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Land suitability Evaluation of Some Sileit projects Soils

Khartoum North

A thesis Submitted in Partial Fulfillment of the Requirements for the M.Sc. Degree in Soil and Water Science

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الآية

قال تعالي:

(وَهُوَ الَّذِي أَنْزَلَ مِنَ السَّماءِ ماءً فَأَخْرَجْنا بِهِ نَباتَ كُلِّ شَيْءٍ فَأَخْرَجْنا مِنْهُ خَضِرًا نُخْرِجُ مِنْهُ حَبًّا مُتَراكِبًا وَمِنَ النَّخْلِ مِنْ طَلْعِها قِنْوانٌ دانِيَةٌ وَجَنَّاتٍ مِنْ أَعْنابٍ وَالزَّيْتُونَ وَالرُّمَّانَ مُشْتَبِهًا وَغَيْرَ مُتَشابِهٍ انْظُرُوا إِلى ثَمَرِهِ إِذا أَثْمَرَ وَيَنْعِهِ إِنَّ فِي ذلِكُمْ لَآياتٍ لِقَوْمٍ يُؤْمِنُونَ (٩٩))

صدق الله العظيم

سورة الأنعام(99)

Dedication

To my mother

My father

My brothers and sisters

My wife and my son

All my family

All my teachers

All my colleagues and friends

With love and respect.

MOZAMEL

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All thanks are due to Almighty Allah who gave me health and strength, and helped me tremendously to produce this work.

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ABSTRACT

This study was conducted in the farm in AL Sileit Agriculture project, the soil of the farm belongs to the Central Clay Plain of the Sudan that has been formed by alluvial deposit of the Nile. Some physical and chemical properties at six sites across the farm have been investigated during this study.

The objectives of this work were the following:

1- To evaluate the suitability of the land at the study area.
2- To verify land qualities and limitations that affect land use.
3- To provide guidelines for use and management of similar soils in the surrounding area.

The results of the study indicated that the soils are variable affected by salinity and sodicity and calcareous. They have non-saline, slightly saline, moderately saline and saline sub soil.Non-sodic, slightly and moderately calcareous soils are all found in the farm. Soil textures are clayey throughout, and infiltration rate is slow.

The whole soil profile is compacted except at the surface and sub surface layer, and calcareous molting are relatively small. These soils are characterized by high water retention; land suitability of study area is S2 according to the limitations (Salinity, fertility).

الخلاصة

أجريت هذه الدراسة لمزرعة بمشروع السليت الزراعي ، تربة المزرعة تنتمي للسهول الطينية الوسطي في السودان والتي تعتبر لحد كبير تربة طينية .

من خلال الدراسة تم التحقق من بعض الخواص الفيزيائية والكيميائية لستة مواقع عبر المزرعة وكان الهدف الاساسي مايلي:

١- تقييم ملاءمة التربة للزراعة وتحديد درجة صلاحيتها.

٢- للتحقق من جودة التربة ومعرفة المعيقات التي تؤثر علي خواص استخدام الارض.

٣- لمزيد من التحقق في هذه التربة وإستنباط موجهات نحو تحسينها وإدارتها .

وقد أشارت نتائج هذه الدراسة ان التربة متغيرة متأثر بالملوحة والصودية والجيرية. غير مالحة ، قليلة الملوحة ، متوسطة الملوحة ، مالحة في التربة تحت السطحية ، غير صودية . منخفضة الي متوسطة الجيرية . قوام التربة طينية في جميع أنحائها . ومعدل التسرب بطئ . كل الافاق تحت السطحية بها إنضغاط وبقع جيرية صغيرة نسبياً. تتميز التربة بالاحتفاظ العالي للماء تم تقييم صلاحية التربة من الدرجة الثانية وفقاً للقيود (الخصوبة ، والملوحة).

CHAPPTER ONE

INTRODUCTION

1.1INTRODUCTION:

Soils differ greatly in their morphological, physical, chemical and mineralogical properties. These differences affect crop response to management inputs. Improper use of soils may reduce yields and as well aggravate degradation. It is therefore, essential to understand the soil conditions to ensure suitable sustainable agriculture and proper conservation.

Soil is very complex system. It is made up of solid, liquid and gaseous materials. The solid phase may be mineral or organic. The mineral portion consists of particles of varying size, shape and chemical composition. The organic fraction includes residues in different stages of decomposition. The liquid phase thatfillspart or all of the pores between the solid particles. The gaseous phase occupies part of the pore space. The composition and proportion of these components greatly influence soil physical properties including texture, structure, and porosity. In turn these properties affect air and water movement in the soil and thus the soils' ability to function. Other important physical properties of soil are color, temperature, compaction, drainage, depth and surface features. The physical properties and chemical composition largely determine the suitability of a soil for its planned use and the management requirements to keep it most productive (Brady and Weil, 2002).

Texture, structure, and porosity influence the movement and retention of water, air and solutes in the soil, which subsequently affect plant growth. Most soil chemical properties are associated with the colloid fraction and affect nutrient availability, and in some cases, soil physical properties. The primary physical processes associated with high sodium concentration are soil dispersion and aggregation.

1.2. Objectives of the study:

1- To evaluate land suitability of a private farm at Sileit area (see location).

2- TO verify land qualities and limitations that affect land use.

3- To provide guidelines for use and management of similar soils in the surrounding area.

CHAPPTER TWO

LITRETURE REVIEW

2.1 Physical properties of soil:

The physical properties of the soil resulting of soil parent material being acted upon by the five soil forming factors **(**Soil parent material, Climate, Topography, Vegetations, and Time).

2.1.1 Soil texture:

Soil texture is a classification instrument used both in the field and laboratory to determine soil classes based on their physical texture. Soil texture can be determined using qualitative methods such as texture by feel, and quantitative methods such as the hydrometer and pipette methods. Soil texture has agricultural applications such as determining crop suitability and to predict the response of the soil to environmental and management conditions such as drought . Soil texture focuses on the particles that are less than two millimeters in diameter which include sand, silt, and clay (the fine earth).

The twelve texture classes in United State system are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. Soil textures are classified by the fractions of each soil separate (sand, silt, and clay) present in a soil. Classifications are typically named for the primary constituent particle size or a combination of the most abundant particles sizes, e.g. "sandy clay" or "silty clay". A fourth term, loam, is used to describe equal proporation of sand, silt, and clay in a soil sample, and lends to the naming of even more classifications, e.g. "clay loam" or "silt loam".

The Chemical and physical properties of soils are related to texture. Fine textured soils generally have a higher capacity for water retention, whereas sandy soils contain large pore spaces that allow leaching.

2.1.1.1 Effect of texture on soil properties:

Soil texture affects a number of some soil physical characterizations such as:

1. Structure
2. Aeration
3. Root penetration
4. Water retention
5. Compaction
6. plasticity

2.1.2 Soil structure:

Soil structure describes the arrangement of the solid particles and of the pore space located between them. It is determined by how individual soil granules clump, bind together, and aggregate, resulting in the arrangement of soil pores between them. Soil structure has a major influence on water and air movement, biological activity, root growth and seedling emergence.

The decline of soil structure under irrigation is usually related to the breakdown of aggregates and dispersion of clay material as a result of rapid wetting. This is particularly so if soils are sodic; that is, having a high exchangeable sodium percentage (ESP) rich in sodium. High sodium levels (compared to high calcium levels) cause particles to repel when wet, and the associated aggregates to disaggregate and disperse. The ESP will increase if the soil is irrigated with salty water (Marshall & Holmes, 1979).

2.1.2.1 Aggregation and structure:

Soil aggregation is cementing of several soil particles into a secondary unit. Soil particles are arranged or grouped together during the aggregation process to form structural units. Aggregation is important for maintaining porosity and soil water movement, and for improving productivity (Nichols et al, 2004).

2.1.2.2 Effect of structure on soil properties:

The structure of soil affects pore space and rates of air and water movement. The size, shape, and strength of structural peds are important to soil productivity. Sandy soils generally have poorly developed structure relative to finer texture soils, because of their lower clay content. When the subsoil has well developed blocky structure, there will generally be good air and water movement in the soil. If platy structure has formed in subsoil, downward waterand air movement and root development in the soil will be slowed. Distinct prismatic structure is often associated with swelling of the sub-soil.

2.1.2.3 Improving soil structure:

The benefits of improving soil structure for the growth of plants, particularly in an agricultural setting, include: reduced erosion due to greater soil aggregate strength and decreased overland flow; root penetration and access to soil moisture and nutrients; emergence of seedlings due to reduced crusting of the surface; and greater water infiltration, retention and availability due to improved porosity.

Productivity from irrigated no-tillage or minimum tillage soil management in horticulture usually decreases over time due to degradation of the soil structure; inhibiting root growth and water retention. There are a few exceptions, why such exceptional fields retain structure is unknown, but it may be associated with high organic matter. Improving soil structure in such settings can increase yields significantly.

2.1.2.4 Soil structure affect on plant growth:

Soil structure affects plant growth in many ways. Roots grow most rapidly in very friable soil, but their uptake of water and nutrients may be limited by inadequate contact with the solid and liquid phases of the soil. This contact is much more intimate in hard soil, but then the growth of the roots is strongly inhibited, so that their foraging ability is poor, and the plant may eventually become short of water or nutrients. However, many soils, even if hard, contain continuous macropores that provide routes for the roots to grow in. The presence of such macropores increases the extent of the root system, but because the roots are clumped within them, the rate at which the roots can extract water and nutrients from the soil between the macropores is considerably slowed. These macropores also provide pores for microorganisms, both symbiotic and pathogenic, so that the response of roots to different tillage treatments may differ markedly on this account alone. Soil structure not only affects the ability of roots to grow and to supply the leaves with water and nutrients; it also induces them to send hormonal signals that slow the growth of the shoot, even if they are currently able to take up adequate water and nutrients.

2.1.3 Soil porosity:

Soil porosity, or pore space, is the volume percentage of the total soil that is not occupied by solid particles.

Bulk density is dry mass of solid per unit volume of soil, and particle density is the density of solids individual soil particle. Bulk density of mineral soils isusually in the range of 1.1 to 1.9 g/cm3. A soil with a bulk density of about 1.32g/cm3 will generally possess the ideal soil condition of 50%solids and 50% pore space. Bulk density varies depending on many factors such as water content, texture, aggregation, organic matter, compaction, soil management practices, soil horizon, and sodium saturation (ESP)(Dudal, 1965).

2.1.4 Soil compaction:

Soil compaction occurs when soil particles are pressed together, reducing pore space between them. Heavily compacted soils contain few large pores and have a reduced rate of both water infiltration and drainage.

Soil compaction can be associated with majority of field operations that are often performed when soils are wet and more susceptible to compaction. Heavy equipment and tillage implements can cause damage to the soil structure. Soil structure is important because it determines the ability of a soil to hold and conduct water, nutrients, and air necessary for plant root activity. Although much research has been conducted on soil compaction and its effects on yields, it is difficult to estimate its economic impact because fields vary in soil types, crop rotations, and weather conditions.

Soil compaction change pore space size, distribution and soil strength. One way to quantify the change is by measuring the bulk density. As the pore space is decreased within a soil, the bulk density is increased. Soils with a higher percentage of clay and silt, which naturally have more pore space, have a lower bulk density than sandier soils (David, 2007).

2.2 Chemical Properties of Soil:

A soil test provides information about a soil chemical properties; the soil test report indicates the levels of the various nutrient elements in our sample as well as soil pH, cation exchange capacity, Base saturation percentage, soil salinity, soil sodicity, calcium carbonate content, soil organic carbon and organic matter and others.

2.2.1. Cation Exchange Capacity (CEC):

Cation-exchange capacity (CEC) is the maximum quantity of total cations that a soil is capable of holding, at a given pH value, available for exchange with the soil solution. CEC is used as a measure of fertility, nutrient retention capacity, and the capacity to protect groundwater from cation contamination. It is expressed as centi-mol of Hydrogen per kg ($cmol_c/kg$ or 100 $meq_c/100g$). Most of the soil's CEC occurs on clay and humus.

2.2.2. Soil pH:

Soil reactivity is expressed in terms of pH and is a measure of the acidity or alkalinity of the soil. More precisely, it is a measure of hydrogen ion concentration in an aqueous solution and ranges in soils from 3.5 (very acid) to 9.5 (very alkaline). Soils with high acidity (<5.5) tend to have toxic amounts of aluminum and manganese. Soils with high alkalinity (>8.5) tend to disperse. Soil organisms are hindered by high acidity, and most agricultural crops do best with mineral soils of pH 6.5; at the neutral reaction varying between pH(6.5-7.5).

2.2.3 Base saturation percentage:

There are acid-forming cations (hydrogen and aluminum) and there are base-forming cations (calcium, magnesium, potassium and sodium). *The fraction of the base-forming cations that occupy positions on the soil colloids is called the* base saturation percentage. When the soil pH is 7, base saturation tends to approach 100 percent and there are no hydrogen ions stored on the colloids.

2.2.4 Soil organic carbon:

The carbon that is fixed by plants is transferred to the soil via dead plant matter including dead roots and leaves. This dead organic matter creates a substrate which soil micro-organisms respire back to the atmosphere as carbon dioxide or methane depending on the availability of oxygen in the soil. Soil organic carbon can also be oxidized by combustion and returned to the atmosphere as carbon dioxide. Some of the carbon compounds are easily digested and respired by the microbes resulting in a relatively short residence time. Others, like lignin, humic acid or substrate encapsulated in soil aggregates, are very difficult for the biomass to digest and have very long residence times. Soil organic carbon improves the physical properties of the soil. It increases the cation exchange capacity (CEC) and the water-holding capacity and it contributes to the structural stability of clay soils by helping to bind particles into aggregates. Soil organic matter, of which carbon is a major part, holds a great proportion of nutrients, cations and trace elements that are of importance to plant growth. It prevents nutrient leaching and is integral to the organic acids that make minerals available to plants. It also buffers soil from strong changes in pH. It is widely accepted that the organic carbon content of the soil is a major factor in its overall health, is a major part of the Carbon Cycle and an important factor in the mitigation of climate change effects.

2.2.5. Soil nitrogen:

Nitrogen is the most critical element obtained by plants from the soil and when deficient is a bottleneck in plant growth. Plants can use the nitrogen as either the cation ammonium, NH_4^+, or the anion nitrate, NO_3^-. Nitrogen is seldom missing in the soil, but is often in the form of raw organic material which cannot be used directly. Nitrogen is also available in gas forms in the soil; however, these quantities are very small and difficult to detect such as: nitrous oxide (N_2O), nitric oxide (NO), nitrogen dioxide (NO_2), ammonia (NH_3) and molecular nitrogen (N_2) present in the air space of the soil.

2.2.6. Soil salinity:

Salts can be transported to the soil surface by capillary transport from a salt laden water table and then accumulate due to evaporation. Salinization occurs when irrigation practices are carried out without due attention to drainage and leaching of the salts out of the soil. Salts can also accumulate due to seawater intrusion, or may occur naturally. Soil salinity increases, salt effects can result in degradation of soils and vegetation. The most common salts are combinations of the cations sodium, calcium, magnesium and potassium with the anions chlorine, sulfate and carbonates and bicarbonates.

2.2.7. Soil sodicity:

Sodicity refers to an excess of exchangeable sodium in the soil. Sodic soils tend to occur general within arid to semiarid regions and are often unstable, exhibiting poor physical and chemical properties, which impede water infiltration, water availability, and ultimately plant growth.

2.2.8. Calcium carbonate content:

Calcium carbonate ($caco_3$) is a salt that is not very soluble and occurs in various forms and concentration in soils. Calcium carbonate in moderate amounts is favorable for soil structure and is often used to correct the pH of acidic soils, but when the level of calcium in the soil exceeds the capacity of the soil to absorb it, it binds with other elements and forms insoluble compounds that are difficult for plants to absorb. Excess amounts of calcium may restrict the availability of phosphorous, boron and iron to plants.

2.2.9. Soil solution:

Soil retain water that can dissolve arrange of molecules and ions, these solutions exchange gases with soil atmosphere, contain dissolved sugars, fulvic acids and other organic acids, plant nutrient such as nitrate, ammonium, potassium, phosphate, sulfate and calcium, and micronutrients such as zinc, iron and copper(Dan, 2000).

2.2.10. Soil organic matter:

Organic matter is the material that is made of carbon, and these substances diffuse naturally in a large way. They form proteins, carbohydrates, fats, nucleic acids and others. Also, the residues of living organisms can be described as organic, such as the remains of decomposing plants or substances that decompose from animals, where these are transported. A fertile and healthy soil is the basis for healthy plants, animals, and humans. And soil organic matter is the very foundation for healthy and productive soils.

Soils contains a variable but relatively small percentage of organic matter in intimate mixture with its mineral components and derived from the remains of plants and animals, including roots, stubble and other residues of harvested crops, and soil micro-organisms such as bacteria, fungi, earthworms. The type and amount of organic matter present in the soil are determined by a number of factors including soil reaction, type of vegetation, the kind of soil microbes present, drainage, rainfall, temperature, and management practices(Foth, 1984).

2.3. Soil degradation:

Land degradation refers to a human or naturally induced or natural damage which impairs the capacity of land to function. Soils are the critical component in land degradation when it involves acidification, contamination, desertification, erosion or salinization. While soil acidification is beneficial in the case of alkaline soils it degrades as it lowers crop productivity and increases soil vulnerability to contamination and erosion. Acidification occurs when these basic elements (Ca+, Mg+, k, Na+) are leached from the soil profile by rainfall or by harvesting of forest or agricultural crops. Soil acidification is accelerated by the use of acid-forming nitrogenous and by the effects of acid precipitation (Dooley, A 2006).

2.4 Soil and Water relationship:

2.4.1 Infiltration rate:

Infiltration is the process by which water on the ground surface enters the soil at a which soil is able to absorb rainfall or irrigation. It is measured in inches per hour or centimeters per hour. The rate decreases as the soil becomes saturated. If the precipitation rate exceeds the infiltration rate, runoff will usually occur unless there is some physical barrier. The rate of infiltration can be measured using an infiltrometer(double cylinder method).

Infiltration is governed by two forces: gravity and capillary action. While smaller pores offer greater resistance to gravity, very small pores pull water through capillary against the force of gravity.

The ease of water entry, storage capacity, and transmission rate are affected by soil characteristic such as soil texture and structure, vegetation types and cover, water content of the soil,and soil temperature (MichaelHogan, 2010).

2.4.2 Hydraulic Conductivity:

The hydraulic conductivity of a soil is a measure of the soil's ability to transmit water when submitted to a hydraulic gradient.

Hydraulic conductivity is one of the important physical properties which determine the behavior of the soil fluid within the soil system under specified conditions. More specifically, the hydraulic conductivity determines the ability of the soil fluid to flow through the soil matrix system under a specified hydraulic gradient; the soil fluid retention characteristics determine the ability of the soil system to retain the soil fluid under a specified pressure condition.

Hydraulic conductivity depends on the soil grain size, the structure of the soil matrix, the type of soil fluid, and the relative amount of soil fluid (saturation) present in the soil matrix. The important properties relevant to the soil matrix of the soil include pore size distribution, pore shape, tortuosity, specific surface, and porosity. In relation to the soil fluid, the important properties include as well fluid density, and fluid viscosity.

Hydraulic conductivity and Cumulative infiltration of water are two interrelated parameters (Gulser and Candemir , 2008).

Hydraulic conductivity is also useful in controlling water infiltration and surface runoff, leaching of pesticides from agricultural lands (Bagarello and Sgroi , 2007).

Hydraulic conductivity depends on the physical characteristics of soil such as the intrinsic permeability, the degree of saturation, the type of soil, bulk density, total porosity and the configuration of the soil pores (Lal and Shukla, 2004).

2.4.3 Coefficient of linear Extensibility: (COIE):

An expansive soil is any soil that has a potential for shrinking and swelling under changing moisture condition (Nelson and Miller ,1992) .Expansive soils experience there dimensional volume change during wetting and drying cycles , increasing volume when wetting and decreasing volume when drying ;hence often have some shrink-swell potential as a result of wetting-drying cycles (Azametal, 2000).

Soil shrink-swell behavior is primarily governed by the type and amount of the dominant clay mineralogy (Davidson and page ,1956).Soil shrink-swell potential is also affected by numerous other factors, such as soil particle shape – and pore- size distribution , texture, water content, rate of moisture change due to natural and manmade drainage(Komornik , 1969).specific surface area , cation exchange capacity ,organic matter ,exchangeable cations , iron content (Davidson and page,1956, Azam et al,2000).

2.5 Soil moisture condition:

2.5.1 Soil moisture content:

The soil moisture content refers to the amount of water present in the soil. It is commonly expressed as the amount of water (in mm of water depth) present in a depth of one meter of the soil.

2.5.2 Saturation:

Saturation is defined as the amount of water that saturates 100g of soil. During a rainfall or irrigation application, the soil pores will fill with water. If all soil pores are filled with water the soil is said to be saturated. There is no air left in the soil at saturation. Soil pores are filled with water, and since plant needs air for their growth they suffer at saturation. Many crops cannot withstand saturated soil condition for a period of more than 2-5 days.

Rice is one of the exceptions to this rule. The period of saturation of the top soil usually does not last long. After the rain or the irrigation has stopped, part of the water present in the larger pores will move downward. This process is called drainage or percolation.

The water drained from the pores is replaced by air. In coarse textured sandy soil, drainage is completed within a period of a few hours. In fine textured clayey soils, drainage may take many days.

2.5.3 Field capacity:

After the drainage has stopped, the large soil pores are filled with both air and water while the smaller pores are still full of water. At this stage, the soil is said to be at field capacity. At field capacity, the water and air contents of the soil are considered to be ideal for crop growth. This takes place usually between 2-3 days after irrigation, depending on soil texture and some other soil properties (Milford, 2001).

2.5.4 Temporary wilting point:

It is the condition of a plant when the soil water stress causes wilting of the plant during the hottest part of the day and the plant recovers during night time under favorable soil water condition without addition of water.

2.5.5 Permanent wilting point:

Little by little water stored in the soil is taken up by the plant roots percolated through the soil or evaporated from the topsoil into the atmosphere. If no additional water is supplied to the soil, it gradually dries out. The dryer the soil becomes, the more tightly the remaining water is retained and the more difficult it is for the plant roots to extract. At a certain stage, the uptake of water is not sufficient to meet the plant's needs. The plant loses freshness and wilts; the leaves change color from green to yellow. Finally, the plant dies.

The soil water content at this stage is called permanent wilting point. The soil still contains some water, but it is too difficult for the roots to suck it from the soil.

2.5.6 Available water content:

Available water capacity is the water held in soil between its field capacity and permanent wilting point. Field capacity is the water remaining in a soil after it has been thoroughly saturated and allowed to drain freely, usually for one to two days. The soil can be compared to a water reservoir for the plants. When the soil is saturated, the reservoir is full. However, some water drains rapidly below the root zone before the plant can use it. The available water content depends greatly on the soil texture and structure.

2.5.7 Available water capacity:

Available water capacity is the maximum amount of plant available to plant by the soil.

2.5.8 Factors affecting available water capacity:

Fine textured soils have greater occurrence of small pores that hold water against free drainage, resulting in a comparatively higher field capacity. However, in comparison to well-aggregated loam and silt loam soils the available water capacity of predominantly clay soils tends to be lower since these soils have permanent wiling point. Soil depth and root restricting layers affect total available water capacity since they can limit the volume of available water for growth.

Root penetration is affected by presence of restrictive layers in the soil profile and hence available water for plants is also affected. Compaction reduces available water capacity through its adverse effects on water movement. Compaction reduces total pore volume, consequently reducing water storage when the soil is at field capacity. Compaction also crushes large soil pores in too much smaller micro pores. Since microspores hold water more tightly than larger pores, more water is held in soil at its wilting point.

Soluble salts play an important role in availability of moisture for plants. Saline soils are formed during soil formation due to weathering of minerals, or as a result of irrigation with low quality underground water. Salt concentration increases as soil water decreases. For soil high in soluble salts, moisture stress results when plants cannot uptake water across an unfavorable salt concentration gradient. Soil with high salt concentration tends to have reduced available water capacity because of its osmotic pressure effect.

CAPPTER THREE

3. Material and Methods

3.1 General Description of the Area:

3.1.1 AL- Sileit area

3.1.1.1. Location and Extent:

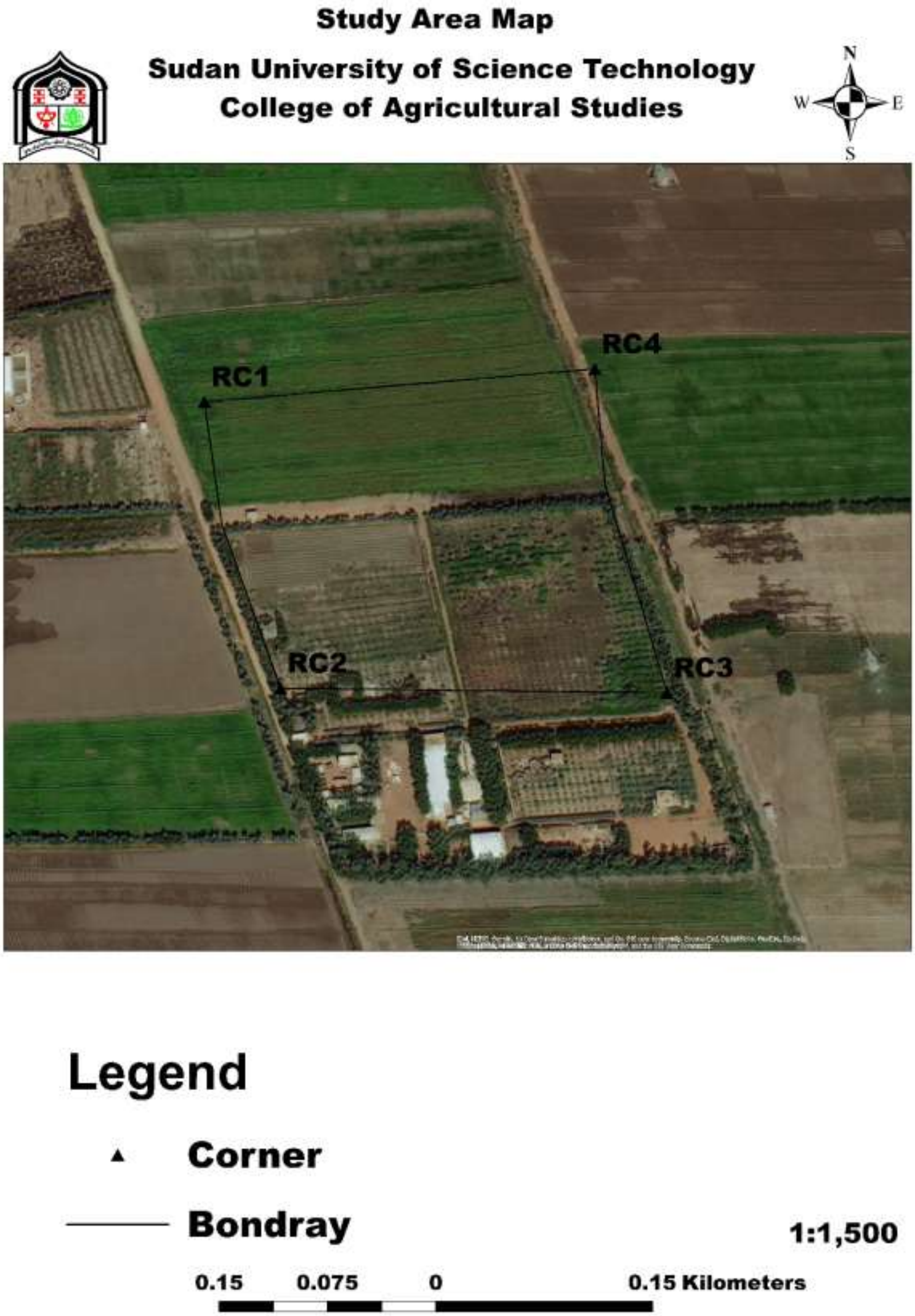
The study area is located 16km east of Khartoum north.

Table 3.1 shows the coordinates that engulf the study area and Figure 3.1 depicts the location of the study area.

Table 3.1 Coordinates enclosed the study area:

	E	**N**
RC1	32.64871	15.69401
RC2	32.64918	15.69223
RC3	32.65159	15.69220
RC4	32.65114	15.69422

Figure 3.1The layout of the Study Area:



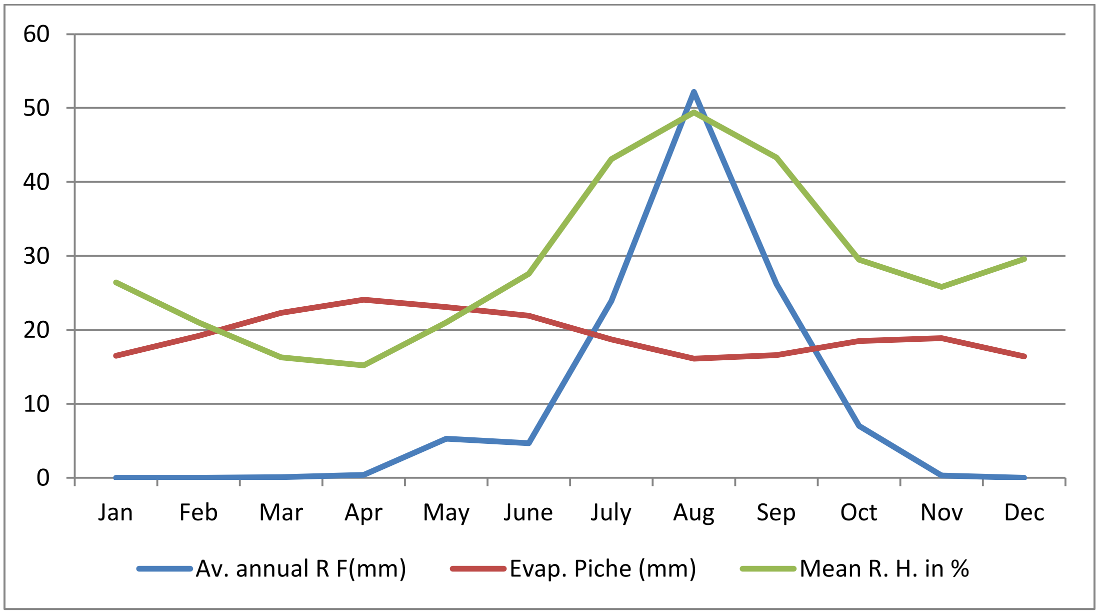
3.1.1.2 Climate:

The study site is within the semi-desert zone. It receives rainfall of about (150-170mm/year), the seasonality and variability both characterize the rainfall in time and space. Generally, in January the average temperature rises from (14 ºC) at dawn to (30 ºC) in the afternoon, while in May; (the hottest month) it rises from (25 ºC to 42ºC).The rainfall starts in June – July and may continue up to September in dry years, winter is known for its prevailing strong northerly wind, which causes sand and dusty storms.

Table 3.2. Climatological normals of Khartoum Station (1981-2010)

Months Temp. ºC		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Mean		23.4	25.0	28.6	32.5	34.8	34.7	32.6	31.6	32.8	32.9	28.7	25.0	30.2
Mean Max		30.9	32.9	36.7	40.6	42	41.5	38.8	37.6	39	39.5	35.7	32.1	37.3
Mean Min		15.8	17.1	20.5	24.4	27.5	27.9	26.4	25.6	26.5	26.2	21.7	17.8	23.1
Av. annual R F(mm)		0.0	0.0	0.1	0.4	5.3	4.7	23.9	52.2	26.2	7.0	0.3	0.0	120.0
Evap. Piche (mm)		16.5	19.2	22.3	24.1	23.1	21.9	18.7	16.1	16.6	18.5	18.9	16.4	19.3
Mean R. H. in %		26.4	21.0	16.3	15.2	21.0	27.6	43.1	49.4	43.3	29.5	25.8	29.6	29.0
Wind	Speed and Direction	16.6 N	17.5 N	17.6 N	15.7 N	14.8 N	15.6 SW	18.2 SW	17.2 SW	14.4 SW	12.5 N	15.5 N	15.2 N	15.9

Figure 3.2 Rainfall, evaporation and relative humidity (RH) of Khartoum meteorological Station during (1981-2010)



3.1.1.3 SOIL:

The soil is silt-clay to clay, the soil is classified predominantly as Aridisols with pokets of Vertisols formed on old alluvium deposits, and Entisols on recent alluvium and aeolian deposits. Most of the soils are salt affected.

3.1.1.4. Land use:

The system of land use in the study area is mostly fodder crops and vegetables.

They are irrigated with Blue Nile water through sileit canal and from the ground water.

3.2. Material:

3.2.1. Soil samples

5 Auger sites have been sampled from Al Sileit area. Samples were taken at three depths (0-30cm), (30-60cm), (60-90cm) the samples were collected by auger from a private farm and one profile, the distance between auger holes was 60 meters.

Table 3.3 Locationof profile pits andauger boring.

Sample NO	**E**	**N**
PR1	32.65006	15.69312
R1	32.64943	15.69253
R2	32.64915	15.69335
R3	32.65097	15.69253
R4	32.65089	15.69346
R5	32.64992	15.69379

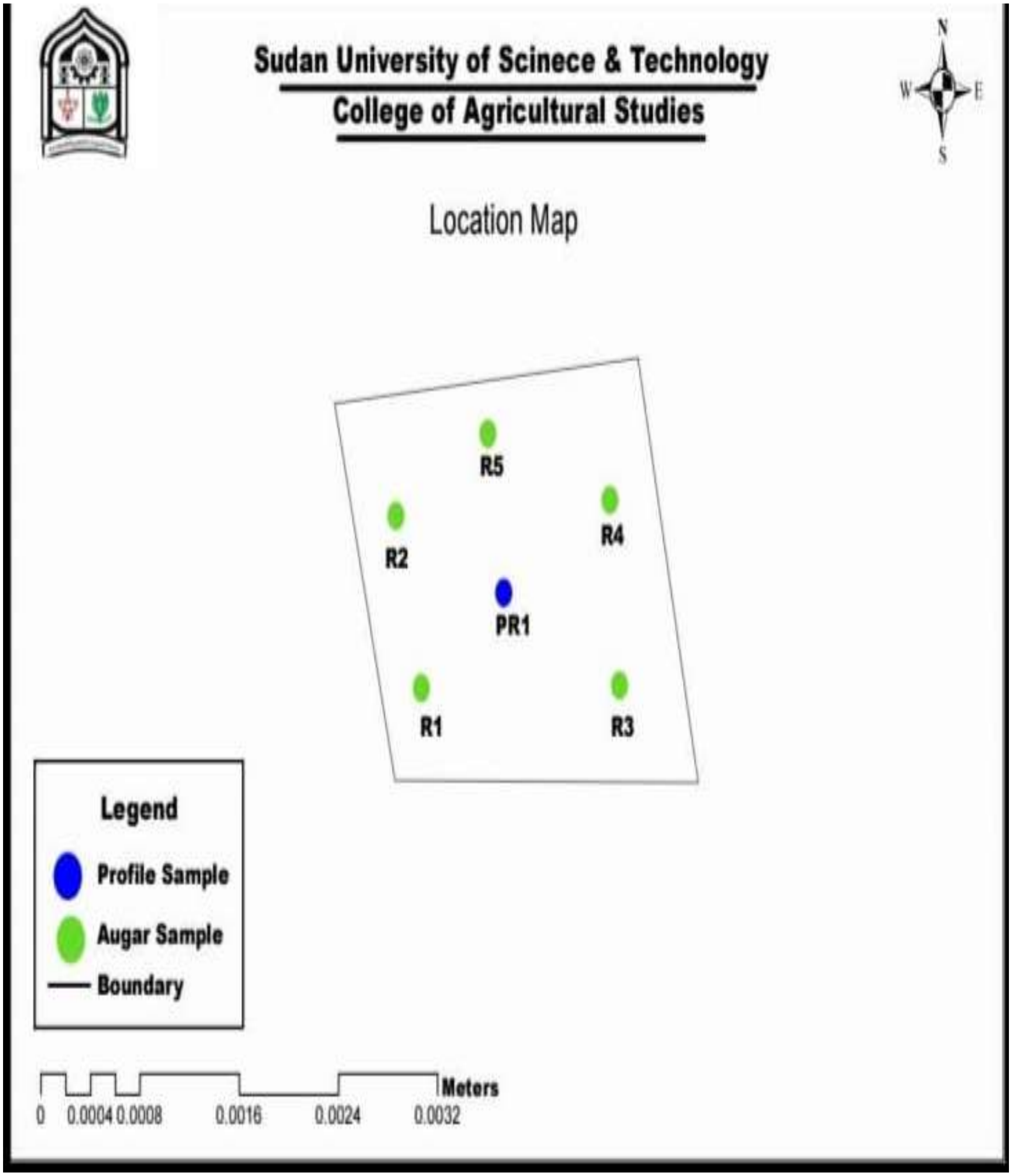
Samples were taken and kept in plastic bags and labeled with the auger number and the depth of the sample and the date.

The profile was divided into pedogenic horizons or layers and each horizon or layer was described according to the Guidelines of Food and Agriculture Organization (FAO).About 1kg of soil was taken from each horizon or layer and kept in a plastic bag and labeled by the profile number. The infiltration rate of water was done near the profile.

Table 3.4Intensity of samples:

Item	**Area = 8 feddan**
Intensity	1/0.75feddan
Number of augers	5
Samples from augers	15
Number of profiles	1
Samples from profiles	4

Figure 3.3 Location of the auger and profile sites:



3.3. Methods:

3.3.1. Samples preparation:

All samples were air dried, ground to pass a 2mm sieve, and the fine earth obtained was stored for laboratory analysis.

3.3.2. Laboratory analysis:

All samples collected were analysed at the (Soil and Water & quality control lab) of Zadna International Company for Investment and the laboratories of faculty of Agriculture studies, Sudan University of Science and Technology (SUST).

The fallowing analyses were carried out:

3.3.2.1. Moisture Content:

Samples were dried in the oven at (105 ºC) and moisture percentage was calculated as follows:

%Moisture =Difference in weight before and after drying /oven dry weight x100.

Results of moisture content were used to express subsequent analytical data on oven dry basis.

3.3.2.2. Soil reaction:

Determined in the saturated soil paste. The pH was read by a glass/calomel electrode (concentrated KCL) system (Model Jenway 3510 pH Meter).

3.3.2.3.Electrical Conductivity (ECe) dS/m at 25° C:

Determined in saturation extract using a digital ECe conductivity meter (Model Jenway 4510 Conductivity Meter).

3.3.2.4. Soluble cations and anions:

Calcium and magnesium titrated against EDTA with (ethylene di amine tetra acetic acid). (Bray,1984).

Sodium and Potassium determine by flame photometer model (Jenway) PFP7 Flame Photometer.

Carbonate and Bicarbonate by titration with hydrochloric acid. (Reitemeier 1943)

Chloride by titration with silver nitrate method (Reitemeier ,1943).

3.3.2.5. Organic Carbon and Organic matter:

Soil organic matter is oxidized with potassium dichromate in sulphuric Acid and determined by titration with ferrous ammonium sulphate solution. A factor of 1.72 is used to convert organic carbon into organic matter. (Walkley black,1965)

3.3.2.6. Total nitrogen:

Micro-Kjeldahl was used. Pre-moistened soil treated with concentrated sulphuric acid for digestion. Saturated solution of NaOH was used for distillation and liberated ammonia was received in 2% boric acid, and titrated with solute standard hydrochloric acid.

3.3.2.7. Available phosphors:

Determined by Olsen sodium bicarbonate extract method, and color intensity measured by spectrophotometer model (Jenway 7315).

3.3.2.8. Cation Exchange Capacity:

The colloidal complex of the soil is first saturated with sodium using sodium acetate, washed with ethanol to remove excess sodium and absorbed sodium was then replaced by ammonium using ammonium acetate, and determined by flame photometer (Bower,1952).

3.3.2.9. Exchangeable cations:

Extracted with ammonium acetate and corrected for the soluble fraction as measured in saturation extract. (Bower,1952)

3.3.2.10. Exchangeable sodium percentage:

Was calculated according to the following formula:

ESP = (Exchangeable Na / CEC) *100

3.3.2.11. Sodium Adsorption Ratio:

Obtained by calculation from the values of soluble Na,Ca, and Mg using the well-known Rachides equation:

SAR = **Na/$\sqrt{}$Ca + Mg/2**

3.3.2.12. Calcium carbonate content:

$CaCo_3$: Soil is treated with dilute HCL and the volume of CO_2 evolved is measured at atmospheric pressure. Accurate weight of pure $CaCo_3$is also treated with HCL and the volume of co_2 evolved is measured, and percent $CaCo_3$is calculated according to the following equation:

CaCo3% =Wt.2 (v1-v3)/wet's (v2-v3) × 100

Where:

Wt.2 = Weight of pure CaCo3

Wt. s = Weight of soil sample

V1 = Volume of CO_2evolved from soil sample

V2 = Volume of CO_2evolved from $CaCo_3$

V3 = Volume of CO_2due to a blank sample

Final results are expressed on oven dry basic by multiplying the result by the following factor:

100+m%/100

M% = moisture percent

Mechanical analysis:

The Hydrometer method was used in this research.

CAPPTER FOUR

4-RESULTS AND DISCUSSIONS:

The description of the profile is given in the appendix. They all meet the requirements of classification as Vertisols.

4.1. Physical and chemical properties:

4.1.1. Soil texture:

The result of particles size distribution analysis for the profile is given Clay content dominantly varies between (31-41%), Silt between (46-61%), and sand between (7-16%).

4.1.2. Infiltration rate:

Optimum basic infiltration rate for irrigation is considered to be in the range of 6.5 cm/h; according to (BIA, 1979).The infiltration rate in Al Sileit farm is slow (2.0cm/h). General, permeability decreases with increasing density, heavy textures and affected by saline and sodic condition. In addition, the pore size distribution influences the rate of change of infiltrability.

4.2. Chemical properties:

Soil reaction: pH (paste) of surface soil samples ranges between 7.5 and 8.2; these values are mildly alkaline (pH7.9) (Richards, 1954). Higher pH values were obtained in auger R4 pH between (8.1-8.5) which may indicate presence of relatively high salt content.

The electrical conductivity values of the saturation extract range between (0.6-7.1ds/m). The weighted average of the soluble salts within the depth 200 cm indicates slight level of salinity (1.5ds/m).

A value of ESP 15 is often regarded as the boundary between sodic and non-sodic soil. In general term, high ESP values have a greater deterious effect on soils with 2:1 lattice clays. Although the onset of adverse physical condition occurs more generally at higher ESP levels in montmorillonitic clays; as indicated by (Richards, 1954).

Sodium Adsorption Ratio (SAR) is another concept of sodicity. It is calculated form concentration of Na, Ca and Mg in the soil solution as they are in equilibrium with their exchangeable forms. The critical value of SAR that indicate problem is slightly lower than ESP. SAR value of only 12 is considered harmful.

Values of cation exchange capacity ranged from 18 to 31 meq/100g.soil. There is considerable variation from sample to sample and the results confirm that percent clay is directly related to C.E.C as expressed in meq/100 soil. Actually C.E.C values are associated with both clay content, type of mineral and organic matter. Inaddition, silt has a slight effect on C.E.C value; According to (Brady and Weil, 2002).

Phosphorus values for these samples range between (2-3ppm) which may indicate that available phosphorus is very poor in these soils. Those sample containing more than 7ppm are considered reasonably supplied with phosphorus; according to (Cooke,1967).

Total nitrogen is (0.1%) which might indicate a very low level of this important element in all soils tested (Metson, 1961).

Similarly, organic matter is very low and the result obtained for organic carbon is between (0.08%- 0.09%).

The values of calcium carbonate range from (8.5-11%). Calcium carbonate has an effect on most of the physical properties of soil including; particle size distribution, bulk density, permeability and availability of nutrients specially phosphorus and microelements (Massoud, 1972).

4.3. Soil genesis:

The soils are believed to be formed from the basic igneous rooks of the Ethiopian high land. The solid geology of the area is composed of ancient formation of cretaceous age outcropping on the western bank of the Nile, with an original lithologically formation, which is given the name of Nubian series; from a topographic point of view, most of the

area under study is flat. The climate of al Sileit area is classified by papadkis, semi-desert climate zone with summer rains, and warm winter; in (Table 3.2). The combined effect of high temperature and strong solar radiation caused the potential evapotranspiration to be very high and significantly exceeds the rainfall in all months (fig.3.2).

Table 4.1 Results of profile samples:

Serial	Depths	SP	pH	E Ce	Ca+Mg++	Na+	SAR	HCO-	CL-	k+	CaCO3	O.C
No.	(cm)	%		(dS/m)	(mmol+/l)	(mmol+/l)		(mmol+/l)	(mmol+/l)	(mmol+/l)	%	%
PR1	0-40	33	8.2	3.5	31.9	31.2	7.8	8.1	12.0	0.2	8.5	0.09
	40-59	37	8.4	3.6	25.5	8.3	2.3	17.1	45.5	0.1	10.5	0.08
	59-104	41	8.4	3.2	17.5	14.0	4.7	13.4	42.0	0.1	11	0.08
	104-130	64	8.2	6.4	47.0	67.9	14.0	15.7	44.0	0.2	11	0.09
Serial	**P**	**N**	**clay**	**silt**	**sand**	**CEC**	**Exchangeable Cation cmol+/100g soil**				**Weighted average**	
No.	**Ppm**	**%**	**%**	**%**	**%**	**cmol+/100g soil**	**Ca^{++}**	**Mg^{++}**	**Na^{+}**	**K^{+}**	**E Ce**	**SAR**
PR1	2	0.1	40	49	11	22	12	17	2	0.1	4.1	8.7
	3	0.1	38	53	9	21	15	12	3	0.1		
	3	0.1	37	55	8	20	13	12	3	0.0		
	2	0.1	41	51	8	21	16	14	5	0.1		

Table 4.2 Results of auger samples:

Serial No.	Depths (cm)	SP %	pH	E C_e (dS/m)	Ca+Mg++ (mmol+/l)	Na^+ (mmol+/l)	SAR	HCO^- (mmol+/l)	CL^- (mmol+/l)	Weighted average E Ce	SAR	pH
R1	0-30	39	7.7	0.9	8.9	8.2	3.9	15.5	44.5	3.7	10.8	7.2
	30-60	62	7.7	3.5	16.6	37.4	13.0	11.2	50.5			
	60-90	64	7.6	7.1	39.7	75.8	17.0	13.2	46.5			
R2	0-30	34	7.8	0.7	11.1	6.3	2.7	12.2	42.5	1.3	5.2	7.5
	30-60	42	8	1.3	12	9.3	3.8	11.3	50.5			
	60-90	52	8	2.2	12	23.8	9.7	12.8	39.5			
R3	0-30	35	7.8	0.6	9.9	5.7	2.6	13.2	37.5	0.7	3.3	7.6
	30-60	41	8.2	0.6	10.7	5.7	2.5	11.6	47			
	60-90	55	8.3	1.6	17.6	15.2	5.1	11.8	37			
R4	0-30	33	8.1	0.6	15.5	5.9	2.1	14.1	34	0.7	2.3	7.9
	30-60	54	8.5	0.6	26.9	5.7	1.5	10.8	39			
	60-90	64	8.5	1	19.1	10.9	3.5	16.2	45.5			
R5	0-30	42	7.5	0.9	11.8	11.3	4.6	11.8	47	1.1		7.7
	30-60	45	7.6	1.1	21.4	21.2	6.4	14.2	38			
	60-90	47	7.9	1.5	19.7	22.8	7.2	12.6	36.5			

Serial No.	Depths (cm)	Soil Texture clay	silt	sand	CEC cmol+/100g soil	Exchangeable Cation cmol+100g soil Ca^{++}	Mg^{++}	Na^+	K^+
R1	0-30	38	46	16	22	14	10	2	0.1
	30-60	40	49	11	31	15	14	6	0.1
	60-90	41	50	9	31	16	14	6	0.1
R2	0-30	35	53	12	18	13	15	1	0.2
	30-60	35	46	9	23	14	9	3	0.1
	60-90	33	60	7	28	12	13	4	0.1
R3	0-30	32	55	13	19	14	13	1	0.1
	30-60	34	57	9	20	16	10	3	0.0
	60-90	31	60	9	22	14	12	0	0.0
R4	0-30	40	49	11	19	13	12	2	0.1
	30-60	29	63	8	18	15	11	4	0.1
	60-90	31	61	8	22	16	10	5	0.1
R5	0-30	36	52	12	21	15	14	5	0.1
	30-60	40	50	10	22	12	11	4	0.1
	60-90	37	54	9	22	14	11	0	0.0

4.4. Soil classification:

The soil of the study area is classified as Vertisol in the U.S.Soil taxonomy system. The soil is classified as ***fine, monmorillonitic, isohyperthermic, Haploustert*** (Soil Survey Staff, 1993).

4.5. Land suitability of study area:

Land suitability is evaluated on the basic of land qualities. Each quality is determined by a number of soils characteristic.

As shown in the table 4.1 the suitability of the study area was classified according to (El-Tom and Kevie, 2003).

Table 4.3.The suitability of the study:

Soil mapping Unit / Land quality	1
Moisture availability	1
Chemical soil fertility	3
Condition for seed Establishment	1
Drainage cond. In grow. Season	1
Workability	1
Possibility for mechanization	1
Salinity	2
Sodicity	1
Erosion hazard	1
Capability for maintainace of surface water	1
Topography for gravity irrigation	1
Soil drainability	1
Suitability classes	S2
Suitability sub-classes	S2fs
Kind of limitations	fs

f = fertility;s = salinity

CAPPTER FIVE

5-CONCLUSION AND RECOMMENDATIONS:

5.1 Conclusion:

1- The soils parent materials are residuum (formed in situ) and Aeolian stand stone deposits developed on the Pediplan flanking the eastern upper terrace of the Nile and they are under continuous processes of reworking especially the surface layers.

2- The soils of the study area are very deep, none cracking sandy loam at the surface layers and have a medium, fine texture of sandy clay loam and sandy clay at the subsoil.

3-Surface mulch mixed with variable thickness of overblown sandy loam (0-10cm) cover all parts of the study area. It seems that some slightly depressional areas trap over blown sands, and form loose surface.

4-The soil of the study area is insufficient in nutrient elements (N, P, and K).

5-The soils of the study area are evaluated as moderately suitable land S2f to S2fs with limitation due to chemical fertility and salinity.

6-The soils are slightly saline, non –sodic.

7-Irrigation water is highly suitable (S1-C1) i.e. Very low salts, very low sodium.

5.2 RECOMMENDATIONS:

In view of the previously cited soil characteristic, soil qualities and the observed field features the fallowing recommendations can be made:

1. Exhaustive, surface irrigated fodder crops (E.g. Abu Sabean) should be limited to small area but berseem could occupy relatively large areas.

2. In order to favor nutrients availability it is recommended to add organic matter and chemical fertilizers.

3. The different soil units of the area should be treated differently as far as management is concerned to maintain sustainability of good production.

4. The persistent wind blowing around the area has accelerated the environmental degradation under the existing arid climatic condition. Shelter belts of parallel lines of trees and bushes planted at short distance across the wind direction to rephrased the farms are essential to halt wind hazards.

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Appendix

Profile description:

Survey area	AL Sileit
Profile No.	PR1
Date	4.9.2019
Author	Mozamel Mohammed
GPS E	32.65006
GPS N	15.69312
Topography	Flat
Slope, %	1%
Site	Al-Siliet project
Landform	Platy
Surface cracks	0
Mulch	0
Other	0
Micro- relief	0
Termitaria per ha	0
Water erosion	1
Wind erosion	1
Land use (agriculture)	Abu Sabean
Water table, cm	None
Drainage class	Moderate
Parent material	Alluvium (River Nile)
Other	0

Depth, cm	Profile description
0-40	Dry; brown (10YR4/3); clay loam; slightly hard dry; friable moist; slightly sticky and slightly plastic wet; moderate fine, medium and coarse sub-angular blocky structure; few fine and common medium pores; common fine roots; slightly calcareous; clear boundary.
40-59	Dry; brown (10YR4/3); silty clay loam; slightly hard dry; friable moist; slightly sticky and slightly plastic wet; moderate fine, medium and coarse sub-angular blocky structure; few fine pores; few medium roots; strong calcareous; clear wavy boundary.
59-104	Dry; dark brown (10YR3/3); clay loam; hard dry; friable moist; sticky and plastic wet; medium massive structure; medium calcium carbonate segregates; few fine roots; slightly calcareous; clear wavy boundary.
104-130	Dry; dark yellowish brown (10YR3/4); clay loam; slightly hard dry; friable moist; slightly sticky and slightly plastic wet; strong massive structure; medium calcium carbonate aggregates; slightly calcareous.


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PR (1)
4.9. 2019