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# Land Degradation Assessment in Rawashda Area, Gedaref State-Sudan "Using Remote Sensing, GIS and Soil Techniques".

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***Abstract-*** The objective of this study is to quantify the lad deterioration in Al Rawasha area in Gedaref State - Sudan. Owing to the availability of vast potential cultivable arable land, good amount of seasonal rainfall, and favourable climatic conditions, Sudan, was qualified to be one of the leading countries in food production worldwide (World Breadbasket). Therefore, rain-fed mechanized farming which was introduced in the 1945 in Al Gedaref area, had rapidly expanded horizontal in the clay plain across the country. But, the development of this type of farming system became a problematic area, particularly in the arid and semi arid zones (GEF, et al., (1999) (Sanyu Consultants inc. (2001). This is because huge vegetation covers was removed without replacement. The situation was aggravated by land misuse (mismanagement, poor agricultural practices, logging, overgrazing, and adoption of inappropriate technology). Consequently, the socio-economic dimensions and environmental quality have been negatively affected. To achieve the above objective, data and information deduced and extracted from fieldwork, remote sensed data, in addition to other sources were used. Remote sensing, GIs and Personal Computer were used to analyze the data. The results of the data analysis indicated that both cultivated and uncultivated lands are degraded but at varied degree. The cultivated soils have more coarse texture and lower fertility and tend to acidity compared to uncultivated soils. Furthermore, the yield of different grown crop showed a trend of fluctuation throughout the study period from 2007 to 2012. Acacia species are found to be dominant tree species beside the unpalatable grazing plant species.

***Index Terms***- Land degradation, Geoinformatics, Crop yield, GIS and Remote Sensing.

## I. Introduction

Land degradation is the process in which the value of biophysical environment is being adversely affected. It also defined as a total deterioration, or total loses of productive capacity of soil for present and future (FAO, 1980). While the term land deterioration more specific definition(s). FAO (2002) defined land deterioration as the loss of production capacity of land in terms of loss of soil fertility, soil biodiversity and degradation of natural resources. Precisely, it is a long term loss of function and productivity of an ecosystem as a result of disturbances from which the land cannot recover unaided (Bai, et al., 2008). Land degradation is a complex. It is a result of various interacting biophysical and human factors. The objective of this study is to identify the causes, understand the mechanisms of land deterioration, the consequences, and produce hard copy of thematic maps which can provide a scientific based solution. However, many studies showed that, land degradation has negative impacts on socio-economic status as well as on environmental settings (Haroun, 2012). There are two main factors contributing to land degradation, namely, the proximate and root causes (underlying driving forces) (Geist, et al., 2004). This; occurs when a process or combination of processes cause a reduction of the potential productivity of land resources, or when the biological productivity decreases under current management leading to a diminishing productivity in the foreseeable future (UNEP, 1992), (prince, 2002). In the study area, land misuse, land misplanning, land mismanagement and adoption of inappropriate technology are the major causes of land deterioration (Sonneveld, 2002, Haroun2007). Anyway, the field data analysis showed a decrease in soil fertility, palatable grazing plant species and yield drop of different cultivated crops. Generally, the increase of both population and animal wealth put more pressure on land resources, as consequences, land deterioration continues. However, various studies displayed that about 40% of the worlds agricultural land is seriously degraded (Ian Sample (2007). Studies by Geist, et al., (2004) on land degradation all over the world showed that agricultural management is the proximate causes associated with desertification in 90% of the cases studied. In Africa, various studies displayed that several countries are seriously threatened by land degradation. The productivity of some lands has declined by 50% due to soil erosion and desertification. Yield reduction in Africa due to past soil erosion may range from 2 to 40%, with a mean loss of 8.2% for the continent (Eswaran, et al., 2001). As a consequence, Africa accounts for 65% of the total extensive degradation crop land of the world (Thiombiano, et al, 2006 Bationo , et al., 2006). According to Lamourdia , et al., (2007), there is an increasing trend of severity and extend of land degradation from the humid zones of the Congo and Zambezi basins (24 to 29%) to the dry areas of the Nile, Niger and lake Chad basins (78 to 86%); and the effects of water and wind erosion are also increasing along these agro-ecological zones. Land degradations in South Asian countries are widespread and have reached a severe degree. The annual loss in productivity is estimated at 36 million tons of cereal (Eswaran, et al., 2001). The main causal is wind, water erosion, water logging and lowering of ground water. The study found that 140 million hectares (43%) of the region's total agricultural land, suffered from one form of degradation or more. Out of this, 31 million hectares were strongly degraded and, 63 million hectares moderately degraded. The worst country affected was Iran, with 94% of agricultural land degraded, followed by Bangladesh (75%), Pakistan (61%), Sri Lanka (44%), Afghanistan (33%), Nepal (26%), India (25%) and Bhutan (10%) [ FAO, and UNEP (1994)]. In Asia, studies reflected that 50% of irrigated soils in Central Asia are Salinized and/or waterlogged (Paroda, 2007). The cause of land degradation is the intensive cropping, mono-cropping, overgrazing, mining, logging, lack of appropriate soil fertility management, and invasive species (UNCCD, 2003). In Australia, about two thirds of agricultural land is degraded by soil erosion, soil salinity, soil acidity and soil contamination Cribb, J (2010). Considering the land degradation on global scale, it is found that the annual loss is about 75 billion tons of soil. Therefore, soil degradation is a serious threat in the United States as well as the world around. It is estimated that the total annual cost of erosion from agriculture in US is about US$44 billion per year (Eswaran, et al., 2001). The main, causes are human activities such as agriculture and deforestation. It is estimated that soil erosion is costing about "$44 billion a year in damage to farmland, waterways, infrastructure, and health" (Kaiser & Proffitt, 2004). It is also predicted that if farmers did not replace the lost water and nutrients, "U.S. crop yields would drop by 8% per year". Moreover, 22,661 species in the United States are threatened (Kaiser, et al., 2004). However, despite the importance of land deterioration, only few data are available. Therefore, it is necessary to carry out this study to obtain accurate, updated and reliable data to enables stockholders, environmentalist, planners and decision makers to select the best options for sustainable land use (Haroun, 2012). Based on the above objective, soil attributes as well as yield of cultivated crops are studied. Integrated remotely sensed and geographical Information System (GIS) technology was used. The results are presented in forms tables, thematic maps and bar charts.

## II. STUDY AREA

Al Rawashda, is located in Gedaref State. It is situated within the latitudes 14º .20´ N and longitudes 35º.40´ E. With total area of 64**,** 280 feddan (Fig1). The area located in the savanna region. It receives an average annual rainfall of 450 mm. The soil is described as cracking clay soil (Harrison et al, 1958). The existing vegetation cover includes bushes, trees and different annual plant species. The dominant tree species includes *Acacia seyal, A. Senegal, A. nylotica* beside other tree species like *Commiphora Africana*, *Bosia senegalensis*. As far as the annual plant species concern, Sudan grass spp., *Cymbopogon spp*. *Sorghum halepense*., *Chorch olitorius, Dactylocetenium aegyptium*, *Striga hermanthica*, *Ipomoea cordofana* , are the most widespread in the study area. However, five (5) land uses are identified, the agricultural land, forestland, rangeland, barren land and residential area. The thick forests and rich ranges of Al Rawasha area have undergone serious deterioration as a result of logging, deforestation and over grazing.

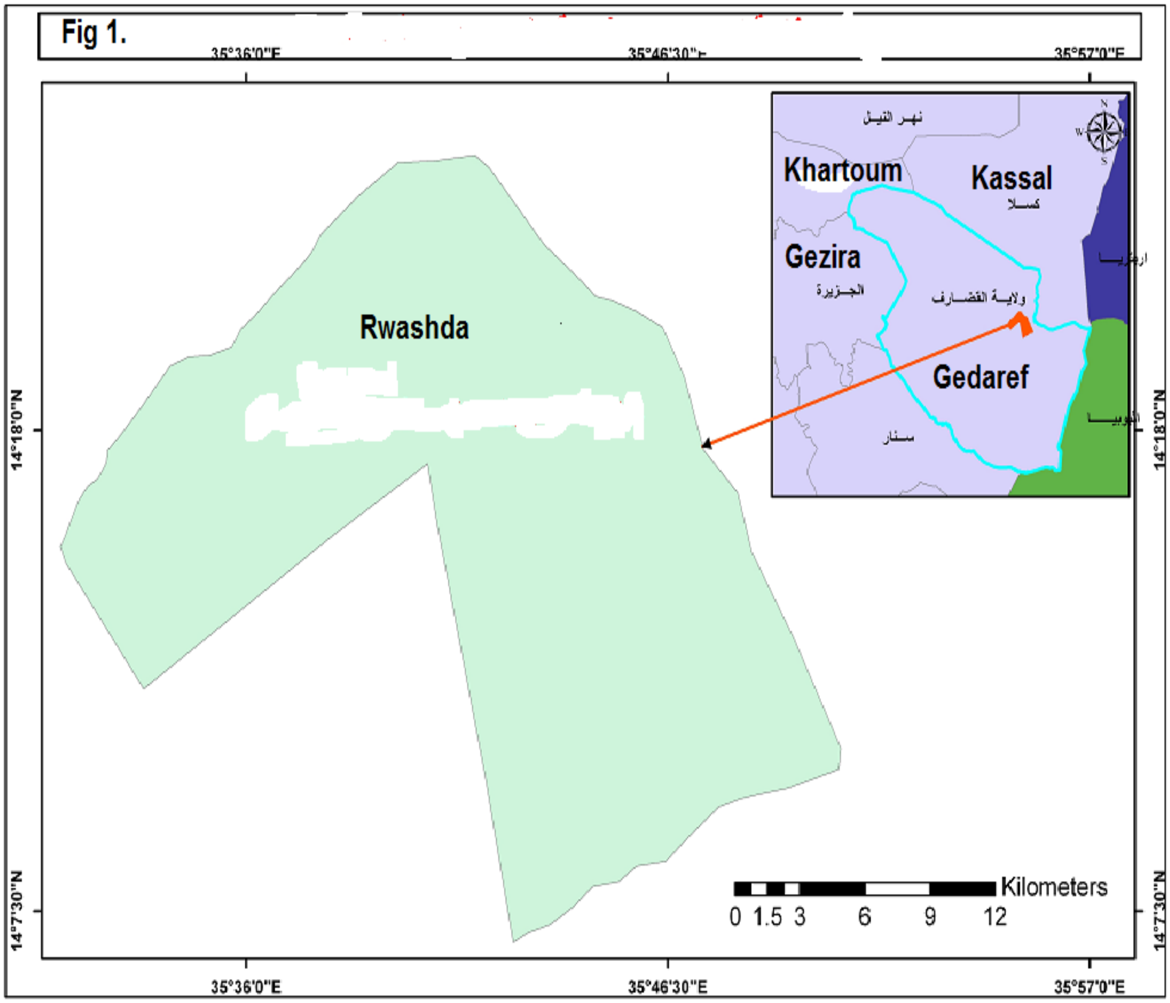


**Fig (1) Location map of the study area.**

## III. METHODOLOGY

- **Remote sensing:**

Field work was conducted during the period from 15 to 25th_ May, 2012. Aided by Global Positioning System (GPS) receivers (Garmin 60C); when check sites were located. Radiometric and image to ground points geometric corrections were conducted. Then, two false colour composite (FCC) subsets images from Landsat TM and ETM dated (2007 and 2012) covering the study area (64280 feddan) were used in this study. Thereafter, the images were analyzed by GIS software.

- **Soil attributes**:

Following the determination of the study area, by Auger, random soil samples were taken from both, cultivated and uncultivated lands. The samples were analyzed in Laboratory of Environmental and Natural Resources Research Institute,-Khartoum-Sudan in 2012). Different soil sample strategies were applied depending on satellite image interpretation, morphological and different physical properties (colour, texture, structure…etc.) to determine:

- Soil Reaction: Soil pH was measured in soil paste using analogue pH-meter JENWAY.
- The Electrical Conductivity (ECe): The electrical conductivity of the saturation extract (ECe) was measured by conductivity meter WAPcm 35 (model cm 35).
- Soil Texture.
- Nitrogen.
- Potassium and,
- Phosphorus.

- **Vegetation attributes measurement:**

Muller method, the so called" The Point-Centred Quarter method" for tree sampling was adopted to determine:

- Types of tree species in the study area
- Dominant tree species in the study area and

Other plant species present in the study area also recorded.

- **Yield of the grown crops:** Yield during 2007 – 2012 is used as an indicator for soil deterioration.

## IV. RESULTS AND DISCUSSION

The results of soil data analysis indicated that most of the soils of the study area are non-saline, slightly alkaline; except some buckets in the middle, top north east, and southern parts of the study area which was slightly saline (Cultivated land) (see figures 2, 3 and table1). Nitrogen, Potassium and Phosphors values indicated that most of the studied areas have lower Nitrogen, Potassium and Phosphors contents. This may be due to water erosion (See Figures 4, 5, 6 and table1).

The spatial variability of ECe for the surface are shown in Figures 2 and table 1 indicating that Soils with values of ECe 1.5 – 3.6 dS/m. This located in the middle, and some eastern parts of the study area.

The results of field work and survey indicated signs of land degradation which might be due to land mismanagement.

The soil Reaction (pH): The analysis of the soil samples revealed that the soil reaction ranged from moderate to slightly alkaline, which is unexpected for soils of arid and semiarid region (see fig 3).

In general, the analysis of soil texture of cultivated land showed various types of soils, these are: Silt loam, Loam, Silty Clay, Silty Clay Loam and silty clay. But the cultivated had greater rate of coarse texture (sand) compared to uncultivated land (Fig. 1). This is may be due to increasing surface water run off and erosion in the cultivated land. As far as the crop yield concern, the average yield of all grown crops is poor, below the world average (Table 2). The reasons may be due to mono-cropping, use of no fertilizer, rainfall irregularity, and poor land management. Similar results were found in Renk area in Upper Nile State and also in different parts of the world (Haroun, 2007). However, adopting some practices had improved the situation. Among these: In Nigeria, study showed that the coarse-textured soils are weak, low productivity, do not retain adequate water and nutrients for sustainable production. They produce poor harvest. By introduction of different field practices, substantial yield increase was obtained (F.K. Salako, 2003). Study under rain fall farming in Faisalabad, Pakistan, reflected that agronomic management practices can improve the soil fertility and crop productivity on sustainable basis. Also, the deep tillage practice with mulch treatments have performed best for soil bulk density, total soil porosity, root penetration resistance and grain yield (Javeed et al., (2013). Another study on long-term effects of management systems on crop yield and soil physical properties of semi-arid tropics of Vertisols indicated that minimum tillage gave high porosity, improved water logging, favoured changes in soil physical, and hydrological properties. Thus, it contributed in increasing and sustaining the crop productivity, which recorded about 5 times higher compared to traditional management system (Pathak, et al., 2011).

Furthermore, the vegetation analysis reflected the domination of *Acacia seyal*, followed by *Acacia mellifera, Acacia nubica* and *Balanites aegyptiaca*. Furthermore, along with the trees, different grasses and other plants species are found which flourish the grazing plants species in the study area.

## V. CONCLUSION AND RECOMMENDATION

The study revealed different signs of land degradation in the study area which is reflected by the changes in soil chemical properties.

The cultivated land showed changes in soil chemical like increase of salinity in some parts and alkalinity in other parts as well as physical properties such as an increase of coarse texture. These changes will have negative impact on soil productivity amd crop yield.

The observed degraded land is due to increased anthropogenic activities as well as natural factors.

Based on these finding the following recommendations can be stated:

1. The reclamation of the slightly saline and/or alkaline pockets of the soils that found in some parts of the study area should be attempted.
2. Application of macro and micronutrients is essential at the following rates:

- Phosphorous is recommended to be applied at the rate of 50 kg / feddan of triple superphosphate (%P = 46% P2O5) applied before sowing. Other sources e.g. diammonium phosphate (DAP= 21% nitrogen) may be used.
- Potassium is recommended to be applied at the rate of 50 kg /feddan before sowing. The recommended source is potassium sulfate to make use of the contained sulfate to lower the pH of alkaline soils which affects the availability of the macro and micronutrients.

3. Effective extension services to be introduced.
4. Introduction of new cropping pattern.
5. To sustain the rain-fed farming, the old design should be changed, modified, redesigned or readjusted so that to address the socio-economic and environmental issues.

3. Mobilization and optimal use of water resources ie. Water harvest and spread techniques. To be adopted.
4. Cultivation of improved varieties.
5. Rehabilitation of range.
6. Immediate action plan towards natural resources (soil, forest, biodiversity, range) conservation is urgently needed

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**Table (1) Results of soil physical and chemical properties of the study area (2012)**

| Sample No. | PH | EC cls mḿ | Total N (%) | P mg/L | K mg/L | Moisture Content | Clay (%) | Silt (%) | Sand (%) | Soil Texture |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.22 | 1.55 | 0.91 | 16.5 | 3.25 | 2.81 | 23.79 | 64.51 | 11.70 | Silt loam |
| 2 | 7.20 | 159.70 | 0.23 | 21.0 | 3.25 | 3.12 | 23.87 | 41.50 | 34.64 | loam |
| 3 | 7.50 | 253.00 | 0.49 | 10.0 | 4.35 | 2.52 | 49.36 | 41.24 | 90.40 | Silt clay |
| 4 | 6.91 | 313.00 | 0. 34 | 18.0 | 1.60 | 2.27 | 29.85 | 51.63 | 18.52 | Silt clay loam |
| 5 | 7.37 | 206.00 | 0.17 | 16.5 | 6.55 | 2.45 | 24.62 | 24.82 | 25.55 | loam |
| 6 | 8.00 | 153.00 | 0.57 | 9.0 | 3.25 | 2.67 | 45.23 | 44.79 | 9.98 | Silt clay |

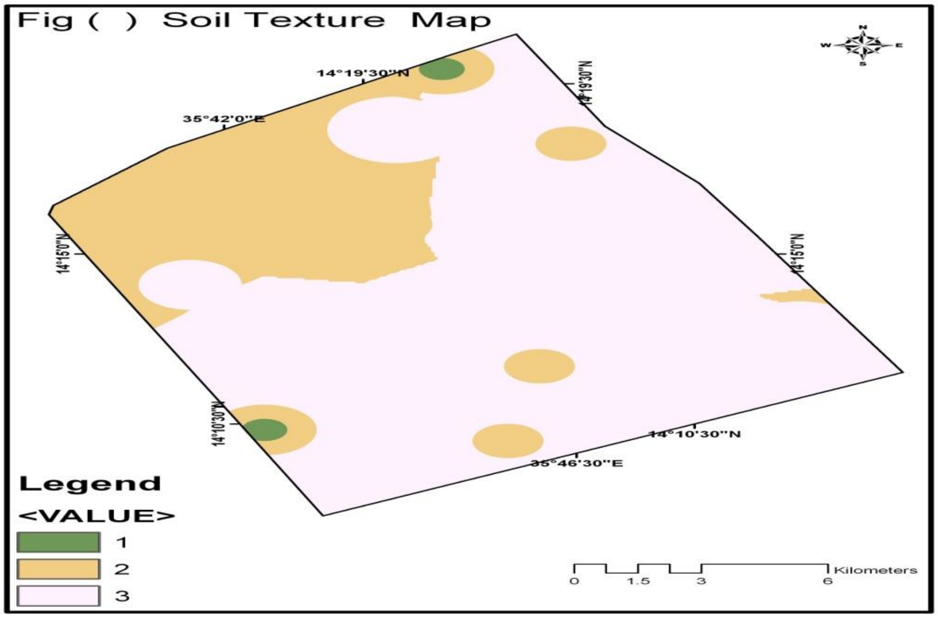


**Figure (2) ECe values**

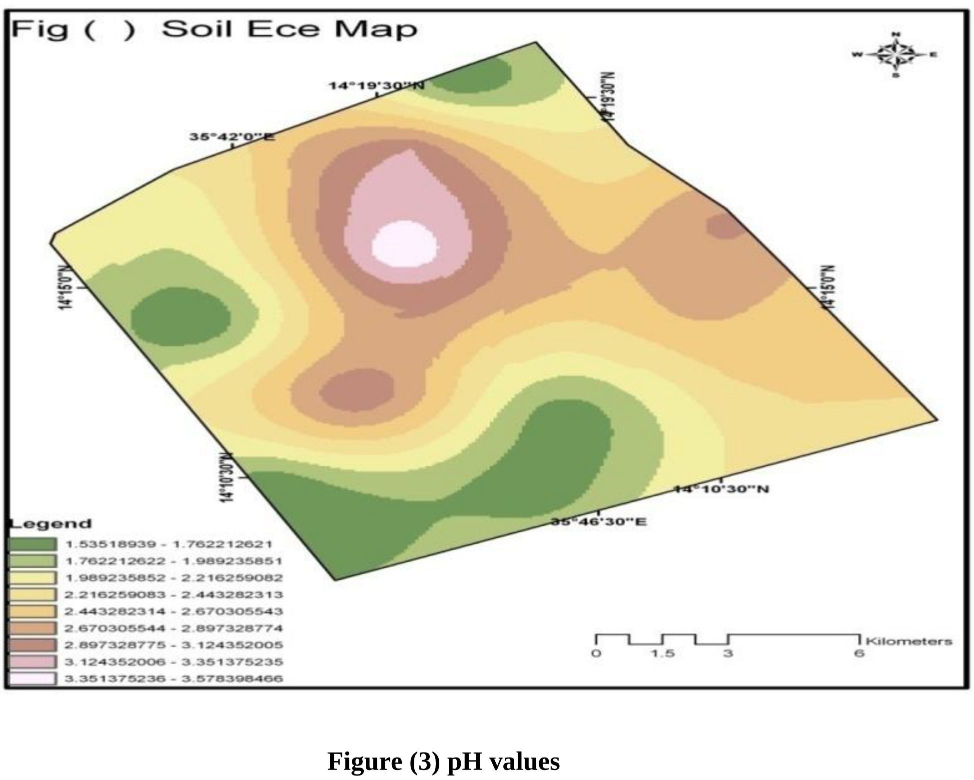


**Figure (3) pH values**

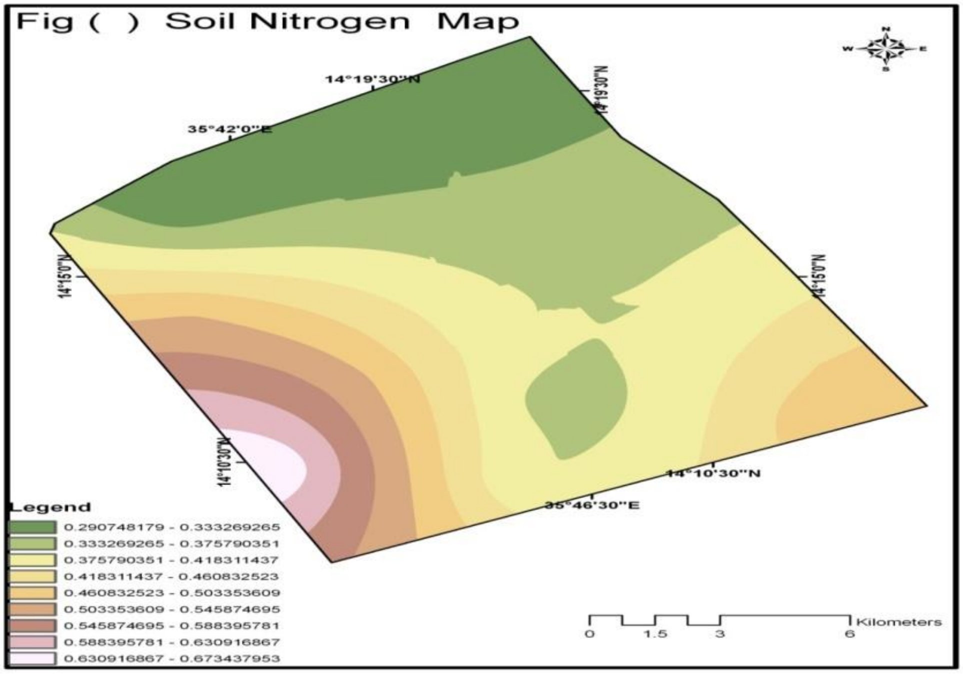


**Fig 4 Soil Nitrogen Values**

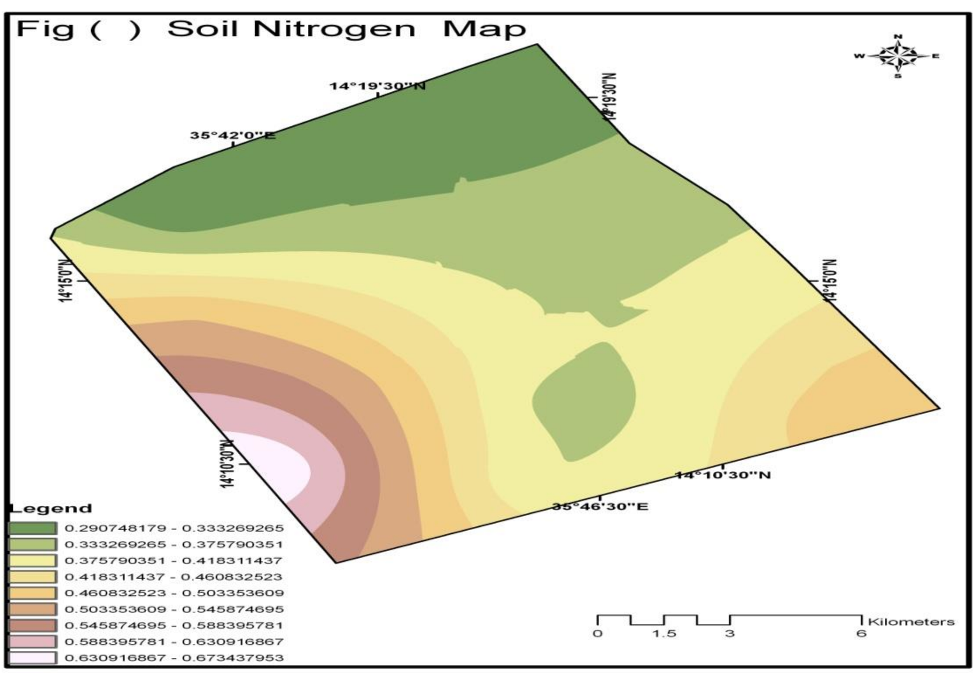


**Fig 5 Soil Phosphors Values.**

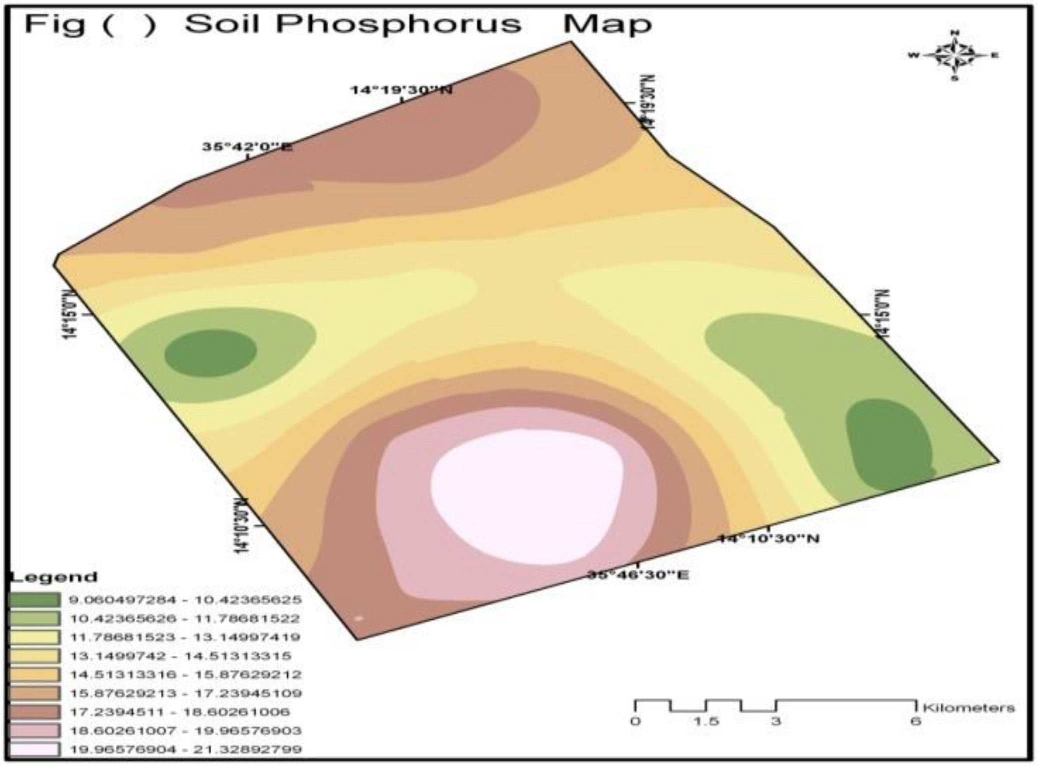


**Fig 6 Soil Potassium Values**

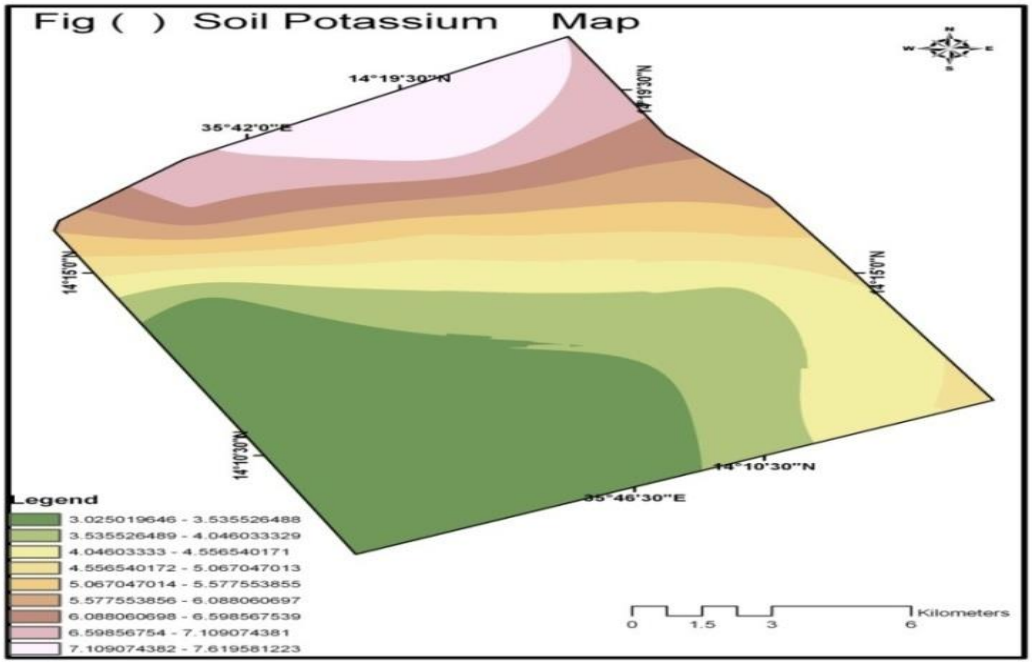

**Table (2): Yield of different grown crops in the study area during (2007/2012)**

| No. | Season | Crop type and yield kental/fed. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Millet | Sunflower | Cotton | Peanut | Sesame | Sorghum |
| 1 | 2007/2008 | 1.75 | 0.175 | 3.54 | 8.0 | 1.75 | 1.7 |
| 2 | 2008/2009 | 3.07 | 0.2 | 2.0 | 7.0 | 3.03 | 1.7 |
| 3 | 2009/2010 | 3.0 | 0.12 | 2.0 | 3.85 | 3.0 | 1.2 |
| 4 | 2010/2011 | 2.88 | 0.122 | 3.83 | 3.31 | 2.88 | 2.59 |
| 5 | 2011/2012 | 2.26 | 0.173 | 3.o | 2.3 | 2.26 | 1.49 |

**Source: Ministry of agriculture, Gedaref State –Sudan (2012)**

**Fig 7: Crop types and yield in the study area (2007-2012)**