# ASSESSMENT OF LAND DEGRADATION USING SOME BIOHYSICAL INDICATORS IN EL – RAWAKEEB DEVELOPMENT PROJECT

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# CHAPTER THREE
# MATERIALS AND METHODS

3.1 Physical characteristics of the study area:

3.1.1 Location: ELRawakakeeb dry land region occupies the area south west Omdurman, some 3 5-40 km west the River Nile. It lies between latitudes 15:2,15:36 N and longitude 32:0,32:10 E and altitude of 420 meters above the mean sea level.(EL Hag *et al*., 1994).Image of the study area is shown on page 36.

3.1.2 Area: ELRawakeeb development project was established during the year 1969/1970 as mentioned by Salih (1977), with an objective targeted using ground water for growing vegetables and fodder to sustain pastoralists besides preventing desert encroachment. The project area was 30 feddans and later expansed to 110 feddans in addition to 40

feddans outside the fence . Due to fmancial and management problems, the project was abandoned and almost covered by sand. 1n1992, ELRawakeeb Desertification Research Station was established in the project area.

**3.1.3 Climate**: According to Walsh (1991), ELRawakeeb lies in tropical semi - arid region whose climate is characterized by a short rainy season ( July-October) and high evaporation potential. The relative humidity values are low and thus indicate the general aridity of the area. Air temperature fluctuates and shows a marked rise (47C°) in May and drops in August due to incidence of the rain. Average soil temperature is 40 C° while average moisture is 12.5% (EL-Hag *et al*., 1994).

**3.1.4 Soil:** ELRawakeeb soil analysis showed that the relative proportions of different soil particles follow the order: sand, silt and clay with sand comprising the highest proportion. Chemically, ELRawakeeb soil is generally alkaline, very poor in nitrogen and carbon, moderate in its bicarbonate and potassium contents and rich in its sodium, calcium and chloride contents (EL Hag *et al.,* 1994). According to the soil taxonomy (USDA, 1975) the soil falls in the order of Aridisols, mixed Koalintic isohyper thermic Gypsic or Typic camborthid.

**3.1.5 Vegetation**: Ahmed (1997) reported that, because of high degree of temperature, scarcity of rainfall, natural vegetation is scattered however, Acacia species are dominant beside some annual shrubs and grasses which grow in rainy season. Recently, there are two rows of eucalyptus and *Acacia mellifera* established as shelter belts.

**3.1.6 Sand dunes**: The strong windstorms resulted in sand dunes formation that scattered all over the west part of the project. Three distinct sand dunes are recognized along and opposite irrigation ditch having the following dimensions (length and height respectively). L07mx 2.l0m, 66mx3.30m and 15x3.60m.(Field survey,2008). The sand dunes are shown in plates (1-5).

**3.1.7 Land use system**: Land use system is mainly pastoral. The traditional agriculture activities are usually carried out. Fodder crops, vegetables and shelter belts are cultivated and irrigated artificially (Ayers and Westeot, 1985).

**3.1 8 Water resources**: People depend on underground water from bore holes and rainfall water for their use and animals. There were three bore holes in the project area to pump water; namely North East, South East and West bore holes (Agabna *et al.*, 2003). But now only the South East bore hole is on work, the others, are no longer used. (Field Observation survey, 2008).

**3.2 Sampling and analysis:**

**3.2.1 Soil analysis:** Soil samples were collected by Augor from four sites (A1 – A4 ).

A1 : East site of the project area .

A2 : North site of the project area .

A3: West site of the project area .

A4: Middle site of the project area .

The distances between augor were 50 m.The augor covered the northern part of the project area. Thirty six bulk soil samples were collected from three successive depths (0 to 0.3 m, 0.3 to 0.6m, 0.6 to 0.9 m) from locations covering the main soils of the project area. Each soil sample was air-dried thoroughly mixed, crushed and passed through a 2 mm sieve — the analysis includes the following parameters:

• Particle - size analysis was carried out by hydrometer method.

• The electrical conductivity of the saturation extract (EC. ), soluble cations ( $Na^+$ , $Ca^{++}$, $Mg^{++}$, $K^+$ ) were determined according to the standard procedure of U.S salinity laboratory staff (1954). pH of saturate paste and soluble anions ($CO_3^{-2}$, $HCO_3^{-1}$and $Cl^{-1}$) were also determined.

• Sodium Adsorption Ratio (SAR), and Organic Matter (OM) were calculated according to the following equations:

- SAR = $\frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$

- OM = 1.274 X organic carbon

The properties of the soil and water are tabulated.

**32.2 Water analysis:** Water sample was taken from the South East bore hole of the project and analyzed to determined cations ($Na^{+1}$. $Ca^{2+}$. $Mg^{2+}$ and $K^{+}$). anions ($CO_3^{-2}$, $HCO_3^{-1}$ and $Cl^{-1}$). pH and SAR according to (USSl, 1954 )

### **3.2.3 Statistical analysis**:

Data subjected to analysis of variance and significance among means was detected using the Duncan Multiple Range Test.

**بسم الله الرحمن الرحيم**

***{ وَآيَةٌ لَّهُمُ الْأَرْضُ الْمَيْتَةُ أَحْيَيْنَاهَا وَأَخْرَجْنَا مِنْهَا حَبّاً فَمِنْهُ يَأْكُلُونَ{*} وَجَعَلْنَا فِيهَا جَنَّاتٍ مِن نَّخِيلٍ وَأَعْنَابٍ وَفَجَّرْنَا فِيهَا مِنْ الْعُيُونِ{*} لِيَأْكُلُوا مِن ثَمَرِهِ وَمَا عَمِلَتْهُ أَيْدِيهِمْ أَفَلَا يَشْكُرُونَ}***

***صدق الله العظيم***

سورة يس الآيات (33-34-35 )

# DEDICATION

To my
Revered parents, and
To my
Great family, and
To
People of my beloved Country, I dedicate
this simple effort.

Mubarak

# ACKNOWLEDGEMENT

Any extensive study is not possible with out cooperation of a number of people and this study is no exception. I wish to express my sincere thanks to Dr. **El Tegani Mohamed Salih** for his valuable suggestions after reviewing the manuscript.

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Also, my gratitude is extended to all those who helped in the completion of this study.

Assessment of land degradation Using Some biophysical Indicators in
El- Rawakeeb Development Project West Omdurman , Khartoum State .
Mubarak El Jack Tawr Naash

# ABSTRACT

This study was initiated to update information and data of El-Rawakeeb dry area and to assess land degradation using some biophysical indicators.

Soil samples were collected by an augor and subjected to laboratory and statistical analysis; samples of water from a bore hole were also analyzed. Interpretation of physical, chemical and field information indicated the presence of land degradation.

Results showed an increase in pH and SAR for the cultivated soil than uncultivated soil . Sand encroachment formulated sand dunes that expanded in the area of the scheme (length and height of 107m; 3.6m).

The results showed that soil texture follow the order sand (66%), silt (14%), clay (20%) and the organic matter is low with overall standard deviation of 6.56 and variation of 39.7. The distribution of soluble cations and soluble anions, showed irregular pattern, although there were no clear differences among different sites and depths, magnesium, calcium and chloride were dominant in the soil of the area.

The results also indicated that, the soil was not saline and the irrigation water is slightly saline; (EC< 4dS/ m) for the soil.

This deterioration can be controlled if some modern land management system is applied and sand dune fixation ,wind break and shelter belt techniques are adopted .

تقدير تردي الأرض باستخدام بعض المؤشرات البيوفيزيائية في مشروع تنمية الرواكيب غرب امدرمان ، ولاية الخرطوم .

مبارك الجاك تاور نعاش

# المستخلص :


أجريت هذه الدراسة لتجديد المعلومات و البيانات عن منطقة الرواكيب الجافة و لرصد تـدهور الارض مستخدماً في ذلك بعض المؤشرات الطبيعية و الإحيائية.

أخذت عينات من التربة بواسطة البريمة و تم تحليلها معملياً وإحصائيا. كما تم تحليل عينات من ماء البئر الجوفي.

دلت التحليلات الفيزيائية و الكيميائية لعينات التربة والدراسات الحقليـة وجـود تـدهور لتربـة المنطقة.

أظهرت النتائج زيادة كل من الأس الهيدروجيني (pH ) ونسبة الصوديوم المد مـص ( SAR ) في التربة التي زرعت عن الأرض البكر .

زحف الرمال كون كثبان رملية على امتداد منطقـة المـشروع ( بطـول وارتفـاع 107 متـر و3.6متر) .

أظهرت النتائج أن قوام التربة يتبع الترتيب رمل (66%)، سلت(14% )،طين 20 %).

وأن المادة العضوية متدنية بانحراف معياري كلي 6.56 و تباين 39.7.

توزيع الكتيونات المذابة والأيونات المذابة نمطها غير منتظم.وعلي الرغم من أنه لـيس هنالـك فروقات واضحة في المواقع والأعماق المختلفة نجد المغنيزيوم و الكالسيوم و الكلور هى الـسائدة فى تربة المنطقة .

كذلك أظهرت النتائج أن التربة غير مالحة و أن مياه الري خفيفـة الملوحـة حيـث التوصـيل الكهربي للتربة أقل من( 4 ملي ديسيسمينز /متر).

يمكن السيطرة على هذا التدهور اذا أستخدم نظام حديث لإدارة الأرض ووقف الكثبان الرمليـة بتبني تقنيات الأحزمة الشجرية ومصدات الرياح.

***Results and Discussions***

Table (1) shows the particle size distribution. The data clearly indicated that the irregular distribution of all fractions how ever, sand was the highest (66.3%, followed by clay (20%) and silt (14%).

Particle size analysis indicates, how ever that natural content of clay was higher for the lower horizons (0.6-0.9m). This pattern could be due to the horizontal variation caused by erosion which exposed different layers at different locations of the project.

The mean clay content table (1) ranged from 16%- to 23%,the standard deviation(SD) and coefficient of the variation (CV) from top soil downwards ranged from 7.48 to 4.92, 56, 24, respectively.

The mean silt content ranged from 11% to 15% while the mean sand content ranged from 74% to 63%.

Results of grain size analysis generally confirm the field observation and consistent with results of El tegani (1975 pH value Table (2) ranges between 6.8 to 6.6 from surface downwards due to irrigation water , evaporation, and movement of salts up wards.

Results showed that soil depth has no effect on the value of pH.

The electrical conductivity (EC) values Table (2) ranged between 0.5 to 0.6mmohs/m indicated that the soil was not saline.

The EC values offered slight evidence suggesting that the irrigation water is less saline.

The organic matter content (OM) Table ( 2) is not fixed among depths because of climatic changes, diversification of vegetation cover, generally it is low due to high temperature of the semi-arid region increases its decomposition.

Mean organic content was 0.38 for the first depth with a rang of 0.46 to 0.45 downwards.

The second depth had significantly greater organic matter than the first depth. The over all Standard deviation (SD) and variation values were 6.56, 39.7.

The extractable cations Table (2) and soluble anions did not exhibit any particular pattern. The data however indicated the dominance of $K^+$/ $Na^+$ among the extractable cations and did not reflect evidence that could be correlated with leaching processes.

Calcium ($Ca^{2+}$) increased with soil depth with mean ranging from 2-3.5meq/L; this phenomenon is perhaps due to non saline irrigation water.

Magnesium and Calcium ($Mg^{2+}$/$Ca^{2+}$) dominated over Sodium ($Na^+$)

cations; this could be as a result of high cation exchangeable capacity (CEC) due to soil parent material.

The distribution of soluble anions also showed irregular pattern. There existed how ever, slight difference between depths. This difference was reflected in chloride (Cl-) and might be obliterate by the up ward movement of the soluble material.

Chloride anions were dominant in all depths with values ranging between (3.9-6.5meq/L) followed by bicarbonate (0.7-0.68 meq/L).

Carbonate anions were almost absent (0.5) in most depths of the soil because their transformation in to bicarbonate.

Water analysis Table (7) showed low values for SAR (5.3) and EC (1.4mmohs/m).

Since SAR is less than 9, and EC is less than 4mmohs Ayers and westcot (1985) stated this water can be used for animals and poultry production.

# Chapter One

# Introduction

The main feature of the dry regions is the occurrence of a long dry season and a short rainy season. The intensity of dryness of a region depends on the number of the dry months, their distribution within the year and the rainfall distribution during the wet season. While most of the region has one distinct dry season some areas, particularly near the equator, tend to have two dry seasons which are sometimes not very clearly defined ( Seif EL Din ,1984).

The United Nations Convention to Combat Desertification (UNCCD,2005) defines Arid, semi Arid and dry sub humid Zones as ‘areas’ other than polar and sup Polar regions, in which the rate of annual precipitation to potential evapotranspiration falls with in the range from 0.05 to 0.65. Hyper Arid zones characterized by a ratio typically less than 0.05.

A global Assessment of Soil Degradation (GLASOD) was undertaken in the early 1990s

(UNEP,1992).The phenomenon of desertification, as a process of land degradation in arid, semi- arid and dry sub- humid areas, as defined by UNCCD, has attracted considerable global attention from international communities during the last three decades. Degradation implies reduction of resource potential one or a combination of process acting on land. These processes include water erosion, wind erosion ,and sedimentation, by those agents ,long term reduction in the amount or diversity of natural vegetation, where relevant, salinization and sodication,(UNEP,1992).

. Land degradation or desertification as it is called in its extreme, is the most serious problem under concern, having its economical, social and ecological effects. It may ultimately be concluded that a combination of factors, involving fragile ecosystems developed under harsh climatic conditions and human activities which are increasing in irreversible magnitude, are the actual causes of the desertification problem in Sudan (DECARP, 1976).The complexity of desertification problem in general and its significant consequences in the area in particular, raised the need for addressing the main forms and causes of land degradation. The UNCCD in article 17, emphasized the necessity of in depth research to search the remedial measures to solve desertification problems. In this, it was required the application of biophysical indicators that suggested by the committee on sustainable development, UNCED,1992.

In this context, the study was initiated to update knowledge of physical, chemical, and biological characteristics in El-Rawakeeb dry land area and to apply some biophysical indicators which influence land degradation.

**Objectives of this study are the following:**

-To assess land degradation.

-To apply some biophysical indicators for assessment.

-To update information and data of EL-Rawakeeb area.

-To test some biophysical indicators for assessing desertification.

# Chapter Two

## Literature Review

### 2.1 Definitions:

Land degradation is a composite term, it has no single readily identifiable feature, but instead describes how one or more of the land resources (soil, water, vegetation, rock, air, climate, relief) has changed for the worse. (Michael and Niamh, 2000).

So, Land degradation is far from being a simple process, with clear outcomes. This complexity needs to be appreciated by the field assessor, before any attempt is made either to define land degradation or to measure it. Land degradation generally signifies the temporary or permanents decline in the productive capacity of the land (UN/FAO definition). Another definition describes degradation as "the aggregate" diminution of the productive potential of the land, including its major uses (rain - fed, arable, irrigated, rangeland, forests), farming system and its value as an economic resource"

This link between degradation and its effect on land use as stated by Michael and Niamh ( 2000), is central to nearly all published definitions of Land degradation. The emphasis on land, rather than soil broadens the focus to include natural recourses, such as climate, water, land forms and vegetation. The productivity of grass land and forest resources in addition to that of crop land is embodied in this definition.

While soil degradation is recognized as a major aspect of land degradation, other processes which affect the productive capacity of crop land, rangeland and forest, such as lowering of the water table and deforestation, are captured by the concept of land degradation. Land degradation is, however difficult to grasp in its totality. The productive capacity of land “can not be assessed simply by any single measure.(Michael and Niamh.,2000).

Therefore, we have to use indicators of land degradation. Indicators are variables which may show that land degradation has taken place. The condition of the soil is one of the best indicators of land degradation. But, in the field further variables are used as indicators of the occurrence of soil degradation.

## 2.2 Degrees of land degradation:

land degradation occurs at widely varying rates ,and to ranging degrees , over the landscape, hillside and between fields. According to the state of deterioration of vegetation cover and degree of productivity of the land, (Babiker *et a*1.,1994) differentiated among four levels of land degradation, they are:-

**2.2.1 Severely degraded land or extreme**: The terrain is unreliable and beyond restoration, original biotic functions are fully destroyed.

**2.2.2 Highly degraded land or strong**: The terrain is non reclaimable at farm level. Major engineering works are required for terrain restoration; .original biotic functions are largely destroyed.

**2.2.3 Moderately degraded land**: The terrain has greatly reduced agricultural activity but is still suitable for use in local farming systems, Major improvement are required to restore productivity partly at farmer’s level, partly with government sub sides, original biotic functions are partially destroyed.

**2.2.4 Slightly degraded land or light**: The terrain has some what reduced agricultural suitability, but is suitable for use in local farming systems. Restoration to full productivity is possible by modifications of the management system at farmer's level original biotic functions are still largely inact.

**2.3 Vulnerability of land to degradation:**

Accelerated land degradation result from the mismanagement of land and generally reflects the mismatch between land use and land quality. A First global assessment of human induced degradation was made by the (GLA SOD) project and high lights areas where the degradation processes have attained levels that require land preservation, conservation, or rehabilitation technologies to mitigate. Land Degradation Assessment of Dry lands (LADA) was initiated by GEF and UNEP in 2000.

**2.3.1 Sensitivity and resilience:**

Sensitivity and resilience are measures of the vulnerability of a land scrape to degradation. These two factors combined to explain the degree of vulnerability. (Michael *and Niamh,* 2000).

**2.3.1.1 Sensitivity:**

Sensitivity is the degree to which a land system undergoes change due to natural forces, human intervention or a combination of both. Some places are more likely to be sensitive to change, for example, steep slopes, areas of intense rainfall or highly erodible soils. These places are subject to natural hazards that make them sensitive to change .Human intervention in these systems can result in dramatic alterations Sensitivity to change can arise as a result of human intervention – for example , in a natural state, forested hill sides may be difficult to degrade, but once converted to farm land, degradation may occur more easily.

### 2.3.1.2 Resilience:

Resilience is the property that allows a land system to absorb and utilize change including resistance to a shock. It refers to the ability of a system to return to its pre-altered state following change. The natural resilience of an environment may be enhanced by the diversity of the land management practices adopted by land user. Degraded land is less resilient than non degraded land. It is less able to recover from further shocks, such as drought, leading to even further degradation.

The sensitivity and resilience of land system could influence land use decision, there by reducing the risk of permanent degradation to the systems.

### 2.3.1.3 Characteristics contribute to sensitivity and resilience:

Michel and Niamh ,(2000) pointed out the factors that affect sensitivity and resilience of an environment as the inherent characteristics of that environment such as nutrients, soil structure , micro – aggregates and soil depth, topography , climate ect, and the human element, in the form of land use and management practices. The salient factors affecting sensitivity and resilience will vary from place to place, so with regard to aspects of land degradation, sensitivity refers to how easy it is to degrade the land, and resilience to how easy it is to restore the land.

## 2.4 Causes of land degradation:

Accelerated land degradation is most commonly caused as a result of human intervention in the environment. The effects of this intervention are determined by the nature of land escape. As stated by Babiker *et al*. (1994), the most frequently recognized main causes of land degradation include:

- Overgrazing of range land;

- Over cultivation of cropland;

- Water logging and salinization of irrigated land,
- Deforestation, and
- Pollution and industrial wastes.

These factors are involved in human activities and climatic inverse impacts. Within these broad categories a wide variety of individual causes are in corporate. These causes may include the conversion of un suitable, low potential land to agriculture, the failure to undertake soil conserving measures in areas at risk to degradation and the removal of all crop residues resulting in soil mining. They are surrounded by social and economic conditions that encourage land users to overgraze, over cultivate, deforest or pollute (Micheal and Niamh, 2000 ).

**2.4.1 Overgrazing:** Besides the actual overgrazing of the vegetation by livestock, these causative factors also include trampling. Overgrazing usually leads to a decrease in the vegetation cover, which increase the water and wind erosion hazard, trampling may cause compaction of the soil, a wide spread effect of over grazing is the encroachment of unfavorable shrubs species.,

**2.4.2 Over cultivation of cropland:** This causative factor is defined as improper management of agricultural land. It includes a wide variety of practices, such as insufficient or excess use of fertilizers, absence of anti-erosive measures, improperly timed use of heavy machinery, ect.

**2.4.3 Water logging and Salinization of irrigated lands:**

This caused by a rise in ground water close to the soil surface or inadequate drainage of surface water, often resulting from poor irrigation management. As a result of water logging, water saturates the root zone leading to oxygen deficiency.

Salinization often occurs in conjunction with poor irrigation management "an increase in salt in the soil water solution".

**2.4.4 Pollution and industrial wastes:** This causative factor usually leads to degradation type ,namely Pollution.

**2.4.5 Deforestation:** This causative factor is defined as more or less complete removal of the natural vegetation. Reasons for this clearing may be the reclamations of land for agricultural purposes [cropping or cattle razing], large scale commercial forestry, road construction, ect.(FAO,UNDP and,UNEP,1994)

**2.4.6 Land degrading Processes:**

According to the study of Michael and Niamh,(2000) it is possible to distinguish between two types of land degrading actions as follows;-

#### 2.4.6.1 Unsustainable land use:

This refers to a system of land use that is wholly inappropriate for a particular environment. It is unsustainable in the sense, that, unless corrected, this land use or indeed any other could not be continued in the future; however, a large input of technology could start a rehabilitation to be devoted. Usually, this is uneconomic ( Sombroek,1979).

#### 2.4.6.2 Inappropriate land management techniques:

They also cause land degradation, but this degradation may be halted (and possibly reversed) if appropriate management techniques are applied.
The effect of land degradation process differs depending on the inherent characteristic of the land, specifically soil type, slope, vegetation and climate. Thus an activity that, in one place is not degrading may in another place, cause land degradation because of different soil characteristics. So, equally erosive rain storm occurring above different soil types will result in different rates of soil loss (Michael and Niamh, 2000). It follows that the identification of the causes of land degradation must recognize the interaction between different elements in the land escape which affect degradation and also the site vulnerability to degradation.

## 2.5 Types of land degradation:

Land degradation can be triggered by various processes that lower the potential productivity of land leading to long term deterioration. These processes are numerous, but for the purpose of this study, the primary focus is on processes of biological, chemical and physical forms of land degradation.

These processes are interacted and could occur due to natural causes, butthey are invariably accelerated by human intervention in the natural environment. *(Barber,and Olson, 1968).*

### 2.5.1 Biological degradation of soil:

It refers to the process that leads to a decline in the humus content of soil through mineralization (Solomon, 1994).

Decomposition of organic matter is a function of microbial activity.(Benzuayehu *et al.*,2002) showed that ,the majority of organic matter is concentrated near the soil surface in the form of decaying leaves and stems so, erosion of top soil results in a rapid decrease in soil organic matter levels and therefore causes loss of food for soil micro-organism, once organic matter layers is depleted. Soil productivity and crop yields decline because of the degraded soil structure and depletion of nutrients.

The stability of soil aggregates is dependent on microbial biomass. Thus, elimination of soil micro-organism causes physical damage to the soil ecosystem. These physical effects may in turn lead to increased erosion, organic matter depletion and further reduction in microbial activities.

A decline in organic matter has a far reaching effect on both chemical and physical properties of soils. It affects soil physical properties through its influences on soil structure and aggregate stability, which therefore influences soil erosion.

The viability of nitrogen and phosphorus is dependent on the organic matter content of the soil. (Benzuayehu *et al* ,2002).

Because of the concentration of organic matter on the surface and its low density, it is one of the first to be removed by erosion and is the hardest to replace **(***Solomon, 1994***).**

The rate of mineralization is high in the absence of natural cover where top soil is exposed to unusually extreme temperature and humidity

Removal of grain and crop residues from the field, without replacement of nutrient such as manure and fertilizer tends to deplete the soil of nutrients, as the natural replenishment can't compensate for the nutrients removed.(Getachew,1991) .

**2.5.1.1 Factors affecting Biological degradation:**

Babiker *et al* **.**,(1994) reported that these factors should be considered**;-**

a. **Climate**: Decomposition of organic matter is a function of microbiological activity, which it self a function of temperature and soil moisture.

b. **Soil:** The rate of decay varies according to the texture of the soil [being faster in a sandy soil than a clay soil], the nature of organic matter, the pH, calcium carbonate percentage. Soil reaction between pH 5.0 and 7.2 has little effect on biological degradation.

c. **Topography:** Slope aspect influences soil temperature and humidity, but slope angle has little influence on biological degradation.

### 2.5.2 Chemical degradation of soil:

Generally nutrients are lost through erosion in run off and in the eroded sediment. Finer soil fractions are the most vulnerable to erosion. Further nutrients losses occur through chemical degradation, i.e. deterioration of properties of the soil that occur as a result of acidification and salinization or sodification. The latter is common in arid and semi- arid areas where rainfall is inadequate to leach excess salts down through the profile. The acidification process may be accelerated through burning and clearing of vegetation, continued use of acid-containing fertilizers and excessive irrigation (Thomas, 1997).

Leaching, a process of translocation of nutrients beyond the reach of crops, occurs in areas of heavy rainfall when there are lengthy periods of rain.(Hagmann,1991). Nutrient depletion can be reduced, if not reversed, if adequate additional nutrients are applied to crops to replace potential losses through leaching, uptake by plants and other processes (OESPO,1999).

#### 2.5.2.1 Factors affecting chemical degradation:-

**a. Climate:** a good index to assess chemical degradation is indicated in the following formula;-

$$\left(\sum_{1}^{12} P - PET\right) - R$$

R; is soil moisture reserve for the humid season where P > PET (Babiker *et al*.,1994).

P;is the precipitation (mm).

PET; is the evapotranspiration(mm).

**b. Soil:** tropical soils are particularly susceptible to chemical degradation if they have a dominantly kaolin tic clay fraction with a low cation exchange capacity (CEC). Both sand soils of high permeability and soils with very low organic matter are also prone to acidification as they have relatively low (CEC).

**c. Topography:** on steep slopes run off increases, while internal drainage and leaching decrease correspondingly. Level topography therefore increases the risk of leaching and acidification.(Babiker *et al*.,1994).

**2.5. 3 Physical degradation of soil .**

Physical degradation may occurs as a result of sealing, compaction, crusting, reduction in aeration and reduced permeability ect. Lack of organic matter and high percentage of very fine sand and silt in soils are some of the factors contributing to surface sealing. (Michael *and Niamh*, 2000).

Crop production requires finely prepared seed bed which affects soil structure, leave the soil devoid of vegetation exposing the latter to kinetic energy exerted from raindrops. In such cases the clods dislodge and seal soil pore spaces. A decrease in soil pore spaces reduce infiltration and in crease over land flow volume and velocity leading to soil crusting, especially when it is dry. The situation is worse when it comes to sowing fine seeds like teff (Eragrostistef) which demand fine seed beds. Overstocking and over grazing of left over residue on cropland after harvesting cause soil compaction due to heavy and continuous trampling by live stock.(Michael *and Niamh*,2000).

Water points and cattle routes are particularly vulnerable to soil compaction, which leads to excessive run off and reduced water infiltration. The bulk density of grazing land was found to be and crusting deterioration are function of the intensity and high compared to ungrazed grass fallow, and crop land respectively (Solomon, 1994).

#### 2.5.3.1 Factors affecting physical degradation.

**a. Climate:** The aggressivity index as for water erosion, is used because sealing and crusting deterioration are a function of the intensity and energy of rainfall. Compaction and structural deterioration are function of soil plasticity during the period where the soil is saturated. Water logging, irrigation and flooding are also factors affecting physical degradation.(Babiker *et al*.,1994)

**b. Soil;** lack of organic matter and a high percentage of fine silt are factors contributing to sealing. It is possible to use a simple index of crusting:

$$Ic = \frac{Z f + Zc}{C} \quad \text{in Which:}$$

$Zf$ ; fine silt.

$Z c$ ; coarse silt

C ; Clay

This index is (1.5) for non crusting soils and (2.5) for soil subject to intense crusting.

**c. Topography:** level topography, as for chemical degradation is an important factor influencing physical degradation, because it increases infiltration.

### 2.6. Principle methods for assessing land degradation:

The examination of field degradation at different scales feeds in to different levels of analysis. Each level has its own particular set of uses. The first and most immediate use of information relating to existing or potential degradation is to identify the risks at field and farm level. Michael and Niamh., (2000) showed that_mapping of fields and detailed site inspection are involved here. The next level is to rank the degree of actual degradation, or future risk of degradation, by reference to their seriousness. This allows the land user to prioritize possible responses to degradation risk and to target parts of the farm where risk is greatest.

The field assessor may use this level of analysis to make semi- quantities comparisons between sites and situation. A third level of analysis is to formalize the prioritization by farmers by attaching monetary values to the costs and to the benefits of any course of action.

Generally four methods are recognized for assessment, as pointed out by Babiker *etal*. (1994).and they are;

### 2.6.1 Direct Observation:

This may be the only possible source of data and serves to verify results by other methods. Results obtained by observation are often quantitative and some times refer to static concepts of degradation rather than dynamic.

### 2. 6.2 Remote sensing Technique:

The value of remote sensing data can be variable especially at large scale with stereoscopic coverage, but some times certain degradation phenomena can only be inferred. Remote sensing documents can be inexpensive and very useful especially when geographic co-ordinates on the margin are available and that change can be monitored over a period of time.

### 2.6.3 Mathematical Models:

At present there are no widely used mathematical models for predicting degradation that are conceptual. However, for several processes empirical parametric models have been developed that give satisfactory results under various condition.

### 2.6.4 Assessment by parametric methods:

The parametric formulae used can be written in a some what generalized form as:

D= f(C,S,T,V,L,M) , in which

D = soil degradation

C = climatic aggressivity factor.

S = soil factor

T = Topographic factor

V = Natural Vegetation factor

L = Land use factor

M = Management factor

The values of the variables are chosen in such a way that solving the equation gives a numerical indication of degradation rate. However, since the formulae describe the processes only approximately, the final result should not be regarded as being exact, but merely as giving an approximate indication of the likely magnitude of degradation (Mustafa,2007), as expressed below.

#### 2.6.4.1 Climate (Rainfall and Wind):

The major components of climate that affect soil erosion are rainfall and wind. Erosive processes are set in motion by the energy transmitted from either rainfall or wind or combination of these forces.

Although the effects of erosion are not easily observed on a daily basis, water and wind are both capable of quickly damaging the soil. Sheet and rill erosion are by far the most wide spread kinds of accelerated erosion and impact agricultural production more than other kinds of erosion.

Soil erosion by rainfall and wind consists of two principal sequential events: The detachment of soil particles from the soil mass and the transportation of the detached particles *(Young and Wiersma, 1973)*.

The power of rainfall to produce erosion is related to rainfall amount, intensity and distribution. Rainfall intensity is more important than rainfall amount and distribution rainfall intensity is to or exceeding 7.5 cm/hr in 5 minutes, 3.6 cm/hr in 15 minutes, 2.5cm/hr in30 minutes, or2.0cm/hr in 60minutesis classified as excessive. *(Krauer, 1988)*. Wischmeir *et al*., (1956) have combined into an empirical equation most parameters affecting water erosion.

The equation, used for predictive purposes, is referred to as the universal soil loss equation:,

$$A = RK (Ls) CP.$$

Where, A is annual soil loss (ton/acre),

R is climatic erosivity (foot. ton), K is soil erodiblity, Ls is length and steepness of slope, and C and P are management factors Although this empirical relation widely used, the determination of individual parameters

must be experimentally determined for different ecological regions of the tropic wind erosion is determined by soil erodiblity, surface soil roughness, wind velocity, wetness of soil, vegetation cover and management practices. Usually when wind speed reaches 25meter per hour, the wind detaches soil particles from unprotected soil. *(Pimentel et al.,1998)*
.

The aggressivity of wind (C) is estimated by an empirical relation that involves wind velocity and precipitation effectiveness.

$C = V^3 / 2.9 (PE)^2$ where:,

V= wind speed

PE= Precipitation effectiveness of Thornth Waite

**2.6.4.2 Soil Properties:**

Each of the major soil class has properties that affect soil degradation differently *(OESPO,. 1999)*. Soils vary in their resistance to erosion partly based on texture and amount of organic matter.

The resistance also depends on soil condition and depth. Soils high in silt and low in clay and sand are highly erodible *(Nill et al,. 1996).*

The high erodiblity of silty soil is explained by their weak structure stability. They rapidly form surface seals upon the impact of raindrops. Erosion is less on clayey soils due to better aggregation and on sandy soils due to the non sealing surface.

Organic matter in the soil improves soil structures, root penetration, water holding capacity and infiltration. With increasing organic matter, erodiblity decreases. ***(****Wischmeier and  Smith,. 1978 ).*The physical and mechanical properties of the soil are very sensitive to the type of exchangeable ions present

The divalent ions, mainly calcium, are the ions responsible for many of the physical properties (Shainberg,1975).

**2.6.4.3. Topography**: the rugged topography and steep slopes affects soil erosion rate through its morphological characteristics. Two of these, namely gradient and slope length, are essential component in quantitative relationships for estimating soil loss.

On steep slopes, soils are generally shallower and their nutrient and water storage capacities are limited. Thus, soil in these areas, when exposed to soil eroding agents, face greater degradation consequences compared to soils in flat areas.

**2.6.4.4 Vegetation**:

Soil erosion rates increase because of vegetation removal, overgrazing and tillage. Vegetation cover reduces erosion. Living and dead plant biomass reduces soil erosion by intercepting and dissipating raindrops and wind energy. Above ground foliage suppress the velocity of water running over the soil decreasing the volume of water and soil loss in the surface run off .plant roots physically bind particles, thus stabilizing the soil and increasing its resistance to erosion.(Greenland and Lal,1977) .

**2.6.4.5 Land use:**

Crops lands and pastures are susceptible to erosion but croplands are more vulnerable because the soil is repeatedly tilled and left without a protective cover of vegetation. The Scio-economic situation in rural areas often leads people to use their environment in appropriately which induce land degradation. In any area the type of land use affects the level of soil protective cover and consequently the rate of erosion and erodiblity. (Solomon, , 1994).

**2.6.4.6 Land management:**

Fallowing has been traditionally used as soil management and fertility restoration strategy as vegetative re-growth during fallowing helps these processes. Where there has been persistent population pressure on arable land, the length of the fallowing period has shortened over time leading to continuous cropping. When land is used more intensively without better quality inputs such as manure and fertilizer, fertility loss and erosion might be exacerbated. (Asefa, 1994).

Tillage operations are some times carried out along slopes. Furrows formed along slopes can not slow down run off compared to those made along contours (Thomas,1991).

Mass movement of soil can be caused by human activity and land use change. Land slides occur in steep areas where the natural balance is upset due to the removal of root-binding forces through clearing of forests and bush for cultivation on steep lands.

## 2.7 Bio-physical impacts of land degradation:

The immediate impact of degradation is on soil productivity leading to impacts on people's welfare. Soil degradation through erosion induces loss in soil productivity.

This bio-physical process, where by soil erosion reduces the quality of the soil and hence its ability to produce vegetation, is the driving force in current debates on food security.(Stocking and Clark,1999).

If degradation is reducing current and future yields, the argument goes; future populations will not be able to feed themselves. Erosion-induced loss in soil productivity may occur through a variety of processes, described in partially scientific terms – i.e.- The professional perspective (Hadals, 1973).

1- Loss of nutrients and organic matter in eroded sediments reduce the total stock of nutrients in the remaining soil that will be available to future crops;

2- Reduction in plant available water capacity, through the selective depletion of organic matter and clays by erosion, increases he chances of drought stress in future crops;

3- Increases in bulk density, surface crusting and other physical effects of soil degradation prevent seed germination and disrupt early plant development.

4- Reduced depth and top soil and exhumation of sub soil by long term soil erosion decrease the available soil volume for plant roots;

5- Increasing acidity through selective removal of calcium cations on the exchange complex affects nutrients availability encourage-phosphorus fixation and induces free aluminum causing severe toxic effects;

6- Reduction in micro-faunal and micro-floral populations affects beneficial processes, such as nitrification;

7- Because of poorer soil properties, loss of seeds and fertilizers, poor germination and other direct process effects of degradation, farming operations become more difficult and less economic.

## 2.8 Land Restoration and Revegtation.

Elhouri, (1985) concluded that, land restoration and revegetation is carried out through execution of corrective measures on land where the degradation has occurred. The current measures usually executed at different levels as follows:

### 2.8.1On cultivated land:

This includes three methods:

**-a**) Agro-silvi Cultural methods:

These are practiced to restore the soil fertility. The traditional system under rain fed condition, is to restore the loss of fertility through bush fallow system.. The fallows systems are not protected and animals graze on them and they receive added fertilization from the dung of animals.

**-b**) Shelter belts:

These are used to protect both irrigated and rain fed farms. Their main function is to protect valuable agricultural land, and irrigation canals from creeping sands. Shelter belts reduce wind velocity, improve the micro-climate and increase life stock yields. `The species used are mostly Eucalyptus, *casuarina* sp, *populus* and *prosopis.* (Elhouri,1999).

**-c**) Plantations:

On seriously degraded irrigation/rain fed crop land salinization is of common occurrence in irrigated lands in some countries, plantation, were established in some of those degraded lands to bring them back to production. Plantations of *Eucalyptus microtheca* and *Acacia*. *senegal* were established in the Gezira and Central clay plain of Sudan..

### 2.8.2 On rangeland:

Degradation of range land is mainly due to over-grazing. Corrective measures carried out are:

- Total protection by fencing and thus restoring the vegetation.
- Seeding of palatable indigenous species, mostly of grass seedlings of various bushes and trees are planted to restore the range.
- Establishment of fire-lines in the dry savanna zones.

### 2.8.3 On forest and wood lands

Fires are considered a cause of degradation in dry savanna zone and fire lines are established along the boundaries of forest reserves.

The objectives of plantation are generally the supply of fuel wood and poles.

### 2.8.4 **On bare land**

Sand and sand dune fixation, when erosion reaches an acute levels and when sand starts to move and threatens habitation, establishment, roads and agricultural lands, Sand dune fixation is carried out, *prosopi and acacias* are used in Sudan.(Bayoumi,1983).

## 2. 9 Land Degradation in Sudan.

### Historical aspect.

Sudan with an area of 2.5 million $Km^2$, falls between longitudes $22^o$ and $38^o$ East and latitudes $3^o$ and $22^o$ North. The country is divided into 26 states, 16 in the North and 10 in the South.(. Musa and Musa,2001)
The National Drought and Desertification Unit [NDDU,1993] surveyed the affected areas in the Sudan covered 13 out of 26 states and it was found that the total area affected by desertification amounts to 1.259.751 $Km^2$, i.e. 50% of the total area of the country.

The exceptions were the states of the south Darfur, south Kordofan, the Blue Nile and the Southern states.

Five classes of desertification were identified in Sudan, the very severe class stretches south the desert over an area of 60.000 $km^2$, followed by severe class(45.000 $Km^{2)}$, the moderate class is of 54000 km square, the slight class is of 56.000 $Km^{2,}$ and the very slight one south of latitude $12^o$ N covering an area of 236,000 km square

The most destructive effects of human activities which are Leading to natural resources degradation in Sudan result from extensive rainfall farming or marginal land, overgrazing ,wood cutting, deforestation, uprooting of shrubs ect. The widely Spread form of land degradation in the country are vegetation degradation and soil degradation.

### 2.9.1 Firstly: vegetation degradation.

Degradation of vegetation takes two main forms**:**

Form involves a reduction in the over all density of vegetation cover, as represented by the biomass (the amount of vegetation material per unit area) and the proportion of land covered by vegetation.

This reduction takes place when trees are cleared for cropping and grazing, cut down for fuel wood or fodder or range land are over grazed (Grainger,1990).

Form involves a change to a less productive type of vegetative cover, involving a modification in species composition, and possibly also in the general types of plants growing in an area.

On over grazed range lands, for example perennial grasses may be replaced by less palatable annual grasses and thorny stunted shrubs, both of which are characteristic of the less productive ecosystems of drier climate.

Both forms of vegetation of degradation can also occur on over cultivated crop land (Grainger, 1990).

#### 2.9.1.1 Factors affecting vegetation degradation:

Mustafa (2007) reported the following to be considered **;**

**a)**: **Demography**: the accelerating growth rate of the population, particularly pastoralists, and their herds of cattle, sheep, goats and camels increased animal and human pressure around watering points and a settlement protecting natural resources and a good strategy for their enforcement is essential for conserving the natural vegetation.

**B)**: **Laws and Legislation**:

The presence of laws and legislations for protecting natural resources and a good strategy for their enforcement is essential for conserving the natural vegetation. Although there are sufficient laws and legislations, there are many loopholes coupled with a weak enforcement system..

**c)**: **Poverty**:

Poor communities in rural dry areas depend on their fragile eco-system for sustenance.

They rely on the natural vegetation for making homes, animal enclosures and for provision of energy. Because of poverty, they are deprived from the use of modern technical and pushed into the vicious circle of poverty.

**d)**: **Horizontal expansion in mechanized rain-fed agriculture**:

Dregne (1985) stated that mechanized rain-fed agriculture by its very nature, poses serious problems for soil conservation and management.

These problems include:

1- Stripping of natural vegetation for cropping.

2-The soil remains bare and therefore subject to soil erosion.

3- Drought tolerant crops are selected for planting, and mono-cropping is practiced.

4-Fertilizers are not applied.

**e**): **Improvement of Animal Health Services**:

The development of veterinary services and water points in rangeland coupled with poor range management and lack of near by markets results in high growth rate of animal population, overgrazing and land degradation.

**f)**: **Government Commitment:**

The government should be committed to reservation of natural resources in term of:

1- Development of natural strategy and action Plan (NSAP) for sustainable use of natural resources.

2- Including of NSAP in the priority list of the natural development plan.

3- Allocating of adequate funds for NSAP implementation.

4- Strengthening the in institutions which are directly responsible for the implementation of NSAP.

5- Involving other stake holders through a popular participate mechanism.

### 2.9.2 Secondly: Soil Degradation

Sudan's Soil Conservation Committee (1994) concluded that, soil degradation and desertification that has occurred since 1944, and continues to occur up to the present are mainly attributed to general land misuse rather than to major climate changes (Ali, 1999).

Five types of soil degradation have been identified in the Sudan according to Abdel Ati,( 2002) wind erosion, water erosion, inflood plain areas, depletion of soil fertility, salinity and alkalinity.

#### **2.9.2.1 Wind Erosion**:

It is particularly prevalent north of latitude 14$^{o}$ N, but in Kordofan, sand is extending south to latitude 10 N, where advancing desert sand threatens most grazing lands. Due to the destructions of the natural vegetation cover through tree cutting, over grazing and fires, about 20% of the latitude 12$^{o}$ – 14$^{o}$ N area has changed in to shifting sands especially around towns and villages.

#### 2.9.2.2 Water Erosion:

Its effect on soil is regarded as serious in equatorial in the south , Gebel Mara and Nuba mountains in the west and the areas south east of Gadarif town in eastern Sudan. Excessive erosion in Equatoria has primarily been caused by the destruction of vegetation cover by fires or clearance for cultivation.

Cultivation crops is practiced on sloping land which, under condition of heavy rains and with out proper soil conservation measures, leads to the leaching of fertile soil.

Water erosion is also problematic in the sandy areas of southern Kordofan and Darfour where repeated cultivation of certain crops is prevailing.

**2.9.2.3 Flooding**:

Flooding is regarded as the main factor causing soil degradation in regions of Upper Nile and northeast of Bahr-elJebel state. About 20% of these areas become marshy during the rainy season (June to September) and the rest become excessively wet.

The problem is exacerbated by river flooding, the slow draining of water caused by the flat relief and the way rainwater collection practiced. Abdel Ati ( 2002) stated that though flooding hinders cropping in the flooding plain during flood season, it also creates suitable conditions for cropping after flood. Land sliding (Haddam ) is also a major problem caused by the weak soil structure and high velocity of the river in Northern and River Nile States.

**2.9.2.4 Depletion of Fertility**:

Soil in Sudan is generally poor in mineral contents and its fertility has seriously and very rapidly been depleted all over the country.

Fertility depletion is more evident in areas under rain-fed cultivation, especially in Kassala, South Kordofan and Blue Nile States.(Abdel Ati,2002).

Fertility depletion in these areas is so high, that average yields are estimated to have dropped by over 50%.

**2.9.2.5 Salinity and Alkalinity**:

It is known that irrigation reduces alkalinity. Even the slowest movement of water (0.2 – 0.5 m/h) is sufficient to leach the solid so that no salinity occurs. However, some irrigated areas a long the Nile in northern parts of Sudan (around Dongla area) are affected by low level salinity. Even here, the soils affected could be reclaimed easily through leaching (.Abdel Ati,2002).

**2.9.3 Consequences of vegetation degradation:**

Mustafa (2007) stated that, in the Sudan, the natural vegetation consisting of woody species and grasses, herbs and shrubs, is degraded by various processes such as: deforestation for establishing mechanized rain – fed farming and, or for settlement, exploitation as a source of energy and construction material, suppression and destruction by uncontrolled bush fires and commercial logging.

Vegetation degradation has many adverse impacts mainly at:

1. On site level
2. Off site level
3. National level

**2.9.3.1 On-site impacts**:

These include the following:

1 .Enhancement of soil loss by soil erosion due to direct impact of raindrops and run off on bare land.

2 .Loss of a continuous source of organic matter, which act as a source of nutrients and cementing agent for binding primary particles into stable aggregates.

3 .Degradation of soil structure and hence destabilization of soil.

**2.9.3.2 Off- site impacts**:

These include the following**:**

1 -Exposing the land for excessive temperatures and desiccating winds and thus deteriorating the micro climate of the area.

2 -Depriving the local community from the economic forest byproducts.

#### 2.9.3.3 National Impacts:

These include the following as pointed by Mustafa (2007 );

1- Reduction of medicinal plants and other economic byproducts.

2- Contributing to adverse Climate change.

3- Modification of energy distribution and relative humidity resulting in reduction of rainfall.

4- Reduction of biodiversity .

The overall impact of these effects is degradation of the physicochemical properties of the natural resources leading to loss of soil fertility, lowering of crop yield and reduction of economic income.

### 2.9.4 Efforts to combat desertification and land degradation:

Sudan has signed all the treaties, declarations and agreements since 1960s and participated in UNCOD,1977.Also it has followed up meeting in1984 where desertification was declared to the future.

In 1991, the Coordination Unit for Combating Drought and Desertification prepared guidelines for the National plan for Combating Drought and Desertification. This national programme included 12 national project and 12 regional/ international project. The projects were distributed among the concerned government units, Forestry Range and Pasture, Animal production, Wildlife, Energy and Cooperating units such as National Council for Research, Institute of Environmental Studies, Higher Council for

Environmental and National Resources, related ministries and organizations.

Sudan has ratified the (UNCCD) in 1995, and prepared the National Action Plan for Combating Desertification in 2002 (Salih,2007).

Bayoumi (1983) indicated that, combating desertification is long-term activity which is very expensive. Rewards are not immediate but future effects are rewarding. If we want to succeed in desertification control, both the government and the people of the Sudan have to be serious about it.
Very drastic measures are needed, some of these are:-

-The government has to halt expansion in mechanized agriculture, both irrigated and rain fed for few years and to spend the money on desertification control.

-Drastic conservation, measures are to be introduced in the form of large skill reservation, villages and town perimeter fencing and guarding, legislation amendments and enforcement of activities strengthened.

-Domestic animals have to be reduced and grazing controlled, endangered regions completely cut off.

-Fires have to be prevented. The people, the armed forces and the regional Government have to co-operate.

-Provision of water points have to be restricted until conditions are improved.

-Reforestation of denuded areas and capacity building.

-Creation of a strong agency for the control, coordination and monitoring of desertification and land degradation.

# CHAPTER THREE
# MATERIALS AND METHODS

**3.1 Physical characteristics of the study area**:

**3.1.1 Location**: ELRawakakeeb dry land region occupies the area south west Omdurman, some 3 5-40 km west the River Nile. It lies between latitudes 15:2,15:36 N and longitude 32:0,32:10 E and altitude of 420 meters above the mean sea level.(EL Hag *et al.*, 1994).Image of the study area is shown on page 36.

**3.1.2 Area**: ELRawakeeb development project was established during the year 1969/1970 as mentioned by Salih (1977), with an objective targeted using ground water for growing vegetables and fodder to sustain pastoralists besides preventing desert encroachment. The project area was 30 feddans and later expansed to 110 feddans in addition to 40 feddans outside the fence . Due to fmancial and management problems, the project was abandoned and almost covered by sand. 1n1992, EL-Rawakeeb Desertification Research Station was established in the project area.

**3.1.3 Climate**: According to Walsh (1991), EL-Rawakeeb lies in tropical semi - arid region whose climate is characterized by a short rainy season ( July-October) and high evaporation potential. The relative humidity values are low and thus indicate the general aridity of the area. Air temperature fluctuates and shows a marked rise (47C°) in May and drops in August due to incidence of the rain. Average soil temperature is 40 C° while average moisture is 12.5% (ELHag *et al*., 1994).

**3.1.4 Soil:** ELRawakeeb soil analyses showed that the relative proportions of different soil particles follow the order: sand, silt and clay with sand comprising the highest proportion. Chemically, EL-Rawakeeb soil is generally alkaline, very poor in nitrogen and carbon, moderate in its bicarbonate and potassium contents and rich in its sodium, calcium and chloride contents (EL Hag *et al.*, 1994). According to the soil taxonomy (USDA, 1975) the soil falls in the order of Aridisols, mixed Koalintic isohyper thermic Gypsic or Typic camborthid.

**3.1.5 Vegetation**: Ahmed (1997) reported that because of high degree of temperature, scarcity of rainfall, natural vegetation is scattered, however, Acacia species are dominant beside some annual shrubs and grasses which grow in rainy season. Recently, there are two rows of eucalyptus and *Acacia mellifera* established as shelter belts.

**3.1.6 Sand dunes**: The strong windstorms resulted in sand dunes formation that scattered all over the west part of the project. Three distinct sand dunes are recognized along and opposite irrigation ditch having the following dimensions (length and height respectively). L07mx 2.l0m, 66mx3.30m and 15x3.60m.(Field survey,2008). The sand dunes are shown in plates (1-5).

**3.1.7 Land use system**: Land use system is mainly pastoral. The traditional agriculture activities are usually carried out. Fodder crops, vegetables and shelter belts are cultivated and irrigated artificially (Ayers and Westeot, 1985).

**3.1. 8 Water resources**: People depend on underground water from bore holes and rainfall water for their use and animals. There were three bore holes in the project area to pump water; namely North East, South East and West bore holes (Agabna *et al.,* 2002). But now only the South East bore hole is on work, the others, are no longer used. (Field Observation survey, 2008).

**3.2 Sampling and analysis:**

**3.2.1 Soil analysis:** Soil samples were collected by Augor from four sites (A1 to A4 ).

A1 : East site of the project area (virgin land).

A2 : North site of the project area .

A3: West site of the project area .

A4: Middle site of the project area .

The distances between augor were 50 m.The augor covered the northern part of the project area. Thirty six bulk soil samples were collected from three successive depths (0 to 0.3 m, 0.3 to 0.6m, 0.6 to 0.9 m) from locations covering the main soils of the project area. Each soil sample was air-dried thoroughly mixed, crushed and passed through a 2 mm sieve . The analysis includes the following parameters:

• Particle - size analysis was carried out by hydrometer method.

• The electrical conductivity of the saturation extract (EC. ), soluble cations ( $Na^{+}$ , $Ca^{++}$, $Mg^{++}$, $K^{+}$ ) were determined according to the standard procedure of U.S salinity laboratory staff (1954). pH of saturate paste and soluble anions ($CO_3^{-2}$, $HCO_3^{-1}$and $Cl^{-1}$) were also determined.

• Sodium Adsorption Ratio (SAR), and Organic Matter (OM) were calculated according to the following equations:

- $SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$

- OM = 1.274 X organic carbon

The properties of the soil and water are tabulated.

**3.2.2 Water analysis:** Water sample was taken from the South East bore hole of the project and analyzed to determined cations ($Na^{+1}$, $Ca^{2+}$, $Mg^{2+}$ and $K^{+}$).And anions ($CO_3^{-2}$, $HCO_3^{-1}$ and $Cl^{-1}$). pH and SAR according to (USSL, 1954 ).

### 3.2.3 Statistical analysis:

Data subjected to analysis of variance and significance among means was detected using the Duncan Multiple Range Test.

# CHPTER FOUR

# RESUTS AND DISSCUSION

## 4.1 Soil Characteristics

### 4.1.1 Mechanical analysis of the Soil from different sites and depths.

#### 4.1.1.1 Particle -size distribution in site A1 .

The data in Table (1) clearly show that the regular distribution of all fractions , and the sand particles were the highest (70.8% ) followed by clay (25.8%) and silt (15,8% ). This trend indicated in other samples that reflected in Tables ( 2 , 3 and 4). In general the data show that the sand fraction was highest in the top layer and lower but almost uniform in the sup-layers. The texture was sand in all layers.

**Table(1): Percentage soil particle-size distribution and texture in A1 .**

| Sample depth(m) | Clay | Silt | Sand | Texture |
|---|---|---|---|---|
| 00 – 0.3 | 20 | 9.2 | 70.8 | Sand,Clay,Loam |
| 0.3 – 0.6 | 23.3 | 15.8 | 60.8 | Sand, Clay, Loam |
| 0.6 – 0.9 | 25.8 | 15 | 60 | Sand, Clay, Loam |
| Total Mean | 22.9 | 13.3 | 64 | |

#### 4.1.1.2 particle- size distribution in site A2:

Sand particles in site A2 was only fraction that decreased regularly along the depth (76.3% , 73% and 72.8%) with total content reached , 73.8% followed by clay 16% and silt 10% . Clay content in this site was the least among all sites as shown in table 2.

**Table (2) : Percentage soil particle- size distribution and texture in (A2)**

| Sample depth(m) | Clay | Silt | Sand | Texture |
|---|---|---|---|---|
| 00 – 0.3 | 12.5 | 11.2 | 76.3 | Sand,ClayLoam |
| 0.3 – 0.6 | 18.8 | 8.8 | 73 | Sand,Clay,Loam |
| 0.6 – 0.9 | 17.2 | 10 | 72.3 | Sand,Clay,Loam |
| Total Mean | 16 | 10 | 73.8 | |

#### 4.1.1.3 particle -size distribution in site A3.

Results presented in Table 3 and Table 4 showed similar soil particles distribution through depth and also in their amount. Total sand content in site A3 , was 64.7% while it was 61.9% in site A4 , and decreased with depth. However ; the total clay content was the highest in site A3 (22.1%) and (19.7%) inA4 and increased with depth.

**Table (3): Percentage soil particle- size distribution and texture in (A3)**

| Sample depth(m) | Clay | Silt | Sand | Texture |
|---|---|---|---|---|
| 00 – 0.3 | 18.3 | 11.7 | 70 | Sand,Clay,Loam |
| 0.3 – 0.6 | 24.1 | 14.1 | 62 | Sand,Clay,Loam |
| 0.6 – 0.9 | 24.1 | 13.3 | 62.5 | Sand,Clay,Loam |
| Total Mean | 22.1 | 13 | 64.7 | |

#### 4.1.1.4 particle- size distribution in site A4 :

particle size analysis indicated that content of clay was higher in the lower depth (0.6 to 0.9) in site A4 and for all site of the project area .

This pattern could be due to the horizontal variation caused by erosion , which exposed different depths at different locations of the project . Total silt content was the highest in this site (18.3%).

**Table (4) : Percentage soil particle- size distribution and texture in (A4)**

| Sample depth(m) | Clay | Silt | Sand | Texture |
|---|---|---|---|---|
| 00 – 0.3 | 12.5 | 10 | 77.5 | Sand,Clay,Loam |
| 0.3 – 0.6 | 22.5 | 23.3 | 54.2 | Sand,Silt,Clay |
| 0.6 – 0.9 | 24.2 | 21.6 | 54.2 | Sand,Clay,Loam |
| Total Mean | 19.7 | 18.3 | 61.9 | |

The over all mean sand content was 66.3% , clay content was 20% and silt 14% . The standard deviation (SD) and co-efficient of variation (CV) from top soil downwards ranged from 4.48 to 4.92, 56 to 24 , respectively

**Table (5) : The over all Mean of Mechanical analysis of the soil samples.**

| Soil depth .(m) | Particle -size distribution % | | | Std. Deviation | Variance |
|---|---|---|---|---|---|
| | Sand | Silt | Clay | | |
| 00 – 0.3 | 74a | 11a | 16a | 4.48a | 56.06a |
| 0.3 – 0.6 | 62b | 16a | 22b | 7.11a | 16.93b |
| 0.6 – 0.9 | 63b | 15a | 23b | 4.92a | 24.28ab |
| Total | 199 | 42 | 61 | 16.53 | 97.27 |

- All figures are means of twelve replicated samples
- Values followed by the same letter in the same column are significantly different at the 5% level of probability using Duncan multiple range test The mean silt content ranged from 11% - 15 % while the mean sand content ranged from 74% - 63 % . Results of grain size analysis generally confirm the field observation and consistent with results of Salih (1975).

### 4:1:2 Chemical analysis of different depths :

#### 4:1:2:1 pH , EC and SAR in site A1

The pH value in all sites was high as indicated in Tables (6 , 7,8 , and 9) . In site A1 , pH ranged from 6.6 to 6.3 and seemed to be varied with depth . SAR value in this site increased with depth from 0.3 to 0.6 to 2.4 , with total value reaching 1.1%.

**Table (6): mean of pH , EC and SAR in ( A1) .**

| Sample depth (m) | pH | EC (dS/m ) | SAR |
|---|---|---|---|
| 00 – 0.3 | 6.6 | 0.39 | 0.3 |
| 0.3 – 0.6 | 6.3 | 0.75 | 0.6 |
| 0.6 – 0.9 | 6.5 | 0.5 | 2.4 |
| Total Mean | 6.4 | 0.55 | 1.1 |

#### 4:1:2:2 pH , EC and SAR in A2 .

Table (7) reveals that , pH slightly decreased with depths (6.8,6 and 6) downwards . This indicated that, site A2 is less alkaline and less saline (EC equals 0.5).

**Table (7): mean of pH , EC and SAR in ( A2) .**

| Sample depth (m) | pH | EC (dS/m) | SAR |
|---|---|---|---|
| 00 – 0.3 | 6.8 | 0.55 | 4.5 |
| 0.3 – 0.6 | 6.0 | 0.37 | 0.17 |
| 0.6 – 0.9 | 6.0 | 0.55 | 0.05 |
| Total Mean | 6.2 | 0.48 | 1.57 |

**4:1:2:3 pH, EC and SAR in A3:**

Table (8) reveals that , site A3 has mean value of pH (6.8) ,SAR (1.5) and EC less that one which indicated no any evidence of salinity .

**Table (8): mean of pH , EC and SAR in ( A3) .**

| Sample depth (m) | pH | EC (dS/m) | SAR |
|---|---|---|---|
| 00 – 0.3 | 6.8 | 0.54 | 2.0 |
| 0.3 – 0.6 | 6.8 | 0.41 | 1.0 |
| 0.6 – 0.9 | 6.7 | 0.59 | 1.5 |
| Total Mean | 6.8 | 0.51 | 1.49 |

**4:1:2:4 pH , EC and SAR in A4:**

Site A4 , has the highest value of pH (7.2) following by site A3 (6.8) , site A1 (6.4) and site A2 (6.2) , this results confirmed that , site A4 has high values for pH ( 7.2) , EC (0.5) and SAR (3.2) compared to the other sites.

**Table (9): mean of pH , EC and SAR in ( A4) .**

| Sample depth (m) | pH | EC (dS/m ) | SAR |
|---|---|---|---|
| 00 – 0.3 | 7.3 | 0.52 | 2.7 |
| 0.3 – 0.6 | 7.2 | 0.44 | 2.8 |
| 0.6 – 0.9 | 7.2 | 0.64 | 4.2 |
| Total Mean | 7.2 | 0.53 | 3.2 |

The over all pH value Table (10) ranges between 6.8 to 6.6 from surface and downwards due to irrigation water , evaporation and movement of salt upward. This result showed that soil depth has no effect on the value of pH.

**Table (10) : Mean of pH ,EC and OM in different depths :**

| Depth(m) | Properties | | |
|---|---|---|---|
| | pH | EC (dS/m) | OM(%) |
| 0.0 – 0.3 | 6.8 | 0.5 | 0.38 |
| 0.3 – 0.6 | 6.6 | 0.5 | 0.46 |
| 0.6 – 0.9 | 6.5 | 0.6 | 0.45 |

The electrical conductivity (EC)values ranged between (0.5to0.6) dS/m in all sites ( A1 , A2 , A3 , and A4 ) indicated that the soil was not saline.

The EC value offered evidence suggesting that the irrigation is less saline

The organic matter content (OM) Table (10) is not fixed among depths because of climatic changes, diversification of vegetation cover , generally it is low due to high temperature of the arid region there for the aridity conditions increase its decomposition.

Mean organic matter content was 0.38 for the first depth with a range of 0.46 to 0.45 downwards .The second depth ( 0.3 to 0.6 ,m ) had significantly greater organic matter than the first depth ( 0.0 to 0.3m) . The overall standard deviation and variation values were 6.56, and 39.7.

The soluble cations and soluble anions Tables (11 , 12 , 13 . and 14) did not exhibit any particular pattern .

**4:1:2:5 Soluble cations and ions in site A1:**

Data shown in table 11, indicated the dominance of $K^+$ and $Na^+$ among soluble cations in site A1 with total values reached (10) for $K^+$ and (5) for $Na^+$.$Mg^{+2}$ tends to decrease with depth from 1.8 to 1.2 to 1.1 meq/1 respectively.

**Table (11): Mean Exchangeable cations and soluble anions (meq/l) in(A1).**

| Sample depth (m) | Cations | | | | Anions | | |
|---|---|---|---|---|---|---|---|
| | $Na^{+}$ | $K^{+}$ | $Mg^{+2}$ | $Ca^{+2}$ | $CL^{-1}$ | $HCO3^{-1}$ | $CO3^{-2}$ |
| 00 – 0.3 | 2.4 | 4.2 | 1.8 | 1.3 | 1.7 | 0.66 | Nill |
| 0.3 – 0.6 | 0.8 | 1.7 | 1.2 | 1.7 | 3.3 | 0.6 | Nill |
| 0.6 – 0.9 | 1.7 | 4.1 | 1.1 | 1.1 | 2.8 | 0.6 | Nill |

**4:1:2:6 Soluble cations and anions in A2:**

Site (A2), indicated similar values for both $Mg^{+2}$ and $Ca^{+2}$ cations about (14) meq/1. Whereas $CL^{-1}$ value reached 10 meq/L. Calcium ($Ca^{+2}$) increased along depth with mean ranging form 1.1 to 7.3 meq/L; this phenomenon is perhaps due to – saline irrigation water.

**Table (12): Mean Exchangeable cations and soluble anions (meq/l) in(A2).**

| Sample depth (m) | Cations | | | | Anions | | |
|---|---|---|---|---|---|---|---|
| | $Na^{+}$ | $K^{+}$ | $Mg^{+2}$ | $Ca^{+2}$ | $CL^{-1}$ | $HCO3^{-1}$ | $CO3^{-2}$ |
| 00 – 0.3 | 4.3 | 2.8 | 3.5 | 1.1 | 2.7 | 0.7 | 0.13 |
| 0.3 – 0.6 | 0.3 | 0.1 | 4.6 | 5.3 | 2.6 | 0.9 | Nill |
| 0.6 – 0.9 | 1.0 | 0.9 | 6.1 | 7.3 | 4.5 | 0.66 | Nill |

**4:1:2:7 Soluble cations in A3 :**

Magnesium and Calcium ( $Mg^{2+}$ & $Ca^{2+}$ ) dominated over Sodium ($Na^{+}$) cations with mean value (8.4) for $Mg^{+2}$ and (9.1) for $Ca^{2+}$ , this could be as a result of high cation exchangeable capacity exchangeable capacity (CEC) due to soil parent material .

The distribution of soluble anions also showed regular pattern. There existed however , slight difference between depths. This difference reflected in chloride ($Cl^-$) that increased with depth from 6.2 to 13.6 and decreased to 4meq/1.

Chloride anion was dominant in all depths followed by bicarbonate (0.6) meq/L.

**Table (13): Mean Exchangeable cations and soluble anions (meq/l) in (A3).**

| Sample depth (m) | Cations | | | | Anions | | |
|---|---|---|---|---|---|---|---|
| | $Na^+$ | $K^+$ | $Mg^{+2}$ | $Ca^{+2}$ | $CL^{-1}$ | $HCO3^{-1}$ | $CO3^{-2}$ |
| 00 – 0.3 | 0.8 | 5.0 | 2.4 | 3.8 | 6.2 | 0.66 | Nill |
| 0.3 – 0.6 | 1.1 | 0.65 | 2.8 | 2.5 | 4.0 | 0.66 | Nill |
| 0.6 – 0.9 | 2.66 | 3.0 | 3.2 | 2.8 | 13.6 | 0.66 | Nill |

**4:1:2:8 Soluble cations and anions in A4 :**

All soluble tend to increase with depth in site A4, but values of ($CO3^{-2}$**)** appeared through all depth $CL^{-1}$ value (11) meq/1 is meager compared to (24) meq/1 in site A3.

**Table (14):Mean Exchangeable cations and soluble anions (meq/l ) in (A4).**

| Sample depth (m) | Cations | | | | Anions | | |
|---|---|---|---|---|---|---|---|
| | $Na^+$ | $K^+$ | $Mg^{+2}$ | $Ca^{+2}$ | $CL^{-1}$ | $HCO3^{-1}$ | $CO3^{-2}$ |
| 00 – 0.3 | 0.11 | 1.6 | 0.7 | 1.3 | 5.0 | 0.8 | 0.13 |
| 0.3 – 0.6 | 3.1 | 3.3 | 1.3 | 2.2 | 2.2 | 066 | 0.2 |
| 0.6 – 0.9 | 4.8 | 3.2 | 3.93 | 2.8 | 2.7 | 0.66 | 0.2 |

Carbonate anions were almost absent in most soil depths because of their transformation .

The over all mean of chemical analyses of the soil samples is illustrated in the following table15 bellow .

**Table (15): Mean of Chemical analysis of the soil samples.**

| Soil depth (m) | Soil properties | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | OC% | OM% | $Na^{+}$ | $K^{+}$ | $Mg^{+2}$ | $Ca^{+2}$ | $CL^{-1}$ | $HCO_3^{-1}$ | $CO_3^{-2}$ | EC dS/m | SAR | Total |
| (0- 0.3) | 7 | 0 | 0 | 4 | 2 | 2 | 2 | 4 | 1 | 0 | 1 | 2 | 25 |
| (0.3-0.6) | 7 | 0 | 0 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 0 | 1 | 21 |
| (0.6-0.9) | 7 | 2 | 0 | 3 | 3 | 4 | 4 | 6 | 1 | 1 | 1 | 2 | 34 |
| Total | 21 | 2 | 0 | 8 | 6 | 9 | 9 | 13 | 3 | 2 | 2 | 5 | 80 |

## 4:2 Water analysis :

The water quality parameters of the South East bore hole are presented in table (16).

**Table (16) :South East borehole water quality parameters of EL- Rawakeeb**

| Cations (meq/l) | | | | | Anions meq/l | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | $Na^{+}$ | $K^{+}$ | $Mg^{+2}$ | $Ca^{+2}$ | $CL^{-1}$ | $HCO_3^{-1}$ | $SO_4^{-2}$ | $CO_3^{-2}$ | SAR | EC dS/m | pH |
| 1 | 0.015 | 8.4 | 6 | 7.5 | 6.4 | 1.2 | 15.31 | Nill | 5.77 | 1.351 | 7.8 |
| 2 | 0.013 | 7.9 | 6 | 7.4 | 6.6 | 1.2 | 14.44 | Nill | 5.02 | 1.35 | 7.8 |
| 3 | 0.013 | 7.8 | 6 | 7.6 | 6.4 | 1.6 | 14.51 | Nill | 4.98 | 1.35 | 7.8 |
| Mean | 0.013 | 8.03 | 6 | 7.5 | 6.47 | 1.33 | 14.75 | Nill | 5.25 | 1.35 | 7.8 |

Generally its clear that , this water can be used for irrigation of most crops with little danger of sodicity ( Hergert and Knudsen , 1997). It showed low value of SAR ( 5.3) and EC (1.4) dS/m .

Since SAR is less than 9 and EC is less than 4 , Ayesrs and Westcot (1985) stated that, such water can be used for animals and poultry production.

**Statistical analysis:** The descriptive statistics for the three successive depths of the soil samples are presented in Tables (17,18 and 19) while their correlations are shown in Figures (1,2,3 and 4).

**Table (17): Descriptive statistics for (0.0-0..3 m) depth.**

| Property | N | Minimum | Maximum | Mean | Std. deviation | Variance |
|---|---|---|---|---|---|---|
| Clay | 12 | 7.50 | 35.00 | 15.933 | 7.457 | 56.061 |
| Silt | 12 | 2.50 | 15.00 | 10.5000 | 3.34392 | 11.182 |
| Sand | 12 | 52.50 | 87.50 | 73.6667 | 9.65150 | 93.152 |
| pH | 12 | 6.10 | 7.40 | 6.883 | 0.42176 | 0.178 |
| EC | 12 | 0.22 | 0.80 | 0.5025 | 09250 | 0.037 |
| SAR | 12 | 0.12 | 7.83 | 2.3763 | 2.90474 | 8.438 |
| OC | 12 | 0.02 | 0.40 | 0.2225 | 0.12031 | 0.014 |
| OM | 12 | 0.03 | 0.68 | 0.3783 | 0.20854 | 0.043 |
| $C1^{-1}$ | 11 | 1.30 | 13.20 | 3.9909 | 3.4691 | 12.035 |
| $HCO_3^{-1}$ | 12 | 0.60 | 1.00 | 0.7333 | 0.13027 | 0.017 |
| $CO_3^{-2}$ | 12 | 0.00 | 0.40 | 0.0667 | 0.15570 | 0.024 |
| $Na^+$ | 12 | 0.01 | 6.78 | 1.8998 | 2.51785 | 6.340 |
| $K^+$ | 12 | 0.14 | 8.61 | 3.6543 | 2.57530 | 6.632 |
| $Mg^{++}$ | 12 | 0.40 | 8.80 | 1.9667 | 2.52527 | 6.377 |
| $Ca^{++}$ | 12 | 0.60 | 8.60 | 2.0167 | 2.15484 | 4.643 |
| Valid N(Iistwise) | 11 | | | | | |

**Table (18): Descriptive statistics for (03-0.6m) depth.**

| Property | N | Minimum | Maximum | Mean | Std. deviation | Variance |
|---|---|---|---|---|---|---|
| Clay | 12 | 15.00 | 30.00 | 22.2083 | 4.11460 | 16.930 |
| Silt | 12 | 7.50 | 25.00 | 15.5417 | 5.94466 | 35.339 |
| Sand | 12 | 50.00 | 77.50 | 62.4167 | 8.36886 | 70.038 |
| pH | 12 | 5.70 | 7.80 | 6.5583 | 0.65845 | 0.434 |
| EC | 12 | 0.13 | 1.16 | 0.4950 | 0.32355 | 0.105 |
| SAR | 12 | 0.01 | 7.93 | 1.1411 | 2.25227 | 5.073 |
| OC | 12 | 0.02 | 0.52 | 0.2683 | 0.16348 | 0.027 |
| OM | 12 | 0.03 | 0.89 | 0.4583 | 0.28084 | 0.079 |
| $C1^{-1}$ | 11 | 0.00 | 4,70 | 2.6909 | 1.48422 | 2.203 |
| $HCO_3^{-1}$ | 12 | 0.60 | 1.60 | 0.7167 | 0.28868 | 0.083 |
| $CO_3^{-2}$ | 12 | 0.00 | 0.60 | 0.0500 | 0.17321 | 0.030 |
| $Na^+$ | 12 | 0.01 | 8.69 | 1.3175 | 2.44733 | 5.989 |
| $K^+$ | 12 | 0.01 | 9.43 | 1.4437 | 2.89475 | 8.380 |
| $Mg^{++}$ | 12 | 0.60 | 11.20 | 2.5667 | 3.00525 | 9.032 |
| $Ca^{++}$ | 12 | 0.60 | 6.00 | 2.9167 | 1.93806 | 3.756 |
| Valid N(Iistwise) | 11 | | | | | |

**Table (19): Descriptive statistics for (0.6 -0.9 m) depth.**

| Property | N | Minimum | Maximum | Mean | Std. deviation | Variance |
|---|---|---|---|---|---|---|
| Clay | 12 | 15.00 | 32.50 | 22.83 | 4.93 | 24.288 |
| Silt | 12 | 7.50 | 25.00 | 15.00 | 5.54 | 30.682 |
| Sand | 12 | 47.50 | 75.00 | 62.58 | 8.48 | 71.902 |
| pH | 12 | 5.40 | 7.50 | 6.542 | 0.68 | 0.464 |
| EC | 12 | 0.16 | 0.98 | 0.57 | 0.29 | 0.086 |
| SAR | 12 | 0.01 | 6.60 | 2.13 | 2.33 | 5.418 |
| OC | 12 | 0.02 | 22.00 | 2.08 | 6.28 | 39.388 |
| OM | 12 | 0.03 | 0.93 | 0.45 | 0.26 | 0.066 |
| $C1^{-1}$ | 11 | 1.50 | 19.10 | 6.49 | 5.57 | 31.009 |
| $HCO_3^{-1}$ | 12 | 0.60 | 0.80 | 0.68 | 0.11 | 0.011 |
| $CO_3^{-2}$ | 12 | 0.00 | 0.60 | 0.05 | 0.17 | 0.0300 |
| $Na^+$ | 12 | 0.01 | 6.26 | 2.52 | 2.34 | 5.462 |
| $K^+$ | 12 | 0.01 | 5.38 | 2.76 | 2.13 | 4.520 |
| $Mg^{++}$ | 12 | 0.04 | 10.20 | 3.58 | 3.09 | 9.574 |
| $Ca^{++}$ | 12 | 0.80 | 8.40 | 3.52 | 2.75 | 7.538 |
| Valid N(Iistwise) | 11 | | | | | |

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

## 5:1 Conclusion:

All physical and chemical quality parameters evaluated in this study were varied through different sites and depths of the project area except for pH value (7) that remained the same through depths ( 0.3 , 0.6 and 0.9 )m and EC value (0.5) that unchanged within sites (Al, A2 , A3 and A4).

The high clay content in the subsoil depth (0.9m) denoted that these sediments increased along depth.

The relatively lower clay content for the upper depth (0.3m) in comparison with the lower depths ( 0.6m and 0.9m) , can be attributed to the horizontal variation within the area . However, the absence of any noticeable clay accumulation at the surface layer indicated that the soil subjected to weak chemical weathering after the deposition . The structure less of the soil matrix and the absence of any change in color, strongly indicated that the soil was subjected to slight weathering after the deposition.

Physical weathering is the characteristic of arid climate such as the climate currently prevailing in the study area. Its worth mentioning that, the high clay content of lower depth suggests that, it’s materials were subjected to intensive chemical weathering prior to the sedimentation This conclusion is in partial agreement with result obtained by (EL Hag *etal,* 1994) who found the soil particles follow the order sand, silt and clay with sand comprising the highest proportion.

Chemically , the soil of the study area is alkaline and very poor in organic carbon , moderate in its bicarbonate and rich in calcium , magnesium and chloride contents. The moderate CEC of this soil is symptom of koalinitic clay mineral of such soil ( ranging between 22-3omeq/l00g.soil).

Prevalent soil degradation processes and problems in the area are largely the result of physical changes For example; strong winds carry soil dust and this wears away exposed soil.

The improper management of the project led to degradation of land and reflected in the acute sand encroachment, accumulation of sand in land of the project. On the other hand , the traditional irrigation method allowed high loss of water. The biophysical indicators show the clear land degradation . The appropriate measures of land use systems with regard to soil and water conservation , suitable shelterbelts and of sand dunes by local plants should be considered in the future . The land use systems by them selves are indicators for monitoring land degradation, desertification and they fall in the following:

Over cultivation.

Over grazing.

cutting.

Bad irrigation methods, etc...

These in the end will lead to declining productivity , which force population displacement or migration.

**5:2 Recommendations**:

great amount of efforts are still to be undertaken to assess land degradation, especially with regard to those quality parameters which are controlled by human. In this regard , there are some points and remarks reached as follows:

• Creation of a strong agency for the control , coordination and of desertification and land degradation.

• Sensitize international and national awareness in order to obtain funds for soil research and particularly for national programs and their priority areas.

• Suitability must refer to use on sustained basis; that is, the use of land must not result in its depletion, e.g. through erosion;

• It is important to understand the changes that take place in the surface layer , in which organic matter and plant nutrients are concentrated.

• Irrigation by ground water needs to be encouraged in suitable areas and embankments could be built across wadis beds to make better use of rainfall water.

• Construction of the suggested canal from the white Nile to the area will maintain the ground water as reserve;

• The natural resources needs to be matched with prevailing social, economic , and health conditions which may be considerably alter production perspectives;

• An extensive study should focus on degradation indicators such as; the force of wind erosion and the type of vegetation cover available in the area.

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