Evaluate of soil salinity, Alkalinity and land suitability for alfalfa cultivation by using Remote sensing, Global Positioning System (GPS) and Geographic Information System (GIS).

Wael Awad Marajan Mohammed[1], Abass Mohamed Elhag Hamed[2], El Moiez Lidin Allah Mohamed Fadul Abdel Karium[3] , Motasim Hyder Abdelwahab[4].

[1]Assistance Professor, Department: Soil and Water Science, College of Agriculture, University of Bahri, Khartoum North (Al-Kadaro), Sudan,.
[2]Associate Professor, Basic Science Department, College of Natural Resources and environmental studies, University of Bahri, Khartoum North (Al-Kadaro), Sudan.
[3]Researcher Associate Professor, Dongola Agriculture Research. Stations. ARC, Sudan,.
[4]Associate Professor, Department of Arid Land and Desert Agriculture, Faculty of Agriculture, Omdurman Islamic University, Omdurman, Sudan

ABSTRACT: The study was conducted in south west Gaab El lagiya area, 35 Km, North-west Dongola City (Gaab El lagiya Site) Northern State – Sudan, during 10 – 22 January 2019 to evaluate the soil salinity, Alkalinity and land suitability for alfalfa cultivation by using Remote sensing, Global Positioning System (GPS) and Geographic Information System (GIS) used in the field. This area was characterized by high groundwater table (level) to less than 60 cm from the soil surface where the water evaporates from the soil surface as a result of high temperatures in desert region, leaving accumulations of salt on the soil surface, which hindered the growth and development of vegetation cover in the study area. Soil grid system of observation auger and profile were done. One auger for (46 feddans) about to have = 116 augers sites for 2depths (0-30cm, 30- 60cm and, vertical and horizontal distance between the Auger sites is 500 meters. Digging and description of soil profiles for the soil unites (indicated by the interpretation of satellite images and Sudan Land Cover maps), to have about 09 profiles covering all the soil unites Soil analysis information (Evaluation Classification & Land Suitability) based on USDA System of classification and WRG. The physical and chemical analysis were carried to investigate the following parameters; The soil salinity used Electrical conductivity (Ece), Soil reaction (pH), sodium adsorption Ratio (SAR), percentage calcium carbonates, mechanical analysis &the textural class. The results revealed that, the pH level (average values) of all samples analyzed are high, slightly to high salinity, slightly to high alkaline, none sodicity and low moisture content, the surface soil is sandy and sandy loams and the sub soil is loamy sand <60 cm depth, excessively drained with clay content < 20%. The study recommended that the soil and environment in the study area were not suitable for alfalfa cultivation.

Key words: Dongola, Gaab El lagiya, Soil, Salinity, Alkalinity and suitability, remote sensing, GIS and GPS.

1. INTRODUCTION:

Natural and man-induced salt accumulation in the soil profile is a major environmental threat with dramatic negative impacts on agricultural production and sustainability, especially in the arid and semiarid regions of the world [1].Salt-affected soils are found in Northern part of Sudan, in arid and semi-arid climates where there is a scarcity of rainfall, and reclamation of these soils is very important. Dongola area is mostly affected by desertification and salinization [1]. Soil salinity is the salt content in the soil; the process of increasing the salt content is known as salinization. Salts occur naturally within soils and water. Salinization can be caused by natural processes such as mineral weathering or by the gradual withdrawal of an ocean. It can also come about through artificial processes such as irrigation and road salt [2] Salinity in dry lands can occur when the water table is between two and three meters from the surface of the soil. The salts from the groundwater are raised by capillary action to the surface of the soil. This occurs when groundwater is saline (which is true in many areas), and is favored by land use practices allowing more rainwater to enter the aquifer than it could accommodate [3]. Soil salinity is the most severe factor that affects the growth of plants. Soil salinity when combined with boron toxicity is found to be most vigorous in actions against growth of plants [4] Alkali or alkaline soils have been defined as soils with high pH-value, which is caused by excessive (usually more than 15% of the exchange sites) amount of exchangeable sodium ions or/and soluble salts capable of alkaline hydrolysis. The most injurious alkaline sodium compounds in the soils and irrigation waters are Na_2CO_3 (sodium carbonate) or $NaHCO_3$ (sodium bicarbonate) [5]. In arid or desert areas where rainfall is slim and places where there are dense forests, soil tends to be more alkaline. Soil can also become more alkaline if it is watered with hard water that contains lime [6]. Alfalfa has historically been classified as moderately sensitive to salinity with yield declines predicted at greater than 2 dS per m ECe (deci-Siemens per meter, electrical conductivity of the saturated soil paste extract). Alfalfa is recognized as a crop that is moderately sensitive to salinity [7]. Standard recommendations state that alfalfa should have a soil pH of 6.5 to 7 or 7.5, which is above the average for most crops (6.2 – 6.8). Actually, not so much attention should be paid to the exact pH figure because, the pH of soil changes constantly, even from day to day, and the pH readings produced by a soil testing lab depend on the methods used [8]. A higher pH is recommended for alfalfa is that alfalfa requires high levels of calcium, and large amounts of lime are applied to raise pH, automatically supplying the crop's need for

calcium. Low pH (below 6.0) can have detrimental effects in reducing or eliminating growth of beneficial soil bacteria, including nitrogen-fixing bacteria, but high quality forage can be grown on acid soil, provided it has balanced and high fertility [8].
The main aim of this study is the evaluate the soil salinity, Alkalinity and land suitability for alfalfa cultivation by using Global Positioning System (GPS) and Geographic Information System (GIS) used in the field.

2. MATERIALS AND METHODS:

2.1 Location and extent:-

The Project area (south west Gabb El Lagiya) Project is a proposed agricultural investment located at 35 Km North-west Dongola City, lies about 15km west Argein – Dongola Street, the area is about 3106.5 feddens (Fig 1).The area is approximately bounded by longitudes and latitudes given below, table (1). The climate of the survey area according to [9]. The mean daily temperature is 29.9 Co and mean daily maximum reaches 41.9 Co in May while the minimum is 15.6 Co in January. The total annual rainfall is 121.4 mm and reaches a maximum of 48.3 mm in August. The mean relative humidity is 28 % and ranges from 15 % in April to 48 % in August. The sunshine duration ranges from 63 % in July to 91 % in November.

2.2 Soil climate:-

The climatic data of Dongola: climatology normal's, 1941-2003 (Tables 3) shows that the differences between mean summer (June, July and August) air temperature and mean winter (December, January and February) air temperature is more than 15 Co. The mean annual soil temperature is estimated more than 22C° and the survey area has a Hyper- thermic soil temperature regime[10].

2.3 Geology and geomorphology:

The main geological formations in the survey area consist of Basement Complex, Nubian sandstone and superficial deposits (alluvium and Aeolian materials).The Nubian Formation of Cretaceous age lies on the Basement Complex and includes subordinate conglomerates, siltstones and mudstones.

2.4 Vegetation:

The survey area lies within the semi- desert zone according to [11].Which is characterized by semi- desert grasses such as Halfa, Ekhraieet and scattered Acacia ehrenbergiana (Salam trees).

2.5 Office methods:

i. Collection of previous studies in the area that covers the target area.
ii. Preparation of location map and other topographic map.
iii. Preparation and interpretation of satellite images.

2.6 Field work:

Land Sat Image 8 (October 2018), Global Positioning System (GPS) and Geographic Information System (GIS) were used in the field work and were contain the following activities: Soil grid system of observation auger and profile were done. One auger for (46 feddans) about to have = 116 auger sites*2depths (0-30cm, 30- 60cm and, vertical and horizontal distance between the Auger sites is 500meters (See Figurer 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 about 09 profiles covering all the soil unites, (See Figure 2). Soil analysis information (Evaluation Classification & Land Suitability) based on USDA (2010) System of classification and WRG (2006).Photos of the area showing some soil profile, Landscape and Geographic Feature.

2.7 Laboratory work:

The physical and chemical analysis were carried to investigate the following parameters; The soil salinity used Electrical conductivity (Ec), Soil reaction (pH), sodium adsorption Ratio (SAR), percentage calcium carbonates, mechanical analysis & the textural class .

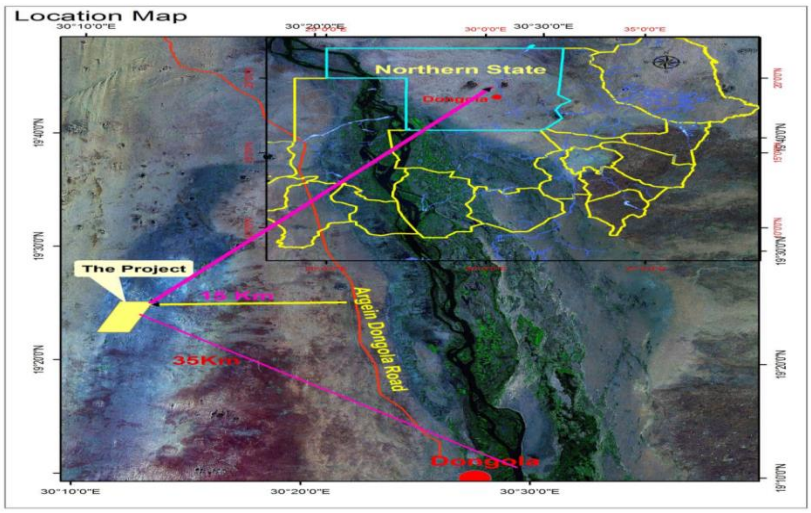


Fig (1): Shows location map of the Study area Base on Land-sat Image 8.

Table (1): shows longitudes & latitudes bounded the project area in UTM System:

Corner	X	Y
1	205732	2149668
2	203901	2144632
3	206481	2144611
4	208318	2149645

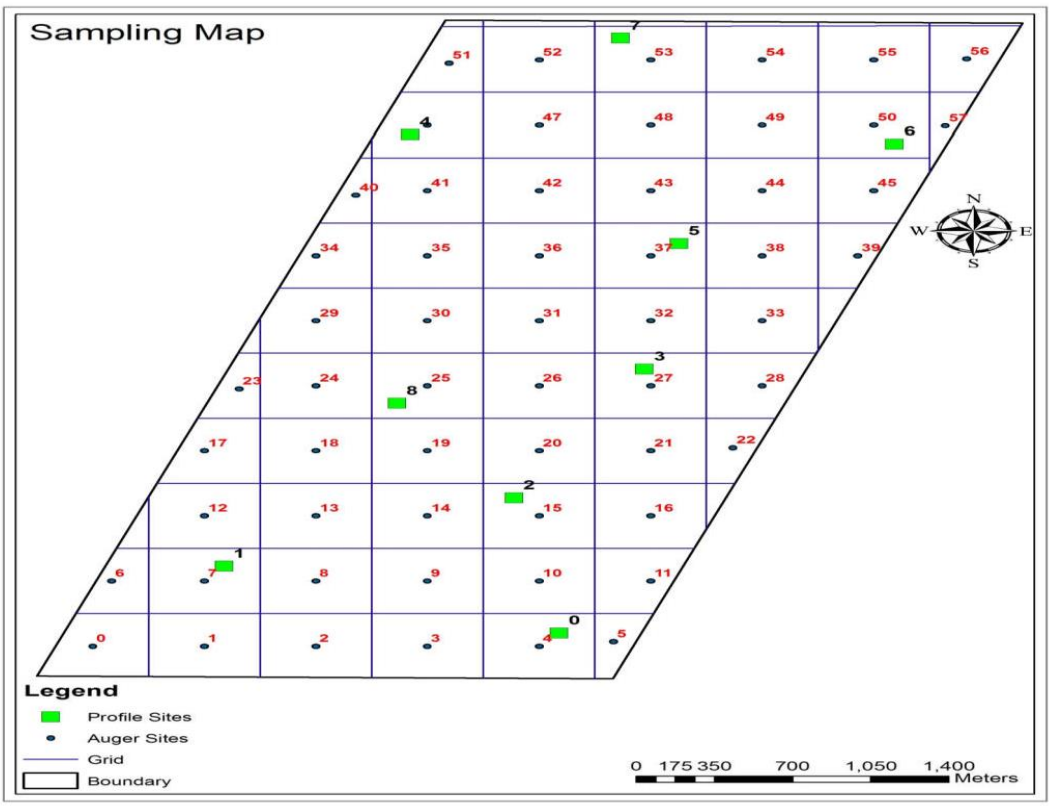


Fig (2) Soil sampling map.

3. RESULTS AND DISCUSSION:

3.1 Soil characteristics:

The role of any soil is to support a plant, whether it is a tree, vegetable, large – scale arable crop, or pasture. The soil has to be a physical support for the plant roots and above ground parts, but it also need to acts a supporting store and supply air, nutrient sand water for growth. As a result we aim to explain the most soil growth limiting factors and their influence in production of different crops in the study area, although there is no such thing as an ideal soil, but there is aplenty that the agronomist and farmer can do to improve this basic growing media, there for we aim to interpreting the analytical data obtained too overcome the most problematic growth factors.

Table (2). Soil reaction (pH):

Soildepths	Ranges	average	guideline	Comments
Surface soil(0-30cm)	6.9–8.8	7.97	6.5-7.5	Slightly alkaline
Sub–surfacesoil	7.4–9.9	8.2	6.5-7.5	Moderately alkaline

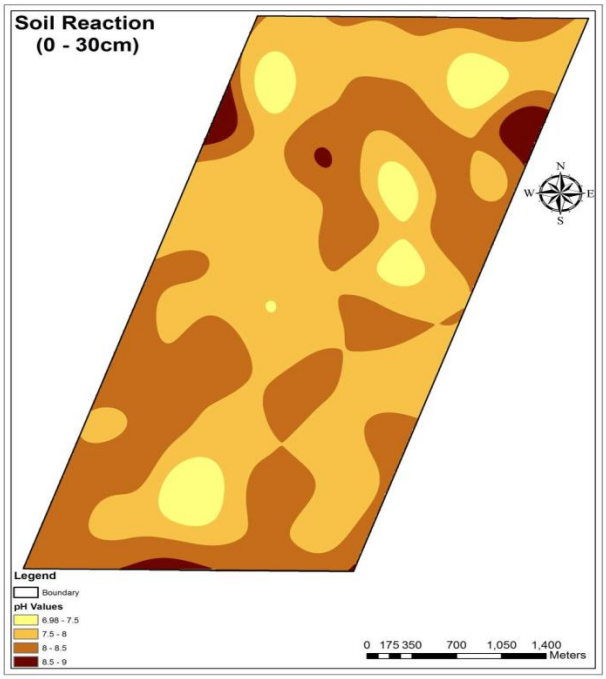


Fig (3)Soil pH in the Surface Soil.

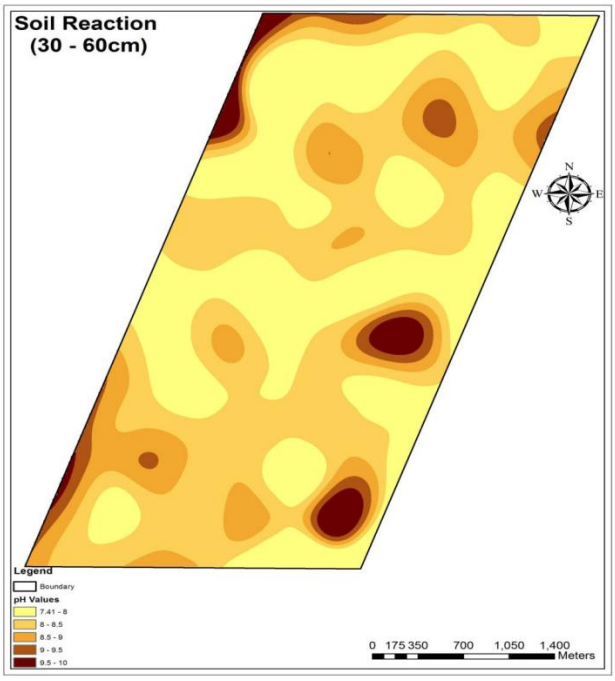


Fig (4) Soil pH in the SubSurfaceSoil.

Table (3).Salinity level (E.Cds/m):

Soil depths	Ranges	Average	guideline	Salinity classes
Surface soil(0-30cm)	3.53–147.5	25.9	<4.0ds/m	Strongly saline
Sub-surface soil (30-60cm)	0.34–139.2	45.0	<4.0ds/m	Strongly saline

The maps below illustrate variation in salinity within the Study area:-

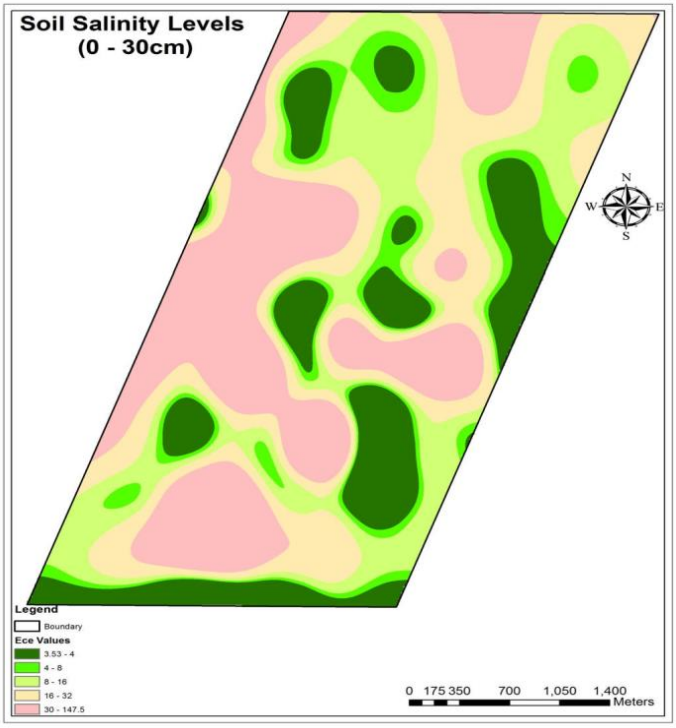


Fig (5) Salinity in the Surface Soil.

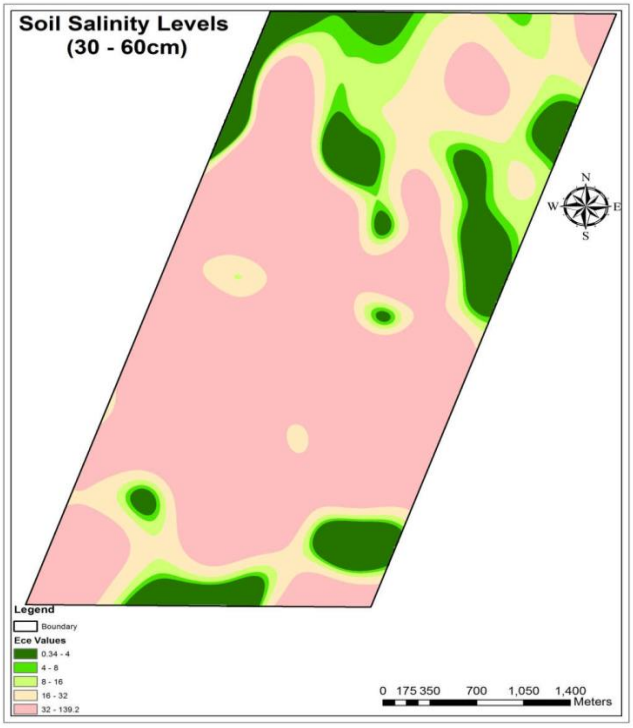
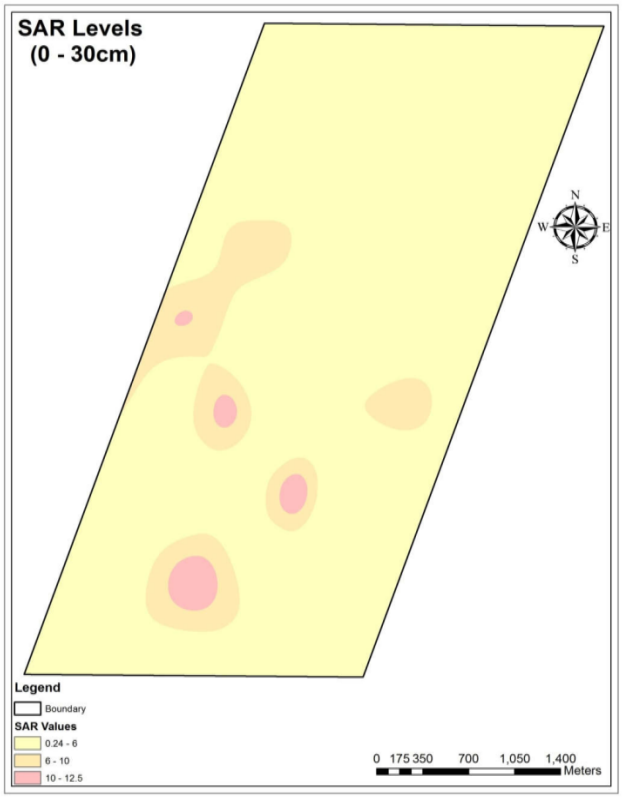


Fig (6) Salinity in the Sub Surface Soil.

Table (4). Sodicity (SAR):-

Soildepths	Ranges	Average	Guideline	Comments
Surface soil(0-30cm)	0.24–12.50	3.50	<13.0	Nonsodic
Sub-surfacesoil (30-60cm)	0.35–29.9	5.83	<13.0	Nonsodic

The maps below showed variations of SAR values:



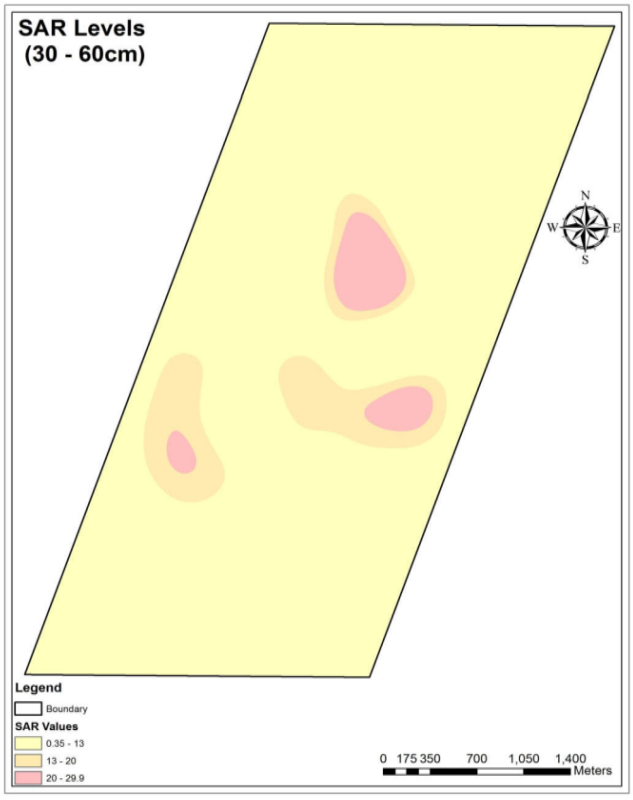
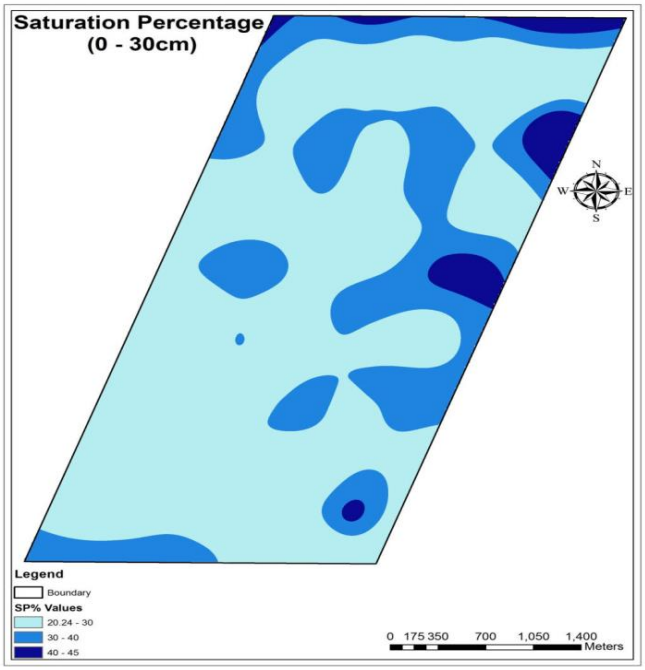


Fig (7) SAR in the Surface Soil. **Fig (8) SAR in the Sub Surface Soil.**

Table (5). Moisturecontent:-

Soildepths	Ranges	Average	Guideline	Comments
Surface soil(0-30cm)	20.2–44.9	28.6	>40%	LowMoistureContent
Sub-surfacesoil (30-60cm)	1.21–61.9	31.2	>60%	LowMoistureContent,HowevertheMoistureIncreasedwith Depth.

The MC% values were illustrated by the fallowing maps:-



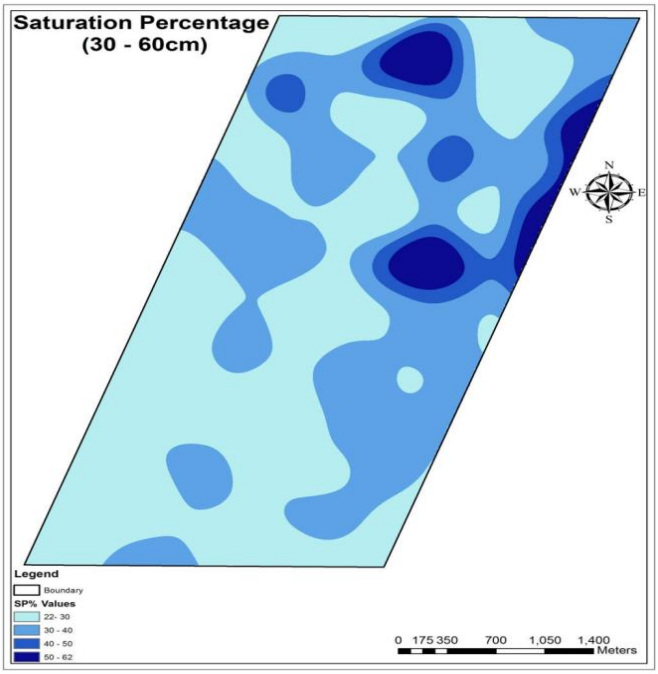


Fig (9) SP% in the Surface Soil. **Fig (10) SP% in the Sub Surface Soil.**

Table (6). Shows typical Soil CEC's:-

Soiltexture	**ExpectedCECmeq/100g**
Loamsoil	10–15
Sandyloam	<5
Sandyclayloam	8–12

Ref.:ARCHER.UK.1985

- **Soil pH:**

The data in table (2) showed that: the pH level in average value is (7.79) of all samples analyzed are high at the surface of soil from 0 – 30 cm and then increased through the depth gradually with average value (8.2) in subsoil see fig (3 and 4). The soil guideline (6.5 - 7.5) relates to the pH at which the soil chemistry is such that the optimum amount of all soil held nutrients are available to the crop. At pH 8.1 the nutrients, phosphorus, iron, manganese, boron, copper and zinc are reduced in availability.

- **Salinity level (E.Cds/m):**

Table 3: revealed that: soil salinity was ranged between none saline to highly saline soils (3.53 to 147.5) ds/m in average with (25.9) at the surface soil, therefore: the salinity increased with depth increase to obtained highly degree in average (45) ds/m in subsurface soil see fig, (5 and 6). Soil salinity is the accumulation of soluble salts in the plant root zone. Accumulation of salts either

leads to changes in the osmatic pressure of the soil solution, restricting the flow of waterinto the plant and/or buildup of elements at toxic levels (particularly problems of sodium and chlorine).

- **Sodicity (SAR):**

The results in table (4) indicated that: there was no sodicity in soil observed in surface and subsurface of soil with average values (3.5 and 5.83) SAR respectively (none sodic soil) see fig. (7 and 8).Sodicity is expressed in terms of (Sodium adsorption ratio), SAR or defined by the values of Exchangeable Sodium Percentage SP%. However Sodicity is particularly problematic in alkaline soils conditions. When the sodic problem is at surface; crusts are formed which inhibit seed germination and when the Sodicity occurs at depths; hard pans formed restricting roots development.

- **Moisture content:**

The data content in table (5) revealed that: the moisture content of study area soil was low at surface and subsurface soil of study area with average values (28.6 and 31.2) SP% respectively. However the moisture content increased with depth (table 5) and fig. (9 and 10). Soil moisture content must be defined to indicate the amount of water stored in the soil at any given time. The most commonly defined soil water content is saturation, field capacity, wilting point, and oven dried.

- **Soil texture:**

The soil texture of study area showed that; the surface soil is sandy and sandy loams and the sub soil is loamy sand <60 cm depth, excessively drained with clay content< 20%. Texture is a measure of the basic particle size constituents of a soil; most commonly the relative proportion of sand, silt and clay that it contains. Texture has highly significant effect on the soil air, water holding capacity and drainage properties of soil. The analytical results revealed that, the study area was characterized by light-medium texture, ranged in textural classes (sandy loam and sandy soils). Having sand (50-75) % Silt (20-30) % and clay <20% unlike the medium texture the lighter soils resulted in low cation exchange capacity (CEC), so the project are suffers from low moisture content and low nutrients holding capacity.

- ✓ **The major kind of land-use in the survey area:**

The proposed major kind of land-use of the survey area is irrigated agriculture.

- ✓ ***The land utilization type:***

The land utilization type is a specific subdivision of a major kind of land use serving the land evaluation and defined as precisely as possible in terms of produce and management, as shown in table (3).

- **The land suitability classification system:**

The land suitability classification system now in use [12] is an approach derived from the FAO Framework for Land Evaluation, as given in[13] to suit the local conditions of the Sudan. The purpose of the land suitability classification is to provide a comparative and qualitative assessment of the potential suitability' of the soil for irrigated agriculture according to limitations and problems. The system is composed of four categories in a decreasing level of generalization, i.e. orders, classes, subclasses and units. Fig. (9) Summarizes the evaluation process.

The application method is the rating of the land qualities into good, moderate, poor and very poor levels in terms of measurable land characteristics. These land qualities included moisture availability, chemical soil fertility, conditions for seedling establishment, drainage conditions in the growing season, workability, adequacy topography for gravity irrigation, soil drainability, salinity, sodicity and erosion hazards. The number and severity of limitations determine the land suitability classes where as the kind soft limitations determine the land suitability subclasses. Units at the tail of the system reflect minor differences in production capacity and/or management requirements within subclasses.

4. CONCLUSION:

This study done to evaluate the salinity, alkalinity and suitability for a proposed project south west Gaab El Laiya area (desert region) for alfalfa cultivation. Field work results showed that This area was characterized by high groundwater table (level) to less than 60 cm from the soil surface where the water evaporates from the soil surface as a result of high temperatures in desert region, leaving accumulations of salt on the soil surface, which hindered the growth and development of vegetation cover in the study area; while the soil laboratory indicate that the soils of the study area are sandy, sandy loams at the surface and loamy sand and excessively drained with clay content at the sub soil it was slightly -strong saline- non-sodic and moderately to high alkaline with low moisture content. The study recommended that the soil and environment in the study area were not suitable for alfalfa cultivation, however this area can be used in cultivation of date palm, oil palm and doum palm.

REFERENCES:

1- AMAL IZZELDIN (2018). FIELD TECHNIQUES FOR RECLAMATION OF SALT AFFECTED SOIL IN DONGOLA AREA. AMAZON.CA.
2- UNDP-related activities in Central and South-Eastern Europe, Caucasus and Central Asia. (2007) Soil salinity" in Water Wiki at Way back Machine.
3- I.C. Gupta, S.K., Gupta, (2017). Genesis and Management of Sodic (Alkali) Soils. Amazon in.

4- Ibekwe A.M., J.A. Poss, S.R. Grattan, C.M. Grieve, D. Suarez. (2010). Bacterial diversity in cucumber (Cucumissativus) rhizo sphere in response to salinity, soil pH, and boron. Soil Biology & Biochemistry. University of California, Davis, CA 95616, USA.
5- Lajos Blask, (2014). Alkalinity, Physical Effects on Soils. Encyclopedia of Agro physics pp 49–52. Springar link book series.
6- Susan Patterson, (2013). What Makes Soil Alkaline – Plants And Tips For Fixing Alkaline Soil? Gardening Know How: https://www.gardeningknowhow.com.
7- Sharon Benes and Dan Putnam, (2019). Alfalfa may be more salt tolerant than we thought. Hay & Forage Grower on pages 6 to 8. Not a subscriber.
8- Harold Willis, (2018). Alfalfa Plants, Alfalfa Soil Types and Seeding Alfalfa. Eco Farming Daily is a publication of Acres U.S.A.
9- Kevie, W. (1976) Climatic zones in Sudan. SSA/Wad Medani ,Sudan
10- Soil Survey Staff. (2010), Key to Soil Taxonomy. USDA Natural Resources Conservation Service. Washington, D.C. USA.
11- Harrison and Jackson. (1958) Vegetation of the Sudan - Agriculture in Sudan, Oxford, London, U.K.
12- Kevie, W. and El Tom.O.M. (2004). Manual for land suitability classification for agriculture in Sudan. SSA/ Wad Medani, Sudan.
13- Brinkman, R. and A.J. Smyth. (1973). Land evaluation for rural purposes. Publication No.17. Wageningen, Netherlands.