Determination of Biophysical Soil Indicators to Investigate Land Suitability for Agriculture Activities Aided by Remote sensing, GIS and Soil survey, South West Dongola, Northern State, Sudan

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ABSTRACT: the study was conducted in western El- Golid locality, about 20 km north west El- Golid town and 60 km south west Dongola city to investigate and determine the suitable lands for the establishment of an agricultural project in the study area, determine the potential land for agriculture through biophysical characters and land topography in the study area using GIS, Remote sensing, soil survey and analysis. The study area covering (6527.2 feddans). This research was based on the data and information extracted from soil survey, remote sensed land-sat 8 images dated 2017, in addition to field observation aided by GPS Garmin 62C receivers and geographic information system were used to generate soil map in the study area. Satellite image was enhanced, interpreted and analyzed using ERDAS Imagine 8.5 and Arc-GIS 10.21, by using the soil salinity and alkalinity levels, moisture content and elevation according to American soil classification system and (FAO, 1990 and 2006). The project area was representative by only one soil unite, S2 mean its medium soil suitability, this is modified from FAO land suitability system (Kevie and El Tom, 1987 and 2004) for agricultural activities, while was divided into 3 sub units, S2m (3262.4 feddans) nearly 50% of the total project area, slightly to moderately alkaline, non saline and non sodic area, S2ma (2817 feddans) 43% was classified as moderately to highly alkaline but non saline non sodic and S2ms(447.6 feddans) 7% this was small matrix represent, highly saline (ECe > 16 dS/m), while slightly to moderately alkaline with non sodic. Based on this study, the potential of plain lands reflex the suitability for agricultural investments.

Key words: El- Golid, Soil Physiochemical Properties, Soil Suitability map, remote sensing, GIS and GPS.

1. INTRODUCTION:

Remote sensing and geographic information system considered as important and effective tools in surveying, studding and mapping lands for the purpose of reclamation and benefiting in supporting local , regional and global food security. Several researches were conducted in this field in Sudan in general and the northern state in particular, Abdelwahab *and Elhag et al (2023),* study the Land Suitability for Irrigated Agriculture Using Some of Soil Properties and Aided by RS & GIS in Sahra Bayuada, El Hag and Abdelwahab et al (2023), Surveying and Evaluating Lands for the Purpose of Agricultural Investments, North East Dongola. Wael and El Hag (2023) Evaluate of soil salinity, Alkalinity and land suitability for alfalfa cultivation by using Remote sensing, Global Positioning System (GPS) and Geographic Information System (GIS). El hag and Abdelwahab et al (2023) Land Suitability and Characterization Study of Soils, Natural Vegetation Cover in Wahat Elnukhila area, Northern Darfur State. El mamoun and El hag et al, (2023) Quantifying the Historical Development of Abugadaf Natural Forest Using GIS-Remote Sensing Analytical Techniques/ Blue Nile State.

Northern State lies in the heart of desert, ecological zone (75-300 mm) between latitudes 17˚ 45 - 19˚ 15’ N and longitude 30˚ 15’-32˚ 00’ E. It has an area of 1,734,000 km2 and an estimated population of 833,743.It is bounded on the east by River Nile State, in the north by Egypt, northwest by Libya and Darfur State, and in the south by the Khartoum and Kordofan State. Alzubair et al., (2021) estimate that the irrigated agricultural area in northern state about 1.337.451 feddans (41.667ha), the state characterized by low rain fall, extreme temperatures and spare vegetation, this was described by Harrison and Jackson (1958) and Sudan NAP (2016). The average annual maximum temperature is 37˚C but the absolute maximum is 49˚C while The average annual minimum temperature is 19˚C and the absolute minimum is 1oC. Due to average annual rainfall is 11 mm/yr, the relative humidity is low, the highest evaporation recorded in May and the lowest in January; the maximum duration of sunshine is 11.9 hours in June and the lowest duration is 9.8 hours in December and the highest vapor pressure occurs in August and the lowest occur in February. In general, clouds are very low and rain increases from north to south. Two seasons were predominant in the State, a hot summer from April to September and cold winter from October to March (Al-Zubair et al., 2021). The northern state is considered one of the most affected states in Sudan by desertification processes, there are two main types of soils along the river Nile: Entisols which are recent alluvial fertile soils that are not salt-affected, and Aridisols in both the upper terrace and desert plain which are old

alluvial soils that are salt-affected. The Entisols are cultivable soils at the close proximity of the Nile bank forming a narrow strip furthermore the land is much fractionated due to land tenure laws, because of these limitation many farmers moved to the upper terraces and desert plains. Nowadays the horizontal expansion of agriculture into the desert plain soils is a must to cope with growing population and market deficit of essential crops. The soils of the study area particularly those of the desert plain, which is a complex depositional low relief landscape, composed of a series of basins, old wadis and fans. The relief is subdued making it very difficult to identify the different landforms. The most obvious process is calcification. The soils of the desert plain can only be identified by the presence or absence of calcium carbonate and gypsum. Their textures vary from heavy gypsic clays to gravelly sand. They are excessively to moderately well drain. The colure of the soils rang from yellowish red to olive brown. The soil depth is variable from less than 0.5 m to more than 2.0 m (Ibrahim et al., 2008). The total area affected by salinity and/or sodicity in this group is about 51000 hectares (Lahmeyer, 2005). Some of the desert soils are very saline and have apparently high ESP. reduction of salt content by leaching also will result in the reduction of ESP, as many of the potentially irrigable lands in Sudan contain some gypsum (Nachtergaele, 1976; fadul, 1978). The present study was undertaken to achieve the following objectives:

1. To investigate and determine the soil traits and land suitability for establishment of an agricultural project in the study area
2. To generate quantitative data on land degradation by estimating some of physiochemical soil indicators via remote sensing and GIS analysis in the study area.

2. MATERIALS AND METHODS:

2.1 Materials:

2.1.1 Study area:

The study area is an a proposed agricultural investment located 20 Km North west El- Golid Town and 60 Km south west Dongola city (See fig 1); the total area is about 6527.2feddans, The area is approximately bounded by longitudes and latitudes given below (table.1). Table 1: shows X & Y bounded the project area in Projected UTM System.

Table 1: the X & Y bounded the project area UTM System.

Corners	X in UTM	Y in UTM
1	225357	2061713
2	225023	2058521
3	225186	2057721
4	226546	2057848
5	227108	2058047
6	227177	2057890
7	235583	2059601
8	233177	2062005
9	231059	2062023
10	230906	2061840

2.1.2 Remote sensing imagery:

Land sat false color composite (FCC) subsets images Land sat 8 dated (2017) and Google earth image, covering the study area (6527.2feddans), were used in this study. The field work was conducted during the period 03 to 21th June 2017 aided by GPS receivers (Garmin 62C).

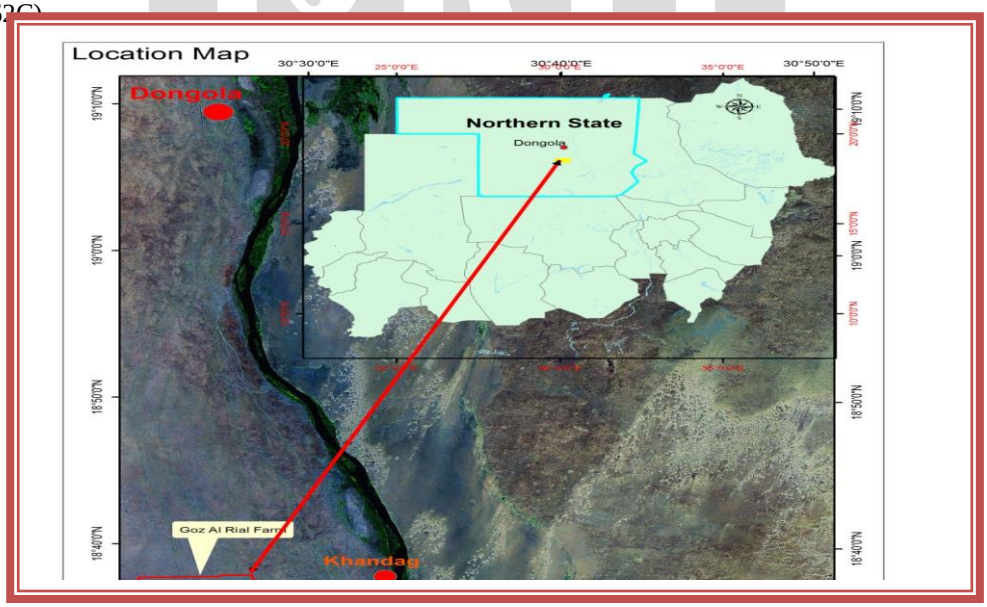

Fig.1. Location map of the study area.

2.2 Methods:

2.2.1 Office methods includes:

i. Collection of previous studies on the study area.
ii. Preparation of location map and other topographic maps.
iii. Preparation and interpretation of satellite images.

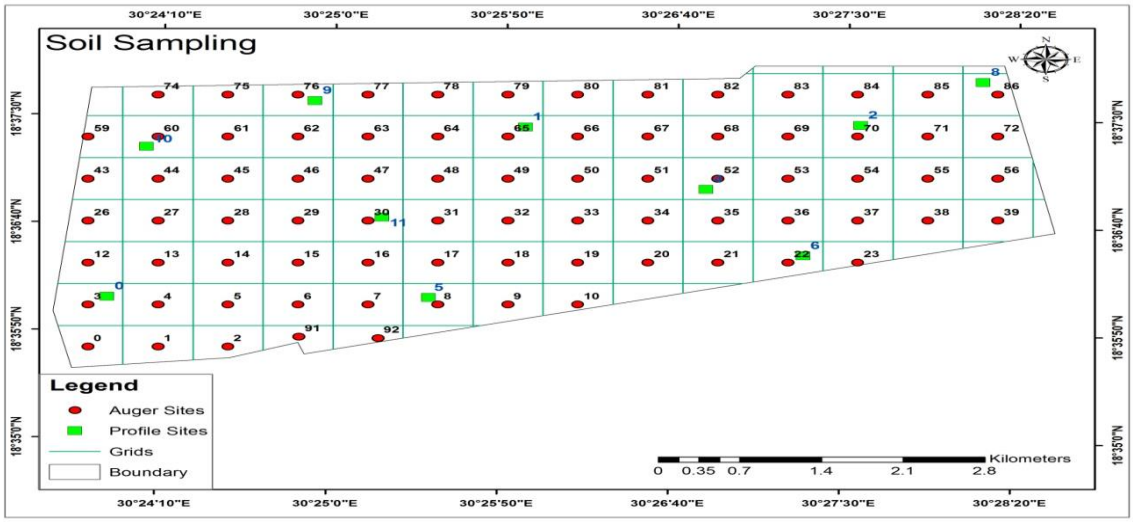

Fig.2.Soil sampling map.

2.2.2 Field work and soil sampling:

Soil samples were collected from different selected locations to cover the variability that observed from satellite image interpretation and Google earth. Global Positioning System (GPS) and GIS were used to locate the position of soil samples (Auger and Profile Sites). Soil grid system using Fishnet methods (Arc GIS) and observation of auger and profile sites were applied for verification and delineation of different soil unites, the intensity of observations was one auger for each 70.9 feddans gave total number of 92 auger sites for 2 depth (0-30cm, 30-60cm and, vertical and horizontal distance between the Auger sites is 500meters (Fig.2). Digging and description of soil profiles for the soil unites (indicated by the interpretation of satellite images and Sudan Land Cover maps), to have 12 profiles covering all the soil unites, (Fig.2). Soil analysis information (Evaluation Classification & Land Suitability) based on USDA (2010) System of Soil classification.

2.2.3 Laboratory work:

The Physiochemical properties were determined in soil saturation extracts of the samples according to the standard procedures of US Salinity Laboratory Staff (Richards et al., 1954) to investigate the following parameters;

1- The Electrical conductivity (ECe) to investigate the soil salinity.
2- Soil reaction (pH) to investigate soil alkalinity and acidity.
3- The sodium adsorption Ratio (SAR) to investigate the soil sodicity.
4- The percentage of the calcium carbonates (%$CaCo_3$), to investigate the soil calcareousness.
5- The mechanical analysis &the textural class, to investigate the percentage of the relative proportions of the soil particle size (sand, silt and clay).

2.2.4 GIS Analysis and mapping:

Geographical Information System (GIS) was used for data capture, input, manipulation, transformation, visualization, combination, query, analysis, modeling and output; an intersection was performed between the classified image, land survey and the soil map of the study area in order to improve the classification results, are shown in Figures 3 to 13, plate 1,2,3 and4 , tables 2 to 5 and appendix.

Results and discussions:

The analytical results of Soil surveying, Soil physiochemical analysis, image interpretations and GIS mapping indicate that the soil of the study area can be classified in only one main unites while it was divided into 3 sub units (classes), according to Quality and current value of cultivation of each sub unit (S2m, S2ma and S2ms) the letters m, a and s denote to moisture, alkalinity and salinity, respectively see suitability map fig (3).

A. Medium soil suitability class, S2m (3262.4 feddans) it represented about 50% of the total project area, are characterized nearly slight-moderate alkaline, non saline, non sodic, with low moisture contents. This area occupy a flat -slightly sloping plains ,while the surface is loamy sands and sandy clay loam some extended below the surface ,covered by about 50-70% gravels at maxima 2.5cm depth with clay contents less than 20.0%, the levels of total nitrogen and organic matter more or less are low with (see the suitability map and plate 3). This area is recommended for development, considering the following:

1- Removal of the surface gravels by (mechanical scrapping).

2- Addition of Organic matter with Agric sulfur at rates of 1.0 ton& 25 Kg respectively to improve water and nutrients holding capacities, similar result have been reported by Ahmed *et al*., (2018).
3- Introducing shelter belts to control erosion hazards.

B. Medium soil suitability class, S2ma is classified as moderately –high alkaline having pH values **(> 8.5),** non saline, non sodic with the dominant limitation of low moisture content due to low water holding capacity .The total area under this class is estimated to cover about (**2817.06 feddans**) occupying scattered units located at the northern &northern –east parts of the project area (see suitability map). This area is recommended for development after adopting further reclamation processes, pointed as:

- ❖ addition of sufficient good quality irrigation water
- ❖ Addition of organic matter (composted manures) at rate of 1.5 tons/fed or/and organic fertilizers, to improve both the water and nutrients holding capacities, as well as it minimize the high pH values obtained.
- ❖ Addition of Agric .sulfur which act with the manures at rate of 50Kg /fed, they both release acids, which are dissolved the $CaCo_3$ accumulated by depths.
- ❖ Addition of chemical fertilizers as sources of NPK and other micro-nutrients include Fe, Cu, Zn and Mn.

C. Medium suitability class, S2ms The soil is classified as non sodic slightly –moderately alkaline and highly saline **ECe > 16 dS/m**. This area covers about **447.7** feddans occupying scattered area located at the most northern boundaries. (Plate 4). This area should be reclaimed by addition of a mixture of composted manures and Agric sulfur at rates of **0.5** ton and **25** Kg/ fed and should be irrigated with a sufficient good quality water for quick salt leaching.

Fig.3.Soil Suitability map.

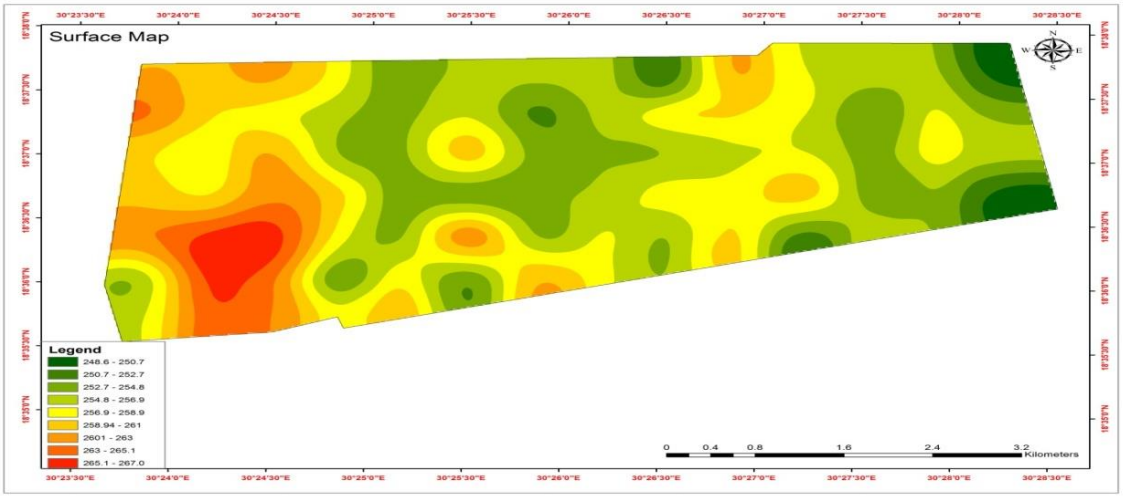

Fig.4.Surface map.

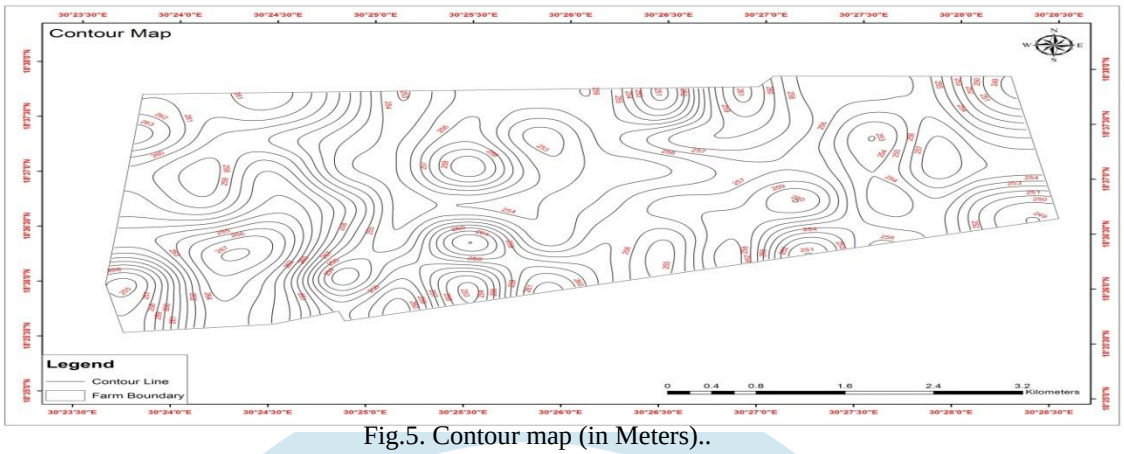

Fig.5. Contour map (in Meters)..

Table.2.The range values of soil pH in the study area.

Soil depths	Ranges	average	guideline	Comments
Surface soil (0 - 30 cm)	**7.1 – 9.66**	**8.49**	**6.5- 7.5**	**Highly alkaline**
Sub – surface soil	**7.0 – 9.88**	**8.11**	**6.5- 7.5**	**Moderately alkaline**

Table. 3. Salinity levels (dS/m).

Soil depths	Ranges	Average	guideline	Salinity classes
Surface soil (0 - 30 cm)	0.3 – 14.2	1.61	<4.0ds/m	Non saline
Sub- surface soil (30-60cm)	0.17 – 45.7	3.63	<4.0ds/m	Non saline

Table.4. Sodicity levels (SAR).

Soil depths	ranges	average	Guideline	Comments
Surface soil (0 - 30 cm)	0.17 – 15.39	1.57	<13.0	Non sodic
Sub- surface soil (30-60cm)	0.41 – 3.18	1.27	<13.0	Non sodic

Table.5. Moisture content.

Soil depths	Ranges	Average	Guideline	Comments
Surface soil (0 - 30 cm)	21.74– 34.90	27.17	>40%	Low Moisture Content
Sub- surface soil (30-60cm)	21.50– 37.70	29.43	>60%	Low Moisture Content, However the Moisture increased with depth due to clay contents.

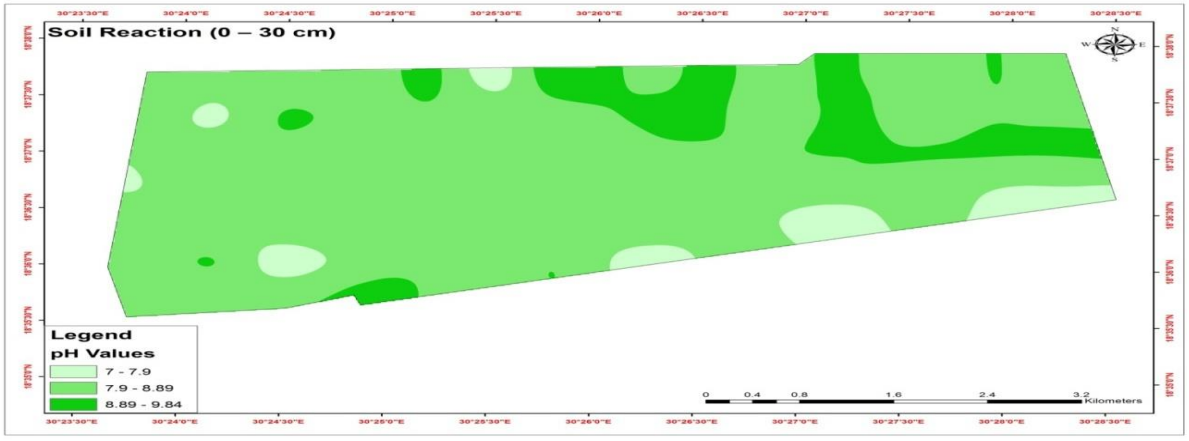

Fig.6. Soil pH (0 – 30cm).

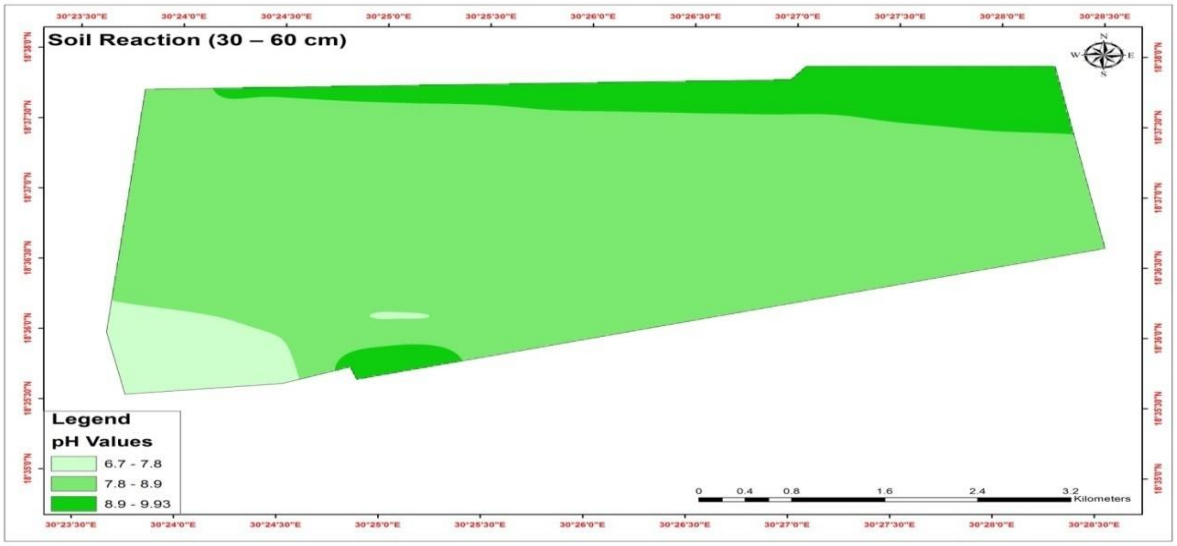

Fig.7. Soil pH (30 – 60cm).

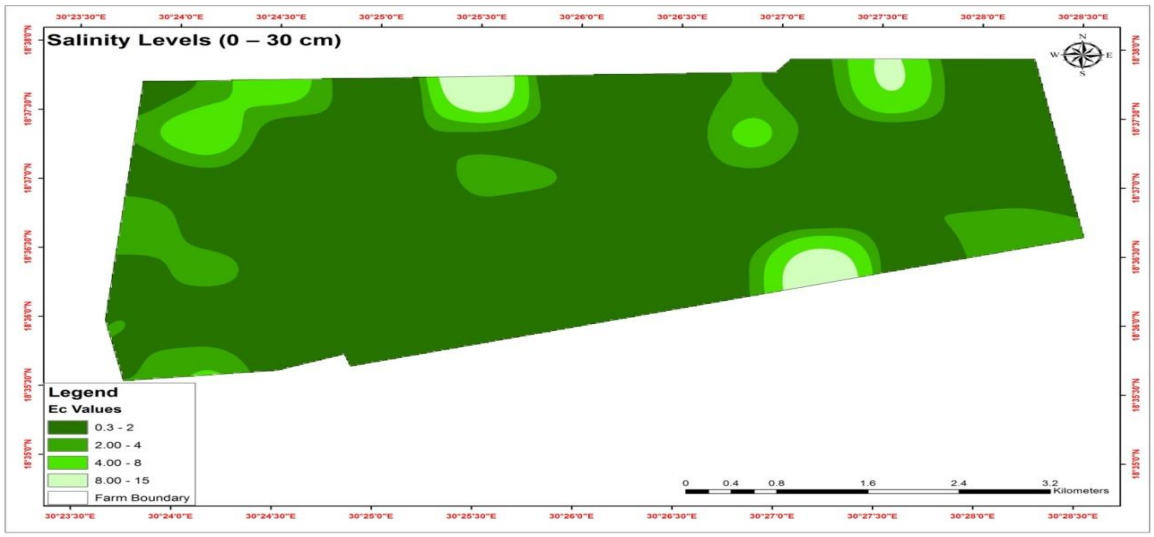

Fig.8. Soil Salinity levels (0 – 30cm).

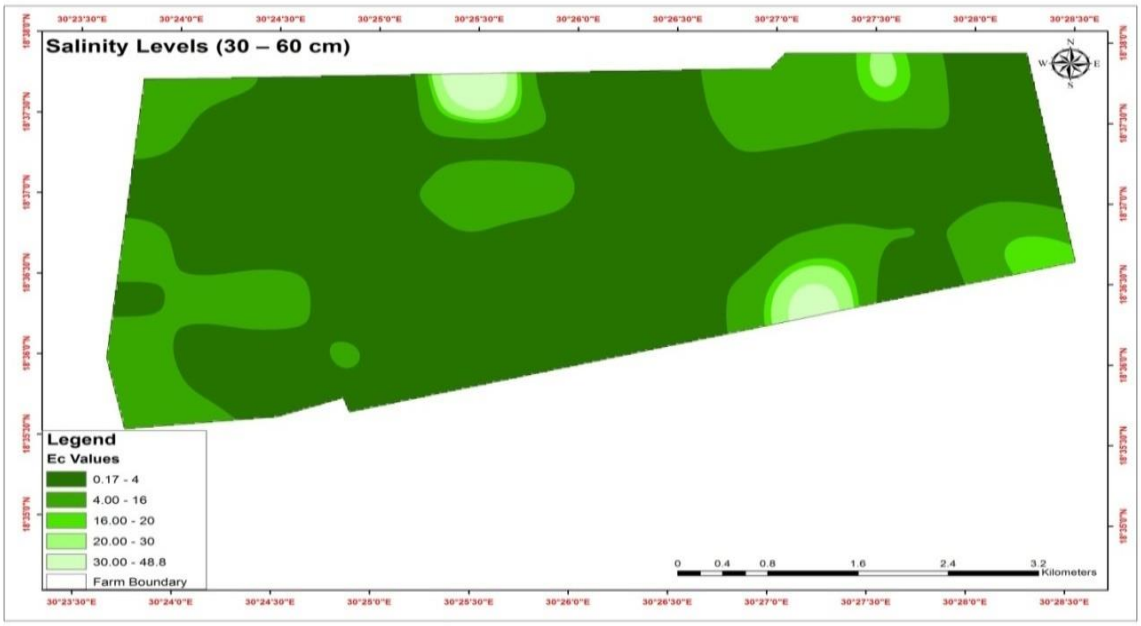

Fig.9. Soil Salinity levels (30 – 60cm).

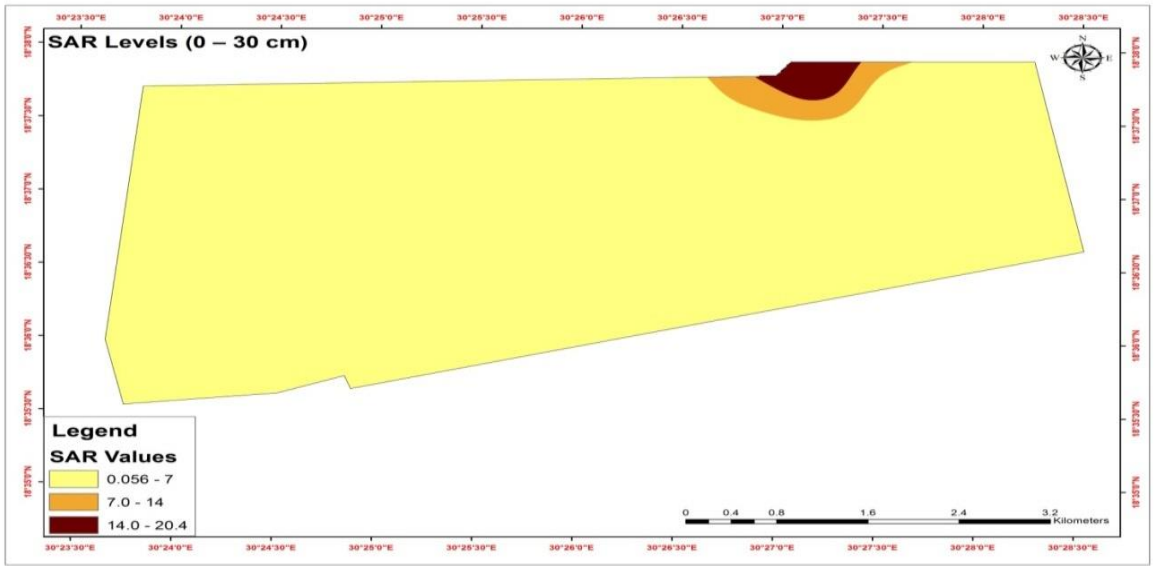

Fig.10. SAR levels (0 – 30cm).

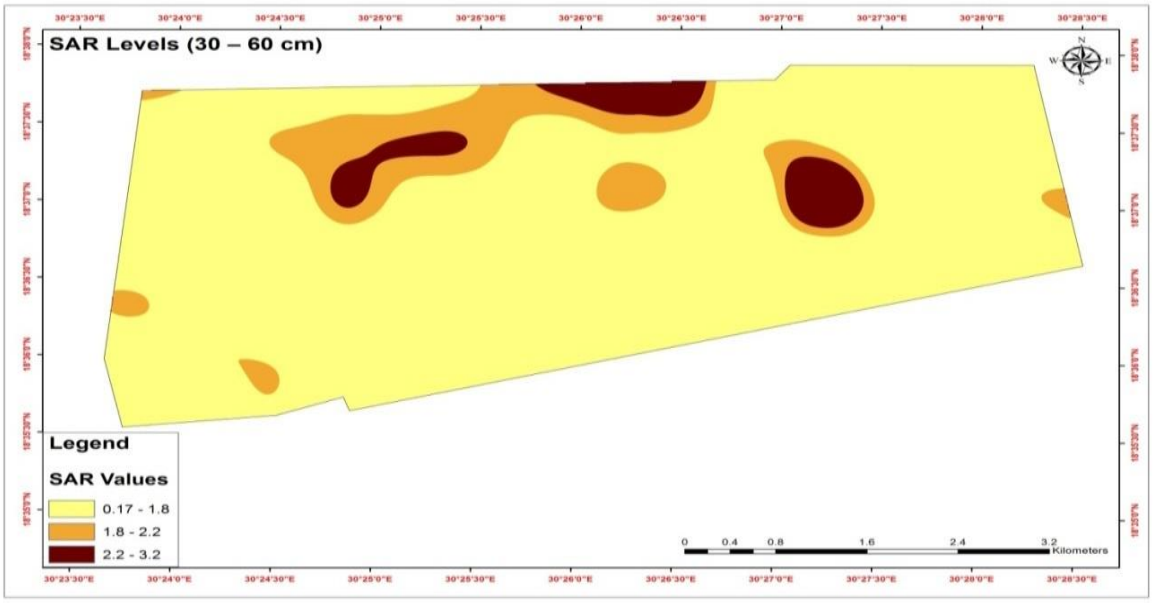

Fig.11. SAR levels (30 – 60cm).

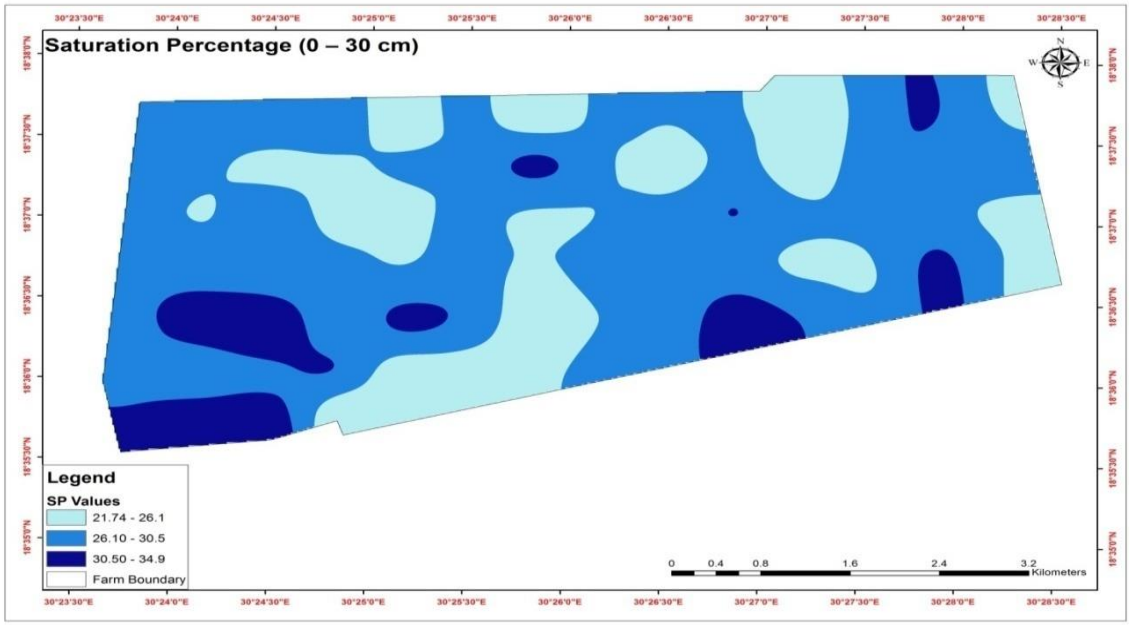

Fig.12. Saturation Percentage (SP% 0 – 30cm).

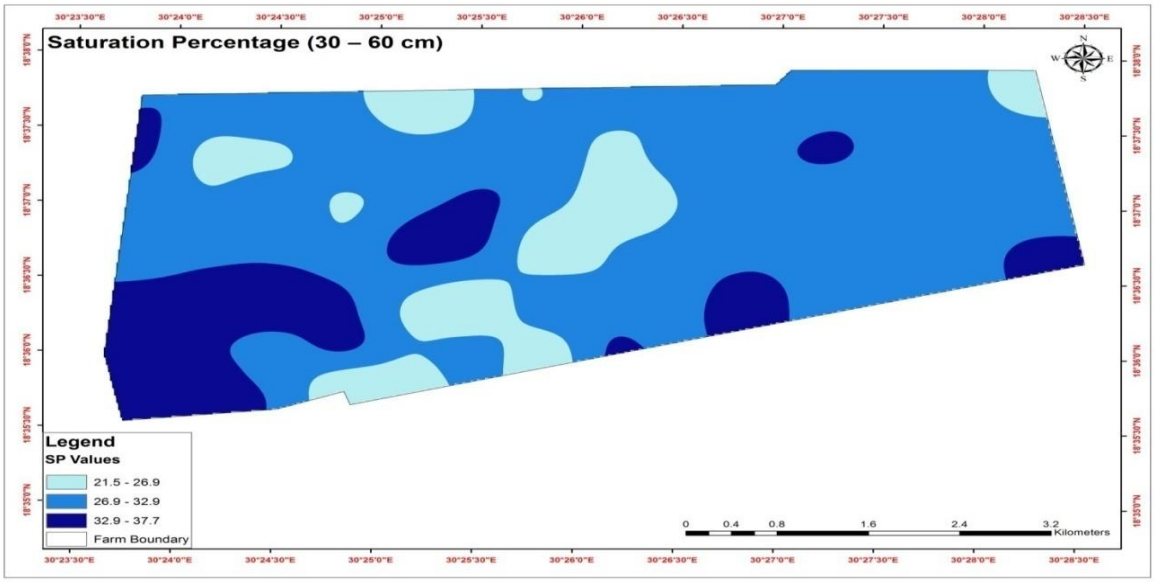

Fig.13. Saturation Percentage (SP% 30 – 60cm).

3. CONCLUSION AND RECOMMENDATIONS:

The study explained the importance of using remote sensing, GIS techniques beside soil survey as basic study for selecting a suitable land for agricultural activities. Soil analysis showed that physicochemical properties of the soil and characterized under three sub groups . From the above mentioned discussion and based on the results, the land to be currently suitable for agricultural activities when fallowing practices are the common and widely used:

- Continued use of chemical fertilizers and organic manure.
- Establishment of shelter belts.
- Use of appropriate irrigation systems.
- Scraping the gravel from surface and land leveling.
- Growing shallow rooted crops.
- Adequate leaching of salt through irrigation.

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Appendix:
Auger sites 0 – 30 cm

1	X	Y	Z	SP %	ph (s)	E.Ce ds/m	Ca +Mg meq/l	Na meq/l	SAR	K ppm
0	225322.70	2058006.70	256.5	31.3	8.03	2.42	7	3.68	1.39	19.8
1	225922.70	2058006.70	264	33.7	8.03	5.05	16.7	4.96	1.21	24.9
2	226522.70	2058006.70	263	33.3	8.63	0.77	2	2.13	1.51	9.5
3	225322.70	2058606.70	255.5	29.2	8.19	1.84	4.7	3.44	1.59	17
4	225922.70	2058606.70	265	28.0	8.9	0.38	3.2	1.43	0.80	6.14
5	226522.70	2058606.70	263.5	29.6	7.5	0.89	2.3	2.29	1.51	10.92
6	227122.70	2058606.70	253.5	30.1	8.33	1.3	4.5	2.58	1.22	16.04
7	227722.70	2058606.70	258	23.1	8.68	0.33	3.2	0.81	0.45	9.56
8	228322.70	2058606.70	253.5	23.1	8.53	0.54	2.2	1.63	1.10	11.6
9	228922.70	2058606.70	260.5	24.3	8.77	0.31	2	0.9	0.64	8.19
10	229522.70	2058606.70	257.5	28.8	7.46	0.42	1.8	1.1	0.82	11.95
12	225322.70	2059206.70	262.5	30.1	8.5	1.31	3.5	2.82	1.51	12.29
13	225922.70	2059206.70	265.5	32.1	8.06	2.65	6.8	3.89	1.49	21.85
14	226522.70	2059206.70	266	32.9	8.48	0.95	2.4	2.29	1.48	11.6
15	227122.70	2059206.70	258	28.0	8.65	0.44	2.2	1.1	0.74	8.87
16	227722.70	2059206.70	255	31.3	8.08	1.59	5.2	2.45	1.07	14.34
17	228322.70	2059206.70	262	28.8	8.85	0.35	1.8	1.22	0.91	5.46
18	228922.70	2059206.70	255	23.1	8.68	0.36	1.5	1.1	0.90	10.24
19	229522.70	2059206.70	257	26.4	8.69	0.48	2.2	1.14	0.77	11.26
20	230122.70	2059206.70	255	27.2	8.43	0.47	3.3	1.06	0.58	12.63
21	230722.70	2059206.70	259	33.3	7.93	2.56	7	3.36	1.27	23.5
22	231322.70	2059206.70	252	30.1	7.1	12.88	56.4	6.76	0.90	45.06
23	231922.70	2059206.70	256	27.2	8.52	0.31	2.7	0.81	0.49	5.46
26	225322.70	2059806.70	260.5	29.6	7.92	3.72	12.3	4.01	1.14	21.5
27	225922.70	2059806.70	259	28.8	8.7	0.68	2.8	1.8	1.08	8.53
28	226522.70	2059806.70	262.5	27.6	8.35	0.7	3.2	1.51	0.84	11.9
29	227122.70	2059806.70	259.5	27.6	8.7	0.69	2.8	2.09	1.25	7.51
30	227722.70	2059806.70	253.5	26.4	8.25	0.89	3.6	1.88	0.99	11.9
31	228322.70	2059806.70	254	27.6	8.49	1.31	4.6	2.45	1.14	16.73
32	228922.70	2059806.70	254	25.5	8.72	0.31	1.5	1.06	0.87	7.51
33	229522.70	2059806.70	255.5	28.0	8.53	0.38	2	1.02	0.72	10.58
34	230122.70	2059806.70	257.5	27.2	8.49	0.34	2.5	0.86	0.54	8.87
35	230722.70	2059806.70	258	28.0	8.32	0.57	2.8	1.22	0.73	12.29
36	231322.70	2059806.70	259.5	25.5	8.61	1.05	2.8	2.5	1.49	13.31
37	231922.70	2059806.70	254	25.9	8.55	0.91	4.4	2.21	1.05	15.36
38	232522.70	2059806.70	254.5	31.7	7.98	2.16	7	2.78	1.05	19.4
39	233122.70	2059806.70	250	25.9	7.85	2.39	8.8	3.07	1.03	23.21
43	225322.70	2060406.70	259.5	27.6	8.05	0.64	4	1.39	0.70	10.24
44	225922.70	2060406.70	257.5	25.9	8.54	0.83	3.5	1.84	0.98	9.56

1	X	Y	Z	SP %	ph (s)	E.Ce ds/m	Ca +Mg meq/l	Na meq/l	SAR	K ppm
45	226522.70	2060406.70	261	28.4	8.63	0.59	3.2	1.55	0.87	7.85
46	227122.70	2060406.70	255	24.7	8.27	0.8	3.2	4.81	2.69	11
47	227722.70	2060406.70	254.5	24.7	8.24	1.17	3.5	4.9	2.62	13
48	228322.70	2060406.70	259.5	27.2	8.22	2.3	6	3.03	1.24	19
49	228922.70	2060406.70	254	25.5	8.26	2.13	7	5.7	2.15	29
50	229522.70	2060406.70	254.5	26.4	8.69	0.39	2	0.99	0.70	8
51	230122.70	2060406.70		28.0	8.77	0.44	3	1.64	0.95	10
52	230722.70	2060406.70	256.5	30.5	8.83	1.2	2.3	1.31	0.86	15
53	231322.70	2060406.70	257	27.2	8.93	0.71	2.5	5.85	3.70	30
54	231922.70	2060406.70	254	27.6	8.94	0.32	2.5	1.08	0.68	40.4
55	232522.70	2060406.70	257.5	27.6	8.99	0.37	2.8	1.17	0.70	31
56	233122.70	2060406.70	255.5	25.5	8.98	0.82	1.5	4.51	3.68	27.4
59	225322.70	2061006.70	263.5	30.1	8.7	2.6	7	2.17	0.82	26.8
60	225922.70	2061006.70	259.5	27.2	7.73	6.75	3.3	2.58	1.42	23.4
61	226522.70	2061006.70	258	25.1	8.92	0.62	2.8	2.17	1.30	30
62	227122.70	2061006.70	255.5	25.5	8.62	0.64	5	4.42	1.98	25.6
63	227722.70	2061006.70	254	26.8	8.75	1.17	4	6.42	3.21	25
64	228322.70	2061006.70	256.5	28.0	8.52	1.71	6.2	4.81	1.93	21.4
65	228922.70	2061006.70	252.5	31.3	8.52	0.37	3	1.35	0.78	30
66	229522.70	2061006.70	255.5	26.8	8.98	0.34	1.2	0.78	0.71	33
67	230122.70	2061006.70	258	23.1	9.13	0.3	3	0.3	0.17	23
68	230722.70	2061006.70	259	27.6	8.13	4.66	19	7.11	1.63	25.9
69	231322.70	2061006.70	257	23.1	9.16	0.62	3.5	2.3	1.23	20
70	231922.70	2061006.70	253	29.6	8.2	0.32	2.8	1.02	0.61	67
71	232522.70	2061006.70	257	28.4	8.78	0.72	2.4	2.95	1.90	30
72	233122.70	2061006.70	254	27.6	8.72	0.59	2.8	1.77	1.06	5
74	225922.70	2061606.70	260.5	28.0	8.36	2.7	9	6.51	2.17	22
75	226522.70	2061606.70	261.5	28.8	8.3	5.64	10.2	8.11	2.54	3
76	227122.70	2061606.70	258	29.2	8.22	1.02	2	2.21	1.56	64
77	227722.70	2061606.70	253	23.1	9.14	0.36	2.7	1.47	0.89	3
78	228322.70	2061606.70	255.5	27.2	7.58	14.2	63	14.32	1.80	14
79	228922.70	2061606.70	255.5	23.1	9.66	0.37	2.3	1.69	1.11	18
80	229522.70	2061606.70	255.5	27.2	8.75	1.17	4.5	4.73	2.23	29
81	230122.70	2061606.70	251.5	26.8	9.09	0.56	2.5	4.16	2.63	38
82	230722.70	2061606.70	261	26.4	8.52	2.27	6.5	26	10.20	32
83	231322.70	2061606.70	257	23.1	9	1.01	4.1	31.16	15.39	40
84	231922.70	2061606.70	256	28.4	8.07	8.16	31.8	10.4	1.84	2
85	232522.70	2061606.70	255	30.5	8.88	0.76	3.1	4.73	2.69	7
86	233122.70	2061606.70	249.5	25.5	8.55	1.13	3.7	0	0.00	18
91	227131.11	2058147.00	257.5	23.1	8.97	0.36	4	0.78	0.39	13
92	227808.44	2058125.84	259.5	24.3	8.79	0.5	3	1.08	0.62	9

1	X	Y	Z	SP %	ph (s)	E.Ce ds/m	Ca +Mg meq/l	Na meq/l	SAR	K ppm
44	225922.70	2060406.70	257.5	28.0	8.73	1.04	4	2.41	1.205	6.
45	226522.70	2060406.70	261	30.9	8.68	0.59	3.4	1.92	1.0413	3.
46	227122.70	2060406.70	255	26.4	9.35	0.37	1	2.3	2.3	
47	227722.70	2060406.70	254.5	30.9	7.95	3.63	11	4.77	1.4382	
48	228322.70	2060406.70	259.5	33.7	7.85	6.42	12.8	4.77	1.3333	
49	228922.70	2060406.70	254	28.8	7.48	6.21	27	5.2	1.0007	
50	229522.70	2060406.70	254.5	23.1	8.94	0.3	2.8	3.38	2.0199	
51	230122.70	2060406.70		27.6	8.34	0.86	3.5	2.73	1.4592	
52	230722.70	2060406.70	256.5	28.8	8.78	0.47	3	1.63	0.9411	3.
53	231322.70	2060406.70	257	28.8	9.2	0.48	2	4.51	3.1891	
54	231922.70	2060406.70	254	28.4	9.15	0.23	2.8	2.25	1.3446	
55	232522.70	2060406.70	257.5	30.9	8.79	0.65	4	1.34	0.67	
56	233122.70	2060406.70	255.5	30.5	8.34	1.78	17.8	6.9	1.6355	
59	225322.70	2061006.70	263.5	34.6	8.22	6.46	23	8.2	1.7098	
60	225922.70	2061006.70	259.5	25.5	8.21	2.02	21.7	6.07	1.303	
61	226522.70	2061006.70	258	25.9	8.9	0.52	2	2.56	1.8102	
62	227122.70	2061006.70	255.5	31.3	9.33	1.3	3	3.64	2.1016	
63	227722.70	2061006.70	254	29.6	9.21	0.55	1.5	2.77	2.2617	1
64	228322.70	2061006.70	256.5	29.2	8.26	3.36	10.8	6.77	2.06	
65	228922.70	2061006.70	252.5	29.6	8.22	2.11	6.8	3.03	1.162	11
66	229522.70	2061006.70	255.5	25.1	9.16	0.61	2.8	2.77	1.6554	
67	230122.70	2061006.70	258	32.5	9.15	0.19	3	2.43	1.403	
68	230722.70	2061006.70	259	30.5	7.8	4.91	20.5	7.81	1.7249	
69	231322.70	2061006.70	257	33.7	7.98	4.12	16.5	7.81	1.9227	
70	231922.70	2061006.70	253	30.9	8.27	0.37	3	1.35	0.7794	
71	232522.70	2061006.70	257	30.9	8.72	3.07	13.2	5.46	1.5028	
72	233122.70	2061006.70	254	30.5	8.19	1.15	5.4	2.47	1.0629	
74	225922.70	2061606.70	260.5	31.3	7.94	4.79	21	7.42	1.6192	
75	226522.70	2061606.70	261.5	31.7	8.13	3.37	22.8	6.76	1.4157	
76	227122.70	2061606.70	258	29.2	8.4	0.85	3	2.82	1.6281	
77	227722.70	2061606.70	253	23.1	9.39	0.36	1.3	1.77	1.5524	
78	228322.70	2061606.70	255.5	27.2	7.5	45.7	194.5	26.04	1.8672	
79	228922.70	2061606.70	255.5	27.2	9.88	0.26	2	2.95	2.086	
80	229522.70	2061606.70	255.5	29.6	8.45	2.57	10.2	8.2	2.5675	
81	230122.70	2061606.70	251.5	27.6	9.42	0.44	2.5	3.99	2.5235	
82	230722.70	2061606.70	261	28.0	7.88	9.93	41	5.64	0.8808	
83	231322.70	2061606.70	257	2.6	0	0	0	0	0	
84	231922.70	2061606.70	256	31.7	7.11	19.66	131.5	5.2	0.4535	
85	232522.70	2061606.70	255	28.8	8.23	3.28	12.8	4	1.118	
86	233122.70	2061606.70	249.5	25.9	8.22	0.6	1.76	1.76	1.3266	12.
91	227131.11	2058147.00	257.5	23.1	8.78	0.35	2.8	0.78	0.4661	
92	227808.44	2058125.84	259.5	25.1	9.03	0.51	2	1.3	0.9192	

Augers Sites 30 – 30cm **Profiles sites**

Profile Sited:

No	X	Y	SP %	pH(s)	E.Ce (dS/m)	Ca +Mg (mmol+/l)	Na (mmol+/l)	SAR	Kppm	$CaCO_3$ %
P0										
0 - 14	225487.7	2058725.6	63	8.42	1.95	4.2	3.32	2.29	16.73	3.2
14 - 45	225487.7	2058725.6	73	7.56	7.13	23	5.69	1.68	20.17	1
45 - 101	225487.7	2058725.6	71	7.34	7.7	24.8	5.61	1.59	11.26	1
P1										
0 - 17	229075.6	2061144.0	70	8.52	0.37	1.2	1.35	1.75	8.19	2.8
17 - 52	229075.6	2061144.0	65	8.22	2.11	6.8	3.03	1.65	11.6	2.2
52 - 100	229075.6	2061144.0	71	7.78	2.05	8	2.33	1.17	7.17	3.3
P2										
0 - 33	231950.0	2061163.8	66	8.2	0.32	2.4	1.02	0.93	7.85	4.3
33 - 64	231950.0	2061163.8	76	8.27	0.37	3	1.35	1.11	5.12	5.5
64 - 92	231950.0	2061163.8	59	8.12	1.2	3.5	2.21	1.67	8.53	15.5
P4										
0 - 20	230621.8	2060251.9	60	8.82	0.47	2.3	1.31	1.22	9.56	2
20 - 50	230621.8	2060251.9	61	8.78	0.47	3	1.63	1.34	3.75	2.2
50 - 110	230621.8	2060251.9	70	8.63	0.54	2	1.68	1.68	4.43	1.8
P5										

0 - 12	228243.1	2058705.8	50	8.37	5.92	28.5	3.48	0.92	18.43	0.5
12-- 36	228243.1	2058705.8	50	8.27	0.65	2.6	1.88	1.65	10.92	0.1
36 - 102	228243.1	2058705.8	65	7.05	14.67	88.4	5.98	0.90	33.46	3
P6										
0 - 13	231454.4	2059300.4	53	8.15	1.13	5	2.04	1.29	15.02	0.5
13 - 58	231454.4	2059300.4	0	0	0	0	0	0	0	0
58 - 93	231454.4	2059300.4	0	0	0	0	0	0	0	0
P8										
0 - 30	233000.6	2061778.3	56	8.55	0.6	3.7	0	0		0.4
30 - 70	233000.6	2061778.3	57	8.22	1	3.5	1.76	1.33	12.47	0.6
70 - 83	233000.6	2061778.3	65	8.14	0.89	3.7	1.92	1.41	5.8	0
P9										
0 - 16	227271.8	2061520.6	63	8.22	0.85	2.7	2.21	1.91	9.21	1
16 - 40	227271.8	2061520.6	65	8.4	1.02	3	2.82	2.31	5.46	0.8
40 - 100	227271.8	2061520.6	80	7.63	6.75	16.3	6.6	2.32	7.85	1
P10										
0 - 15	225824.7	2060866.4	50	8.6	1.01	2.8	2.58	2.19	11.6	1
15 - 32	225824.7	2060866.4	77	7.73	5.81	21.7	6.07	1.84	33	1
32 - 58	225824.7	2060866.4	78	8.21	2.02	9	6.85	3.23	7	2.5
58 - 100	225824.7	2060866.4	75	7.23	7.68	36	8.41	1.98	12	3
P11										
0 - 11	227846.6	2059855.5	62	8.57	0.77	3.8	3.94	2.86	15	2

11-- 30	227846.6	2059855.5	67	8.25	1.13	4	5.9	4.18	14	1.5
30 - 106	227846.6	2059855.5	75	7.88	2.05	7.5	4.47	2.30	7	0.5

Continue Profiles Results:

P ppm	O.C %	O.M %	T.N %	sand%	silt %	clay %	tex. Class%	CEC meq/100gs
P0								
7	0.70	1.2	0.06	70	17.8	12.2	loamy sand	10.5
5	0.87	1.5	0.075	67.5	22.5	10	sandy loam	12
2.2	0.99	1.7	0.085	60	22.5	17.5	Sandy Clay Loam	15
P1								
6.2	0.99	1.7	0.085	75	17.5	7.5	loamy sand	8.5
5.3	1.22	2.1	0.105	72.5	20	7.5	loamy sand	10.2
4.5	1.34	2.3	0.115	65	20	15	Sandy Clay Loam	15
P2								
3.5	0.93	1.6	0.08	77.5	12.5	10	loamy sand	11.8
2.2	1.10	1.9	0.095	72.5	12.5	15	loamy sand	12.2
2	1.16	2	0.1	70	17.5	12.5	loamy sand	12.2
P4								
6.5	1.16	2	0.1	70	17.5	12.5	loamy sand	12
4.2	1.28	2.2	0.11	75	15	10	loamy sand	10.5
2.3	1.34	2.3	0.115	70	17.5	12.5	loamy sand	12
P5								
8.2	0.70	1.2	0.06	77.5	10	12.5	loamy sand	10.2
5.3	0.99	1.7	0.085	70	17.5	12.5	sandy loam	14
3.1	1.28	2.2	0.11	62.5	20	17.5	Sandy Clay Loam	15
P6								
2.5	0.70	1.2	0.06	77.5	7.5	15	loamy sand	8.6
0	0.00	0	0	0	0	0	0	0
0	0.00	0	0	0	0	0	0	0
P8								
8.6	1.28	2.2	0.11	77.5	12.5	10	loamy sand	10.6
5.2	1.34	2.3	0.115	77.5	7.5	15	sandy loam	13.6
3.3	1.45	2.5	0.125	67	15.5	17.5	Sandy Clay Loam	15
P9								
8.5	1.40	2.4	0.12	75	7.5	17.5	sandy loam	14.5
6.6	1.57	2.7	0.135	70	15	15	loamy sand	10.2
3.2	1.63	2.8	0.14	62.5	20	17.5	Sandy Clay Loam	12.2
P10								
8.2	1.05	1.8	0.09	77.5	7.5	15	sandy loam	10.6
4.3	1.22	2.1	0.105	75	12.5	12.5	sandy loam	12.5
2.5	1.28	2.2	0.11	75	12.5	12.5	sandy loam	12.8

2	1.51	2.6	0.13					
P11								
6.8	1.05	1.8	0.09	75	10	15	sandy loam	12.8
4.3	1.22	2.1	0.105	72.5	15	12.5	sandy loam	13.5
3.5	1.40	2.4	0.12	70	15	15	sandy loam	14.2