicates if the soil is suitable for a given crop and whether it is potentially toxic or available for crops (Halder, 2013). The spatial variability distribution mapping of soil pH illustrates that 31.97 % (7676.57 ha) and 62.64 % (15040.70 ha) of the total area were slightly and moderately alkaline, respectively (Figure 8 and Table 5).

Spatial variability of the soil texture: Most of the physical soil properties depend on the class of soil texture. Texture is therefore one of the most crucial properties of soil. In the area under investigation, there were three different texture classes: sandy loam, loamy sand, and sand. The reclassified soil texture map shows that 63.17% (15166.91 ha), 30.41% (7301.93 ha) and 1.20% (287.33 ha) of the studied area were loamy sand, sand, and sandy loam soils, respectively (Figure 9 and Table 5).

The slope's spatial variability: The research area's slope ranged from 0% to 16%. According to the reclassified slope map, the slope varied from flat to nearly level (0 - 1) with an area 3802.44 ha (15.84, 4%), very gently to gently sloping (1- 2) with an area about 2608.30 ha (10.86%), gently sloping (2 - 5) with an area 13612.64 ha (56.69%) and sloping (5 - 10) with an area about 3204.81 ha (13.35%) as shown in Figure 10 and Table 5.

Table 5. Spatial variation of some land evaluation criteria.

Soil depth (cm)	Area (Hectare)	%
Deep soil	3043.78	12.68
Moderately deep soil	17795.82	74.11
Shallow soil	1916.57	7.98
EC (dS m^{-1})	**Area (Hectare)**	**%**
Non saline	183.46	0.76
Slightly saline	13711.36	57.10
Moderately saline	8722.34	36.33
Highly saline	139.01	0.58
Calcium carbonate (%)	**Area Hectare)**	**%**
Moderately calcareous	5412.86	22.54
Strongly calcareous	17203.09	71.65
Extremely calcareous	140.22	0.58
pH	**Area (Hectare)**	**%**
Slightly alkaline	7676.57	31.97
Moderately alkaline	15040.70	62.64
Strongly alkaline	38.90	0.16
Texture class	**Area (Hectare)**	**%**
Loamy sand	15166.91	63.17
Sand	7301.93	30.41
Sandy loam	287.33	1.20
Slope (%)	**Area (Hectare)**	**%**
Flat to Nearly level (0 - 1%)	3802.44	15.84
Very gently to gently sloping (1- 2%)	2608.30	10.86
Gently sloping (2 - 5%)	13612.64	56.69
Sloping (5 - 10%)	3204.81	13.35
Strongly sloping (10 - 15%)	547.77	2.28
Moderately steep (15 - 30%)	226.75	0.94
Steep (>30%)	8.58	0.04

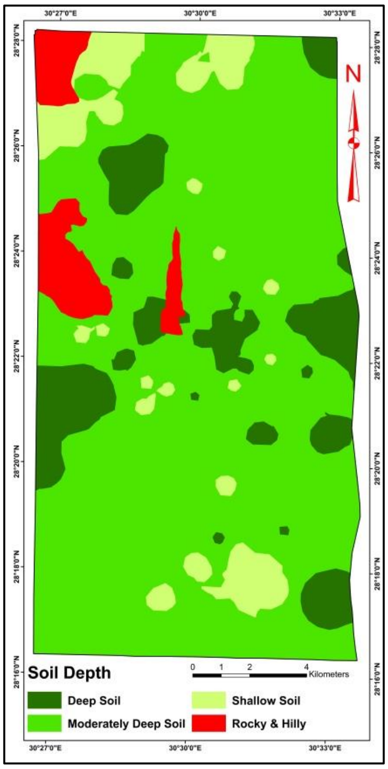

Fig. 5. spatial variability distribution of soil depth.

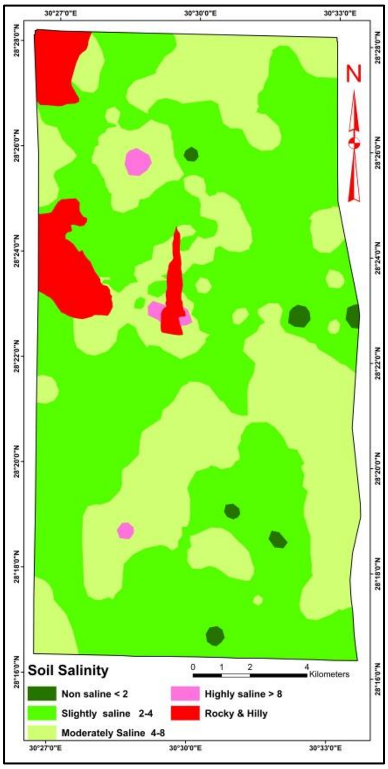

Fig. 6. spatial variability distribution of soil salinity.

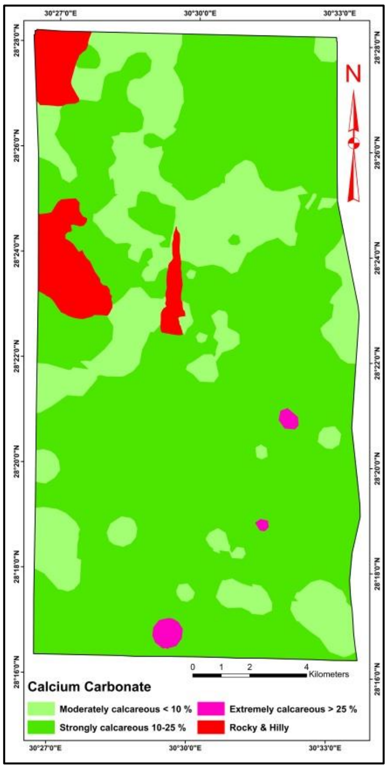

Fig. 7. spatial variability distribution of $CaCO_3$.

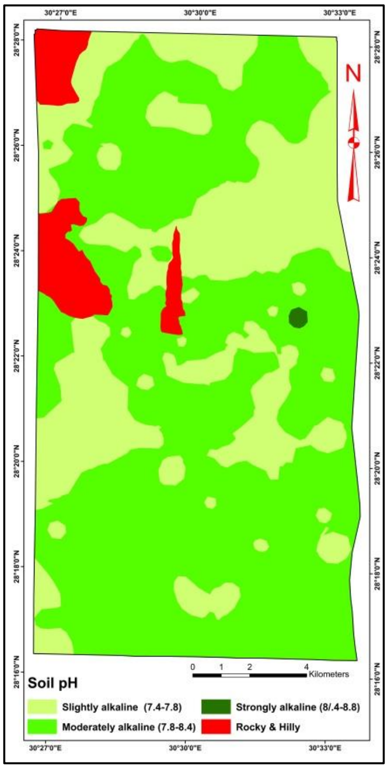

Fig. 8. spatial variability distribution of soil pH.

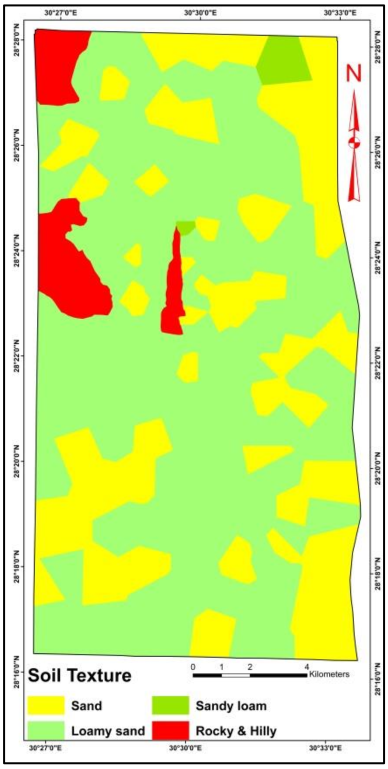

Fig. 9. spatial variability distribution of soil texture.

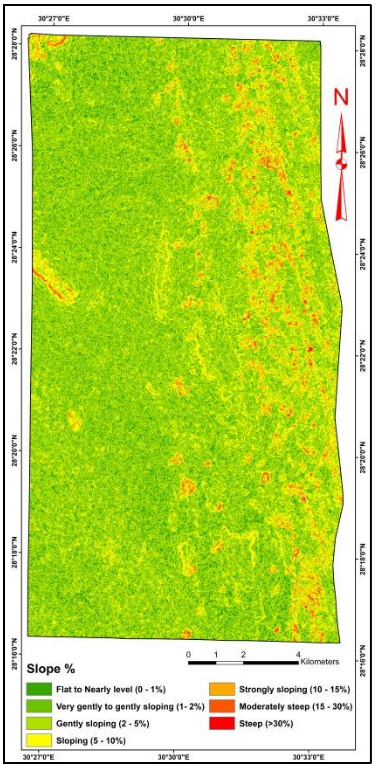

Fig. 10. spatial variability distribution of surface slope.

3.4 Land capability

Land capability evaluation of the studied area was performed using modified Stori index and the rating of land capability classes is presented in Table 6 and Figure 11. Accordingly, the land capability of the study area are grouped into three grades; Grade

3 covered an area of 1105.96 ha occupied 4.61% of the study area. While grade 4 occupied an area of 20682.83 ha represented 86.14% of the study area. Finally, grade 5 occupied the smallest area (967.38 ha) represented 4.03 % of the study area.

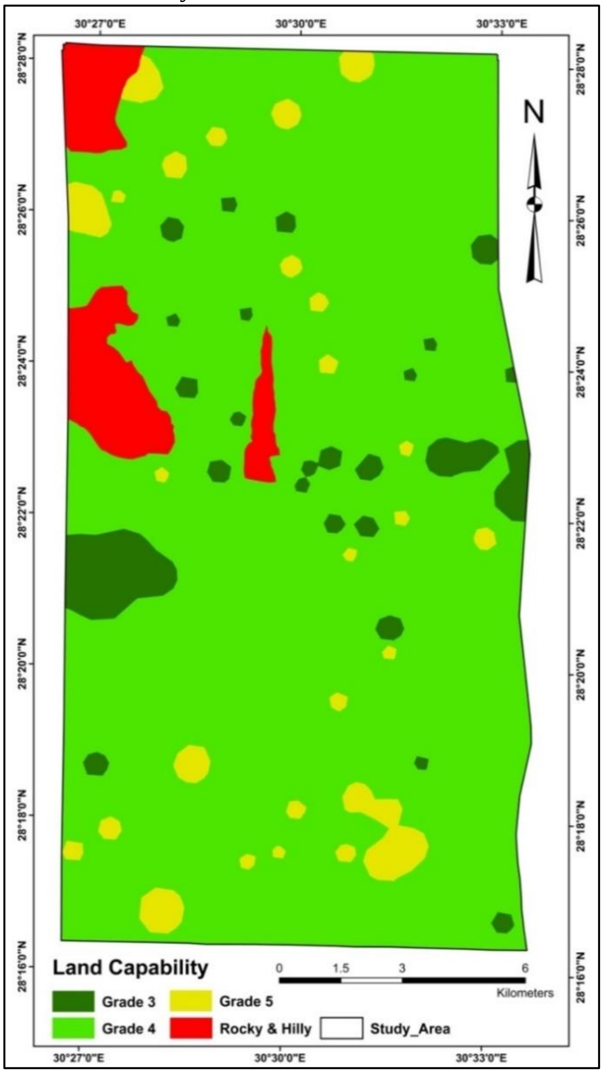

Fig. 11. Land capability map.

Table 6. Area in hectares of different land capability classes.

Land capability class	Area (hectares)	% of the studied area
Grade 3	1105.96	4.61
Grade 4	20682.83	86.14
Grade 5	967.38	4.03
Rocky & Hilly	1255.11	5.23
Total	**24011.28**	**100.00**

3.5 Land Suitability Evaluation

Specifications of the relevant crop requirements and their calibration with the characteristics of the soil parameters are necessary for the assessment of land suitability. The land use suitability evaluation tool (LUSET), computer-based software, was utilized to assess the land suitability analysis of the examined soils. In order to determine agricultural land suitability, sixteen crops were chosen, namely, peach, mango, citrus, olives, beans, wheat, sugar beet, barley, pea, pepper green, tomato, onion, groundnuts, sesame, sunflower and soybeans (Table 7).

Fruit crops: As shown in Table (7) and Figure 12 the most suitable fruit crops in the studied area are mango, citrus and olives. The findings showed that 83.85% (20120.7 ha), 74.7% (17937.7 ha), 71.8% (17248.8 ha) and 31.2% (7481.6 ha) of the research area are moderately suitable (S2) for growing olives, citrus, mango and peach, respectively. While 60.2% (14454.9 ha), 22.9% (5507.3 ha), 20.1% (4818.5 ha) and 11.0% (2635.5 ha) are marginally suitable (S3) for peach, mango, citrus and olives, respectively.

Field crops: Barley is distinguished by its relatively high resistance to salinity and drought**.** Results in Table (7) and Figure 13 indicated that 77.6% (18620.9 ha) are highly suitable (S1) for barley while 17.2% (4135.3 ha) of the study area are moderately suitable (S2) for growing barley. Wheat is considered as a main crop and the most important cash crop in the study region. Results in Table (7) and Figure 13 indicated that 55% (13211.9 ha) are highly suitable (S1) for wheat while 39.7% (9544.3 ha) of the study area are moderately suitable (S2) for growing wheat. As shown in Table (7) and Figure 13, 84.1% (20196.7 ha) and 80.7% (19379.4 ha) are moderately suitable (S2) for beans and Sugar beet while 10.7% (2559.5 ha) and 14.1% (3376.8 ha) are marginally suitable (S3) for beans and Sugar beet respectively. Sugar beet is regarded as a valuable crop in the study area due to its lower water requirements than other crops, greater tolerance to salt, and shorter cultivation time than sugar cane. Consequently, sugar beet is regarded as a beneficial and promising crop in Egypt, especially in the El Minia region.

Vegetables crops: According to the analysis of land suitability for tomatoes, 17418.9 ha (72.5%) and 5337.3 ha (22.2%) were moderately suitable and marginally suitable, respectively. While land suitability analysis for onion illustrated that 2768.4 ha (11.5%) and 19987.7 ha (83.2%) were highly suitable and moderately suitable, respectively. Moreover, results in Table (7) and Figure 14 indicated that 79.7% (19146.3 ha) and 79.9% (19191.0 ha) of the study area are moderately suitable (S2) while 15.0% (3609.9 ha) and 14.8% (3565.2 ha) of the study area are marginally suitable (S3) for pea and green pepper, respectively.

Oil crops: Sunflower are said to be a very profitable and productive cash crop with a high profit margin. Based on the land suitability analysis for sunflowers, 1914.2 ha (8%) and 20842.0 ha (86.8%) were highly suitable and moderately suitable, respectively. Soybean is considered relatively resistant to salinity. Results in Table (7) and Figure 15 showed that 84.3% (20242.9 ha) are moderately suitable (S2) 10.5% (2513.3 ha) are marginally suitable (S3) for soybeans cultivation. The land suitability analysis for sesame and groundnuts demonstrated that 19053.5 ha (79.4%) and 18119.6 ha (75.5%) were moderately suitable, respectively. While 3702.7 ha (15.4%) and 4636.6 ha (19.3%) were marginally suitable, respectively. Sesame is considered as one of the most well-known highly profitable cash crops.

Feed crops: Alfalfa is regarded as a highly advantageous cash crop with a high gross profit margin and a supported residual impact on soil fertility, while sorghum is thought to be moderately resistant to salinity. Based on the land suitability analysis for alfalfa, 21129.3 ha (80%) and 1626.9 ha (6.8%) were moderately and marginally suitable, respectively. While 19714.0 ha (82.1 %) and 3042.2 ha (12.7%) were highly and moderately suitable for Sorghum cultivation, respectively. Also results shown in Table (7) and Figure 16 showed that 2209.2 ha (9.2%) and 20546.9 ha (85.6% of the total area) are highly suitable (S1) and moderately suitable (S2) for millets cultivation. While 86.1% (20667.9 ha) and 8.7% (2088.2 ha) of the study area are moderately (S2) and marginally suitable (S3) for maize production.

Table 7. Areas in hectares of land suitability classes for different crops.

Crop	Area	S1	S2	S3	N	Rocky	Total
Peach	Hectare	--	7481.6	14454.9	819.7	1255.1	24011.3
	%	--	31.2	60.2	3.4	5.2	100
Mango	Hectare	--	17248.8	5507.3	--	1255.1	24011.3
	%	--	71.8	22.9	--	5.2	100
Citrus	Hectare	--	17937.7	4818.5	--	1255.1	24011.3
	%	--	74.7	20.1	--	5.2	100
Olives	Hectare	--	20120.7	2635.5	--	1255.1	24011.3
	%	--	83.8	11.0	--	5.2	100
Beans	Hectare	--	20196.7	2559.5	--	1255.1	24011.3
	%	--	84.1	10.7	--	5.2	100
wheat	Hectare	13211.9	9544.3	--	--	1255.1	24011.3
	%	55.0	39.7	--	--	5.2	100
Sugar beet	Hectare	--	19379.4	3376.8	--	1255.1	24011.3
	%	--	80.7	14.1	--	5.2	100
Barley	Hectare	18620.9	4135.3	--	--	1255.1	24011.3
	%	77.6	17.2	--	--	5.2	100
Pea	Hectare	--	19146.3	3609.9	--	1255.1	24011.3
	%	--	79.7	15.0	--	5.2	100
Green Pepper	Hectare	--	19191.0	3565.2	--	1255.1	24011.3
	%	--	79.9	14.8	--	5.2	100
Tomato	Hectare		17418.9	5337.3	--	1255.1	24011.3
	%		72.5	22.2	--	5.2	100
onion	Area	2768.4	19987.7	--	--	1255.1	24011.3
	%	11.5	83.2	--	--	5.2	100
Groundnuts	Hectare	--	18119.6	4636.6	--	1255.1	24011.3
	%	--	75.5	19.3	--	5.2	100
Sesame	Hectare	--	19053.5	3702.7	--	1255.1	24011.3
	%	--	79.4	15.4	--	5.2	100
Sunflower	Hectare	1914.2	20842.0	--	--	1255.1	24011.3
	%	8.0	86.8	--	--	5.2	100
Soybeans	Hectare	--	20242.9	2513.3	--	1255.1	24011.3
	%	--	84.3	10.5	--	5.2	100
Maize	Hectare	--	20667.9	2088.2	--	1255.1	24011.3
	%	--	86.1	8.7	--	5.2	100
Sorghum	Hectare	19714.0	3042.2	--	--	1255.1	24011.3
	%	82.1	12.7	--	--	5.2	100
Millets	Hectare	2209.2	20546.9	--	--	1255.1	24011.3
	%	9.2	85.6	--	--	5.2	100
Alfalfa	Hectare	--	21129.3	1626.9	--	1255.1	24011.3
	%	--	88.0	6.8	--	5.2	100

4. Discussion

In land suitability studies, remote sensing, geo-statistics, geographic information systems, and crop simulation models are the most widely, popular, successfully and dynamic methods utilized to assess the suitability of significant and important crops in many countries (Aldabaa & Yousif, 2020; Iliquín Trigoso et al., 2020; Mugiyo et al., 2021; Yousif et al., 2020; Yousif, 2019; Yousif & Ahmed, 2019). In the current study, we determined change detection of vegetation cover and land suitability through integration of LUSET, remote sensing and GIS in the West of Samlout region, El-Minia Governorate, Egypt. The employed procedure is recommended as appropriate for comparable investigations conducted in different regions (Yousif, 2018; Yousif et al., 2020; Yousif & Ahmed, 2019).

Results of change detection demonstrated that vegetation areas were expanded with 0.98 %, which represented an area of (234.72 ha), 17.98 % (4317.39 ha), and 18.96 % (4552.11 ha) during three periods (2011 to 2016), (2016 to 2021), and (2011 to 2021), respectively (Figure 3, Figure 4 and

Table 2). The utilization of the digital elevation model (DEM) in this investigation area held great significance in the extraction of elevation data and the construction of the slope map as well. The examined area's altitude varied from 46 to 197 m above sea level (Figure 1). The slope of the study area was reclassified according to (FAO, 2006), which was varied between 0% and 16%. The most common slope classes in the study area were gently sloping with an area 13612.64 ha (56.69%) and flat to nearly level with an area 3802.44 ha (15.84, 4%).

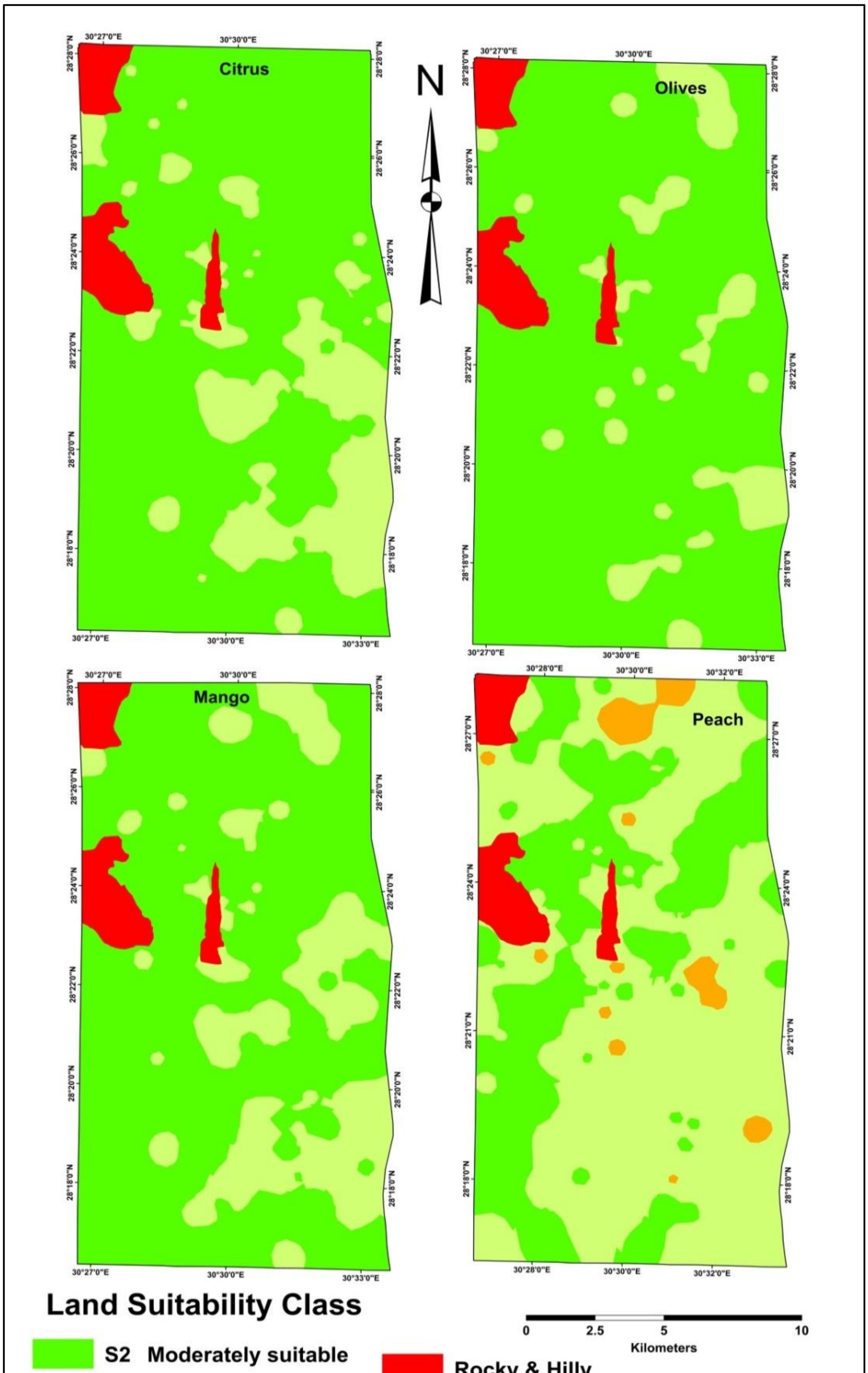

Fig. 12. Land suitability map of some fruit crops.

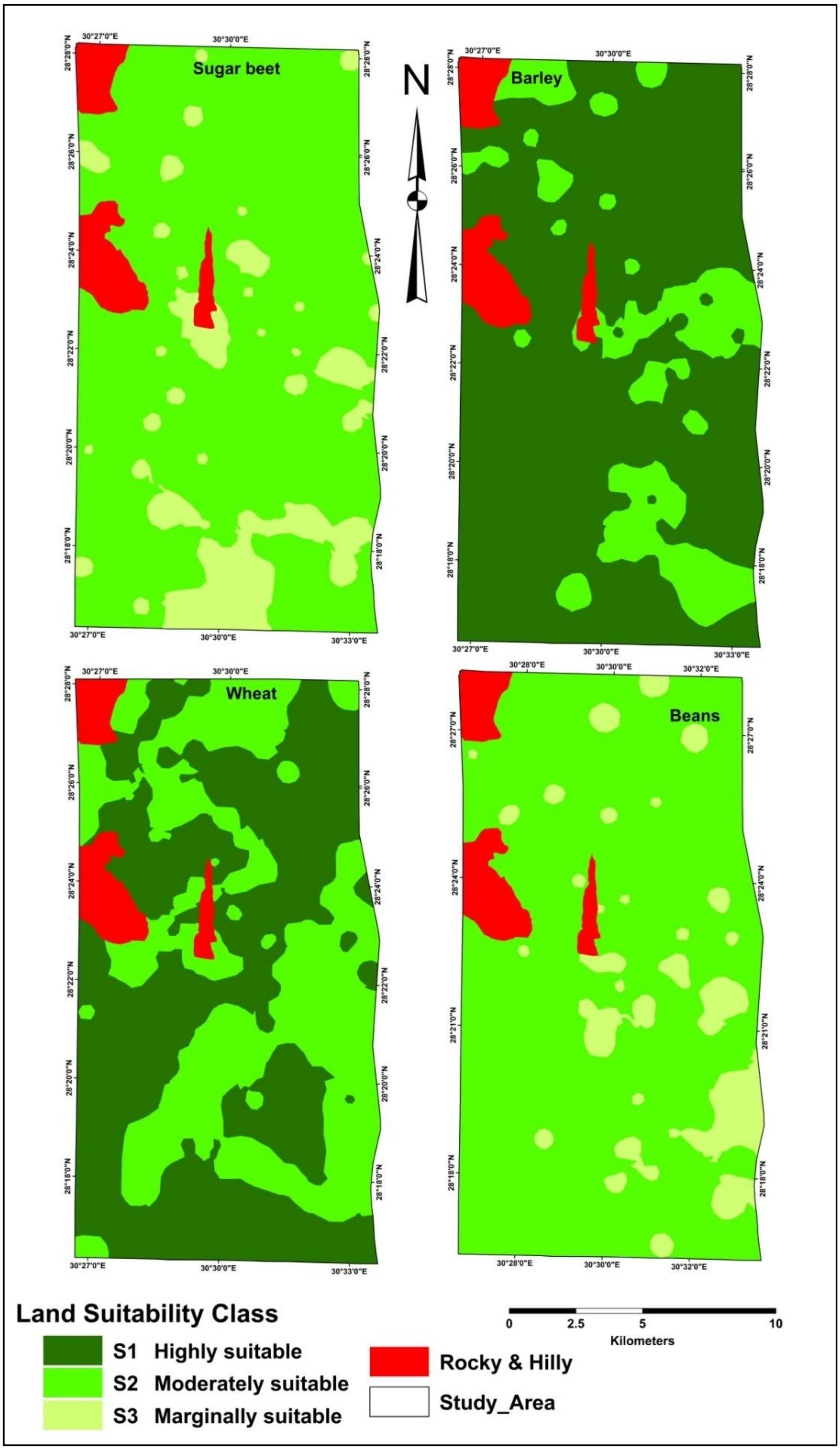

Fig. 13. Land suitability map of some field crops.

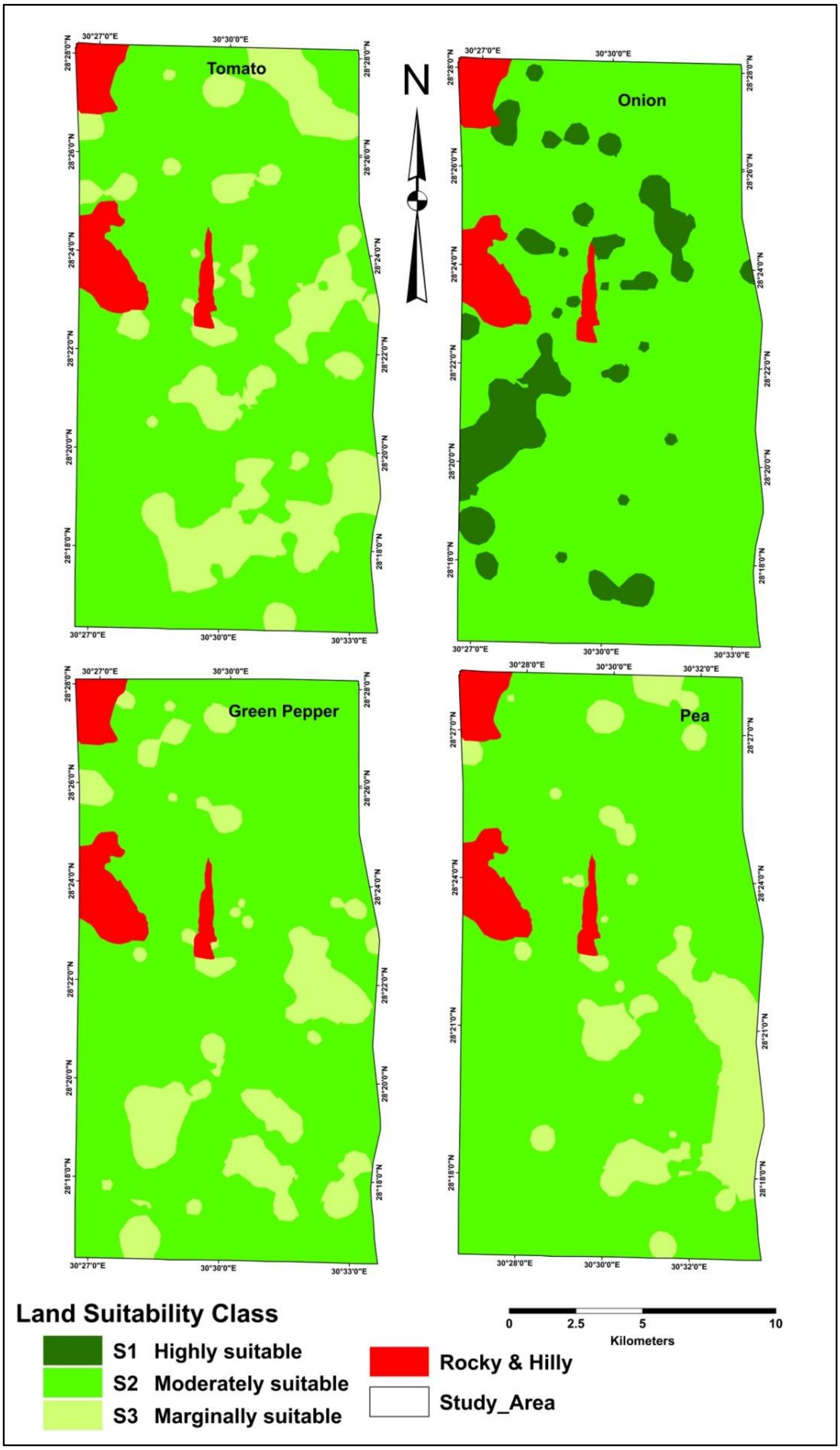

Fig. 14. Land suitability map of some vegetable crops.

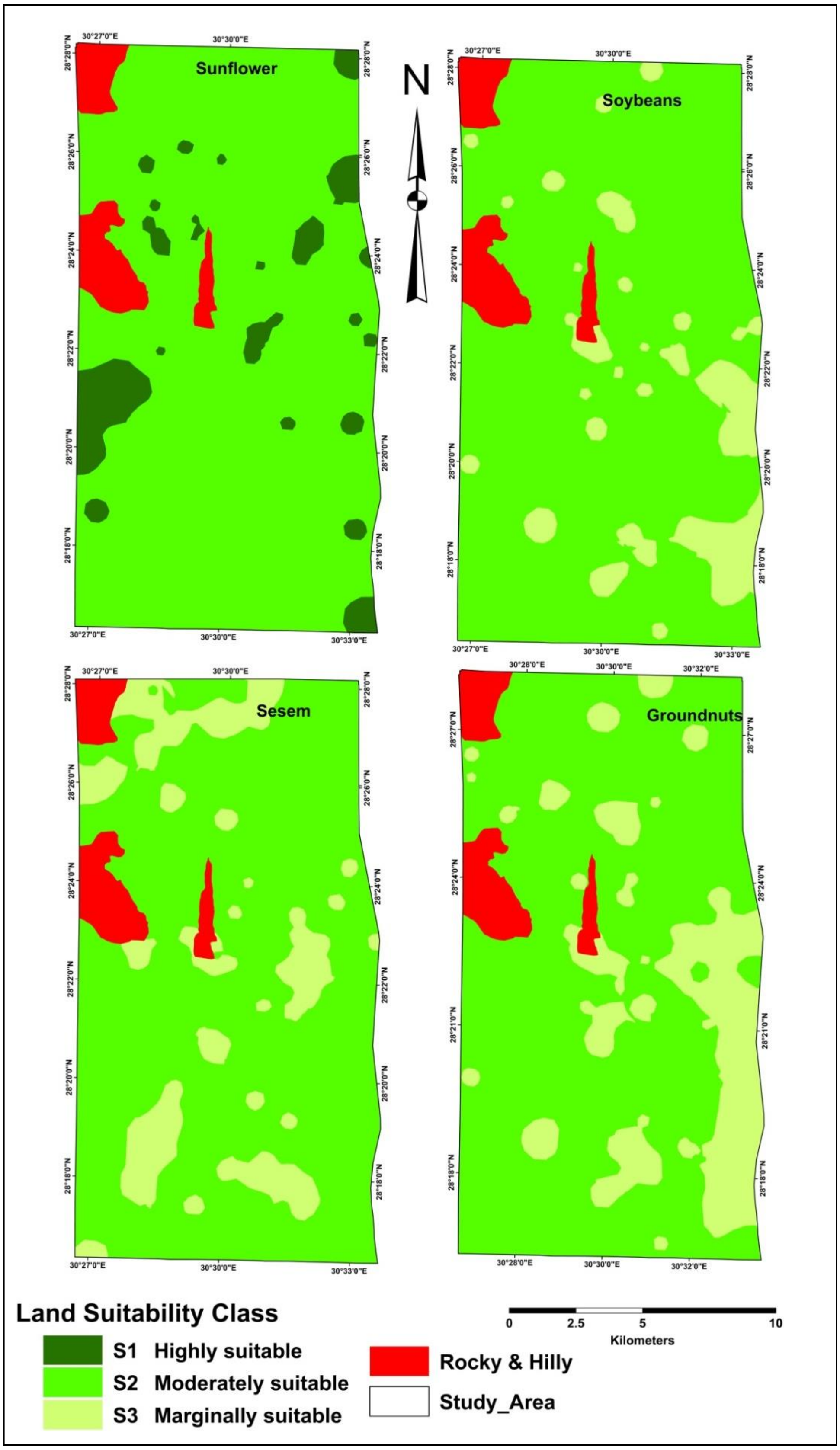

Fig. 15. Land suitability map of some oil crops.

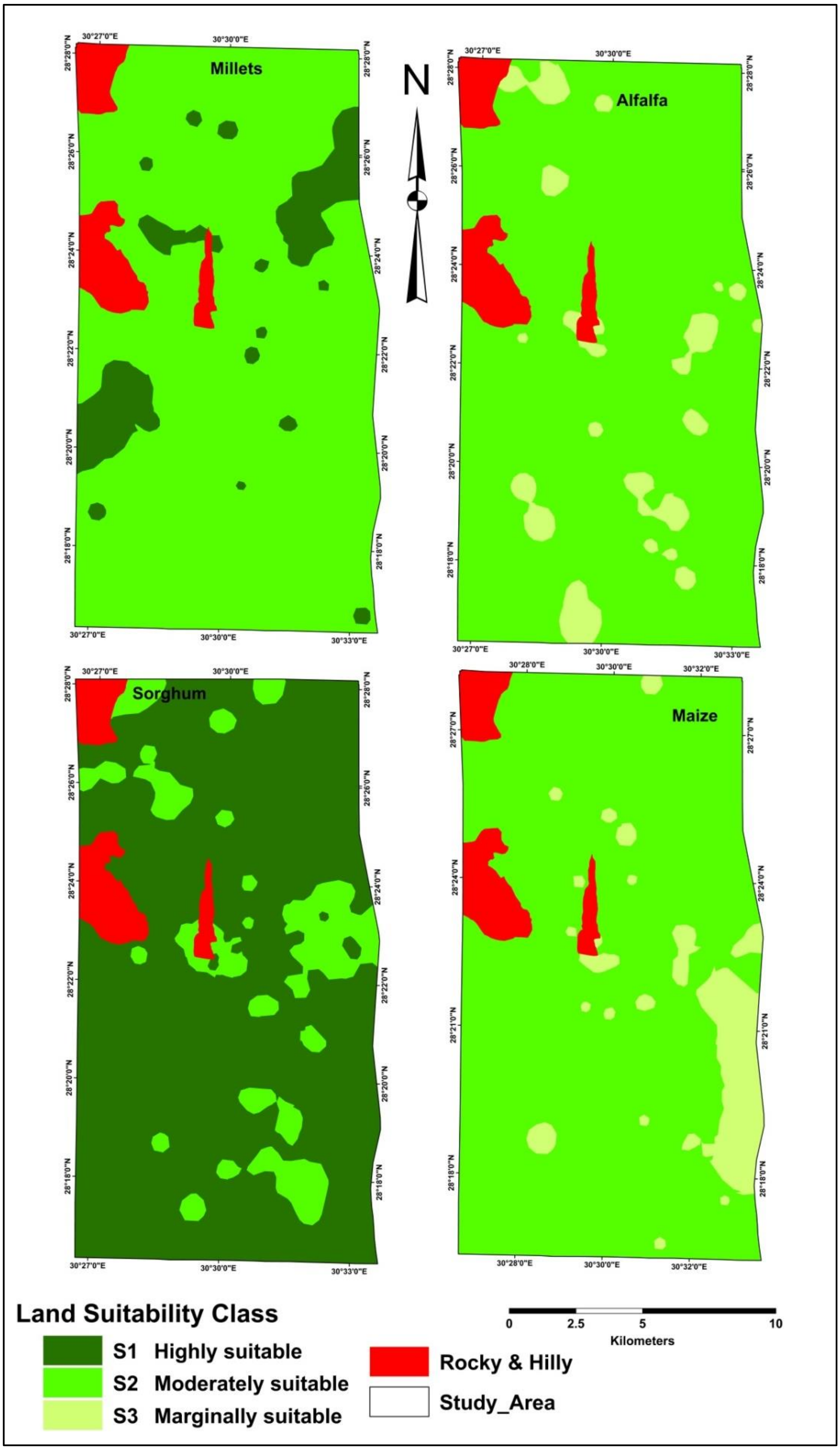

Fig. 16. Land suitability map of some feed crops.

Soil depth ranged between shallow and deep soils. Moderately deep soils (50–100 cm) was the most common class which represent 17795.82 ha (74.11%) as shown in Table 5 and Figure 5, this is consistent with (Yossif & Taher, 2020; Zakarya et al., 2021). Loamy sand, sandy soils were the most common texture class in the study are representing 63.17% (15166.91 ha) and 30.41% (7301.93 ha) of the studied area, respectively (Figure 9 and Table 5). Soil salinity level was slightly saline and moderately saline soils constituted about 13711.36 ha (57.10%) and 8722.34 ha (36.33%), respectively (Table 5 and Figure 6), with very small and scattered areas that were none saline (0.76 %) and highly saline (0.58 %). Our results are in agreement with (Rashed, 2020; Yossif & Taher, 2020; Zakarya et al., 2021).

The source of salinity was thought to be caused by the predominance of aridity and the lack of precipitation for most of the year, with the possible exception of rare abrupt flash floods that occur once every few years. The pH values of the soils ranged from 7.36 to 8.82, indicating that they were slightly to moderately alkaline in reaction (Figure 8 and Table 5). Calcium carbonate contents varied from 1.50% and 37.27%, where the studied soils classified as moderately calcareous and strongly calcareous soils (Figure 7 and Table 5). In our study, land capability evaluation of the studied area was performed using modified Stori index (O'geen, 2008). The output of our research conducted that class 4 was the dominant land capability class in the research area representing an area of 20682.83 ha (86.14%) as illustrated in Table 6 and Figure 11.

In connection with the assessment of the land capability, the most severe limitations were coarse texture, effective soil depth and calcium carbonate content followed by salinity conditions. Our results are in agreement with (Azzam, 2016; Mohamed et al., 2019; Rashed, 2020; Yossif & Taher, 2020; Zakarya et al., 2021). Analysis of land suitability is one of the most useful tools for planning and managing land resources, and it is a requirement for sustainable agricultural management (Debesa et al., 2020). A land suitability classification of the studied soils was evaluated by using land use suitability evaluation tool (LUSET), a computer- based program (Yen et al., 2006).

The output of our research concluded that the most suitable fruit crops in the studied area were mango, citrus and olives where 83.8 5% (20120.7 ha), 74.7 % (17937.7 ha), 71.8% (17248.8 ha) and 31.2% (7481.6 ha) of the study area were moderately suitable (S2), respectively. Moreover, only 31.2% (7481.6 ha) of the studied soils are moderately suitable for peach cultivation. Meanwhile, the output of field crops suitability indicated that 77.6% (18620.9 ha) and 55% (13211.9 ha) out of the whole area were highly suitable (S1) for barley and wheat, respectively. Suitability of vegetable crops indicated that onion was the most suitable crop in the study area occupied an area of 2768.4 ha (11.5%) and 19987.7 ha (83.2%) as highly suitable (S1) and moderately suitable (S2), respectively. Followed by pea, green pepper, and tomato occupied 79.7% (19146.3 ha), 79.9% (19191.0 ha), and 17418.9 ha (72.5%) as moderately suitable (S2), respectively. With regarding to the oil crops, the finding of this research conducted that the sunflower was the highest suitable crop in investigated area occupied 1914.2 ha (8%) and 20842.0 ha (86.8%) as highly suitable (S1) and moderately suitable (S2), respectively. Followed by soybean and sesame occupied 84.3% (20242.9 ha) and 19053.5 ha (79.4%) as moderately suitable (S2), respectively.

Finally, sorghum and millets as feed crops were the most suitable crops occupied 19714.0 ha (82.1%) and 2209.2 ha (9.2%) as high suitable (S1), respectively. Followed by alfalfa and maize occupied 21129.3 ha (80 %) and 86.1% (20667.9 ha) as moderately suitable (S2), respectively. The agricultural crop rotation plays a main role in maintaining the equilibrium of nutrients and fertilizers in the soil, and consequently eliminates weeds, keeps the soil fertile and contains good amounts of organic matter; certain vegetable crops prefer a greater affinity towards a higher proportion of nitrogen, phosphorous, and potassium, thus necessitating the utilization of animal-derived fertilizers (AbdelRahman et al., 2021; Abuzaid, AbdelRahman, et al., 2021; Abuzaid, Jahin, et al., 2021; Lenz-Wiedemann et al., 2010; Leteinturier et al., 2006; Lorenz et al., 2013; Singha & Swain, 2016). Furthermore, it will preserve soil fertility over the short and long terms, as well as soil quality, which will increase production capability and the degree to which the soil is suitable for a variety of crops.

5. Conclusion

In the present study, the remote sensing data were used to delineate the temporal and spatial land cover changes in west Samlout area, El-Minia government, Egypt. Moreover, Storie index and LUST were used to assess land capability and suitability for different crops in the investigated area, respectively. It may be useful to estimate agricultural lands and water features and monitor how they evolve using the application of remotely sensed data combined with GIS tools. Applying vegetative indices, particularly SAVI, could conserve time, money, and effort by estimating agricultural lands more precisely, even in places that are difficult to reach. The findings showed that, between 2011 and 2021, the investigated area's vegetation areas increased considerably, a trend that was caused by the expansion of land reclamation and agriculture initiatives. The obtained findings revealed that the vegetation areas were increased with a percentage of 18.96% during the period from 2011 to 2021. The yearly rate of vegetation change that dependent on SAVI were grew by 910.42 ha year^{-1} between 2011 and 2021. By applying Storie index for soil capability, the results represented that there were three capability classes in the studied area; Grade 3, grade 4, and grade 5 occupied 4.61%, 86.14%, and 4.03% of the study area, respectively. The main limiting factors for soil capability in the study area were the shallow soil depth, high salinity, high alkalinity, and coarse texture. The spatial analyses of crop land suitability showed that the most suitable field crops is barley followed by wheat, beans, and sugar beet. Onion is considered as the most suitable vegetable crop followed by tomato, pea and green pepper. Sunflower is considered the most suitable oil crop followed by soybean, sesame and groundnuts. With regarding to feed crops, sorghum is considered the most suitable crop followed by millets and alfalfa. While olives is considered the most suitable fruit crop followed by citrus and mango trees. Furthermore, results indicated that the temperature, soil salinity, slope, depth, and coarse texture were the most limiting criteria for suitability. Therefore, we may conclude that determining the land suitability is a crucial first step in estimating the soil's maximum productivity in the context of conservation. Furthermore, the soil maps for agricultural suitability designed in this research can be beneficial in performing the management processes. Moreover, the soil maps created in this study for agricultural suitability may be useful in carrying out management procedures. To achieve the maximum production, the study area should undergo a significant reclamation process that includes removing the excess salts and improving the drainage conditions. For irrigation where water is applied drop by drop at or near the plant root zone, trickle, or drip, is advised. Finally, the agricultural crop rotation is very crucial to preserve soil fertility over the short and long terms, as well as soil quality, which will increase production capability and the degree to which the soil is suitable for a variety of crops.

6. Conflicts of interest

"There are no conflicts to declare".

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