عمـــادة البحـــث العلمـــي
DEANSHIP OF SCIENTIFIC RESEARCH

Sudan Journal of Science and Technology
Journal homepage:
http://jst.sustech.edu/

Some Soil physicochemical Characteristics Affected by Land Use Change at El Salaam Locality, South Darfur State, Sudan

[1]Adam Burma Ahmed, [2]Abdelbasit Elmagboul [2]Mohamed Abdo Desougi, [3]Siddig A. Mohamed Ali,, and [2]Galal Abas Fashir Kodeal
*University of Zalingei, Faculty of Forestry Science, Department of Forests, Zalingei, Sudan
*Sudan University of Science and Technology, Faculty of Forestry and Range Science
*University of Zalingei, Faculty of Agriculture, Department of Agronomy, Zalingei, Sudan
Co-respondent author: burmaahmed@gmail.com

ARTICLE INFO

ARTICLE HISTORY
Received: 31/7/2020
Accepted: 20/10/2020
Available online: December 2020

KEYWORDS:
woodland, cropland, fallow land, physicochemical, soil characteristics, land use change

ABSTRACT

The study was carried out at El Salaam Locality, South Darfur State that located between 11 º 37' and 11º 80' northern latitudes, and 24º 62' and 25º 10' eastern longitudes. The aim of this study is to assess the effects of different land use types namely (woodland, cropland and fallow land) on physicochemical characteristics of soil. 48 soil samples were collected at 0-30 cm, 30-60 cm, and 60-90 cm depths of three different adjacent land uses conducted 12 profiles 4 for each sample site. Some soil physicochemical characteristics were tested. Statistical Analysis System SAS was applied for raw data analysis. One-way analyses of variance (ANOVAs) procedures were used to compare the means values between the different land use types. Separation of the means of the soil properties was performed using Duncan significance test {$p<0.05$}. There were significant differences in soil physicochemical characteristics within depth in same sites. Also the result showed that lands use type has significant effect on soil physicochemical characteristics. Moreover, there was high significant difference in soil bicarbonate value across LU types and the amount of bicarbonate in cropland increased more than fallow and woodland, Land use changes from woodland into cropland which resulted in significant decreases in silt content, aggregate stability, N, P, K, and organic matter, and with this change bulk density, sand content and pH value was increased significantly. The result concluded that land use change has significant effect on soil physicochemical characteristics and the follows period must be use to improve soil bulk density characteristic.

Introduction:

The terms "land use cover" and "land use" are often confused. Land cover is the observed physical and biological cover of the earth's land, as vegetation or man-made features. In contrast land use is "the total of arrangements activities and inputs that people undertake in a certain land cover type. Conversion of natural forest and woodlands is still the main strategy and source of land for agricultural expansion in most developing countries. Sudan provides a typical example where about 200,000 ha of natural woodlands and forest are annually replaced by dry land mechanized agriculture Jimpy (2012). Semi- desert and low rainfall savannah on sand, represent 25 percent of Sudan's agricultural land, are at considerable risk of further desertification UNEP (2006). From 1990 to 2005, Sudan lost 11.6 percent of its forest cover, or approximately 8,835,000 hectares. In Darfur region particularly a third of the forests cover was lost between1973 and 2006 UNEP (2006). The pressure on land resources and ecosystems has intensified greatly over the past several decades due to land use changes created by increasing population, economic development and global markets, exacerbated locally by land governance issues. Consequently, continuous cropping without soil conservation practices or fallow periods, which caused soil degradation and nutrient depletion Kibet (2013). In addition to intensive land use associated with the current socio-economic conditions often results in various types of environmental deterioration such as land degradation, declining crop yield, and deforestation Kendawang *et al.,* (2004), Mohawesh *et al.,* (2015).

Moradi *et al.*, (2015) stated that land use change of natural ecosystems to the managed ecosystems has deleterious effects on soil characteristics. In addition to that different land uses and plowing can lead to the destruction of soil structure and reduced performance due to changes in the pores and the pores size distribution. Land use conversion may cause important change in physical and chemical characteristics of soil and can affect soil fertility, increase soil erosion or cause soil compaction Kiakojouri, and Gorgi. (2014). The conversion of forest into cropland is known to deteriorate soil physical properties and making the land more susceptible to erosion since macro aggregates are distributed Abad *et al.,* (2014). Soil bulk density is highly depending on soil texture and the densities of soil minerals, (sand, silt, and clay) and organic matter particles Matano *et al.,* (2015).

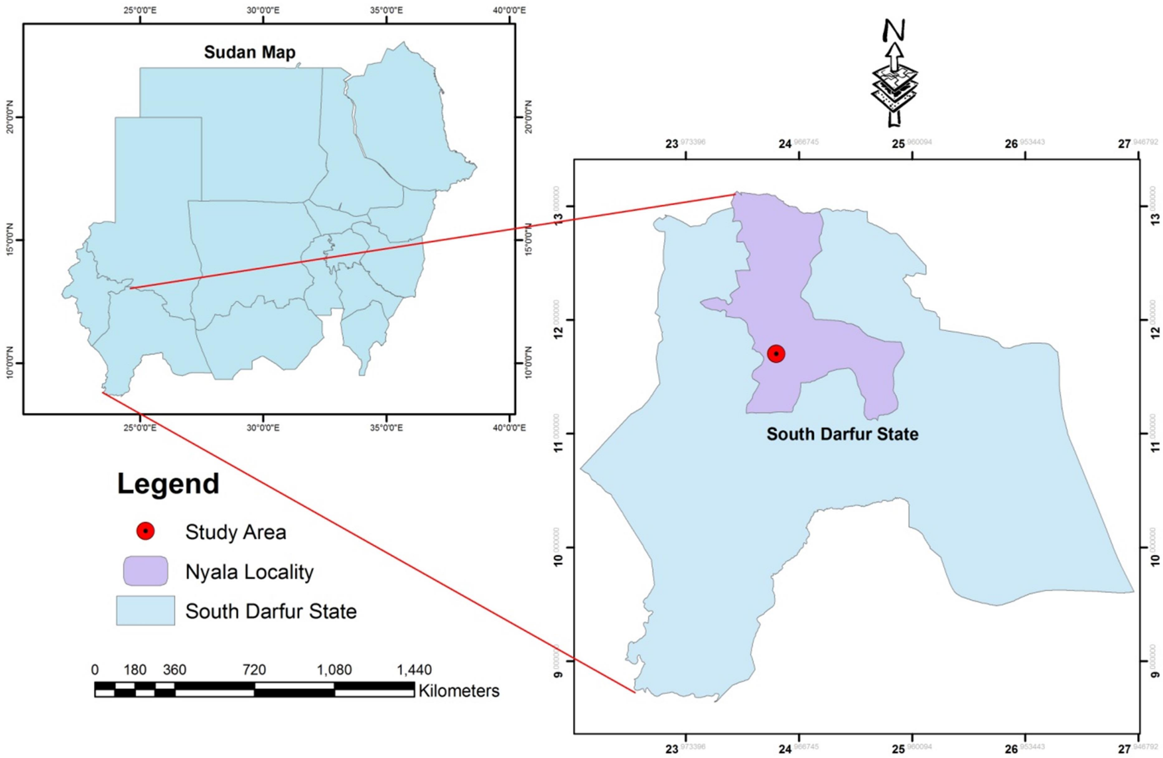
Changes in land use and management can cause significant changes in carbon storage and flows Jong, (2000). Soil organic matter (SOM) plays an important role as nutrient reservoir and source for plants, especially in the tropical regions where soils are strongly weathered and often contain small amounts of available nutrients such as nitrogen (N) and Phosphorus (P). Mishra, (2014) stated that the maximum 10 to 12% dry weight of organic matter is reported in good grasslands. In disturbed situations like a cultivated field, the amount may be as less as 1%. Also

The conversion of tropical forests into land for agriculture might have negative impacts on soil characteristics and the carbon budget to explore history of land management, and diversely affect soil Carbon (C) and Nitrogen (N) levels. Forested soils maintained high levels of organic matter comparable to soil from continuously cultivated fields, which exhibited lower than those in soil kept under prolonged fallow Mhawish (2014). Conversion of forest to cultivated land causes an appreciable change in organic matter content resulted in nutrient imbalances, reduction in water-holding capacity, iron, aluminum, nitrogen, calcium, magnesium, potassium, phosphorus, and cation exchange capacity (CEC). As in Kordufan and Darfur in western Sudan, cultivation of marginal lands (traditional farming), exhaust soil organic matter, reduce soil fertility, and enhance soil erosion Mustafa (2007).the objectives of the study was to assess the effects of three land use types (woodland, cropland and fallow land) on physiochemical characteristics of soil.

Materials and Methods:

The Study Area:

This study was conducted at El Salaam Locality, where is located in the southern Darfur at southern part of Nyala locality, and lies between the latitudes 11º 37' N and 11º 80' N, and the longitudes 24º 62' E and 25º 10' E and covers an area of 450,000 Km^2. El Salaam area has a dynamic climate regime; It was classified into Low Rainfall Savanna ecological zone, which is extended from Kordufan to Darfur region in Sudan. Macdonald and parteners (1974) mentioned that the annual rainfall average ranging between 500 mm to 800 mm lies entirely within this formation vegetation type. And the annual range of the temperature is reached high with a maximum of more than 40°C between April and May and a minimum around 25°C during winter season.



Map (1) Study area map

Source: developed by researcher (2019)

The area characterized by sandy soil occurs throughout the Qoz Land System and on scattered sand dunes within the other Land Systems with coarse textured soils and aeolian origin. As Hinderson (2004), furthermore, it is high in water permeability and has a low fertility locally named Qoz sands.

Soil Sampling and Analysis:

Soil Data Collection:

There were 12 sample plots conducted at the three land use types that identified in woodland, cropland and fallow land four sample plots in each site. Sample sites were selected and located by GPS. The intentional behind selecting this area for the study is variations among land use practices. However, random systematic sample method was used. Moreover, 48 soil samples were collected at three different depths: 0-30, 30-60 and 60-90 cm intervals during 10 - 21 May 2016 before rainy season began. Open dig pits were drilled by using shovel appropriately for soil samples collection. The soil samples were air- dried and passed through 2 mm sieve to remove stones, roots, and large organic residues. Then they were analyzed in Soil Laboratory in Faculty of Agriculture Studies, Sudan University of Science and Technology, Shambat, Khartoum. Physicochemical characteristics were investigated such as soil texture was determined by using Hydrometer Method FAO (1970). Soil Bulk Density BD four sample plots were conducted, the samples were collected from cultivated fields and woodlands four samples for each site by using a Standard Bulk Density ring Matano *et al* (2015). This involved a cylindrical metal with size 3.71 sq./cm^3 by driven into the soil until at the same level with the ground. The sample was removed by digging around the ring with the trowel underneath it to prevent any loss of soil. Excess soil from the sample was removed with a flat bladed knife and the bottom of the sample made flat and even with the edges of the ring. All samples were packed in a polyethene bag and sealed off by rubber bands. Moreover, each polyethene bag was identified by series number site such as woodland-1, cultivated field-2 and fallow land-3.

Woodland, Cropland and Fallow land

ISSN (Print): 1605 427x e-ISSN (Online): 1858-6716

Source: snapped up by researcher (2019)

Soil Analysis:

Particle size distribution was determined by the hydrometer method Bouyoucous (1951). Soil organic carbon (SOC) content was determined by using the Walkley-Black method Nelson and Summer (1996). Soil pH and electrical conductivity (EC) were measured by a pH/Conductivity meter Rhoades, (1996). Total nitrogen (TN) was determined by the Dumas Combustion method Bremner (1996). The Available phosphorus (P_{ava}) was done by the Bray and Kurtz (1945) method furthermore, extractable potassium (K) was measured by flame Photometer. Cations Exchange Capacity (CEC) was done by the Ammonium Acetate method buffered at PH 7 Sumner and Miller (1996). Carbonate ($CaCO3$) was determined by pressure calcimeter method Richard and Donald (1996).

Statistical Analysis:

Statistical Analysis System SAS was applied for raw data analysis. One-way analyses of variance (ANOVAs) procedures were used to compare the means values between the different land use types. Separation of the means of the soil properties was performed using Duncan significance test {p<0.05}. Additionally, Pearson's correlation coefficient was employed to evaluate the relations between the soil physicochemical characteristics.

Results and Discussions:

Table (1): The effect of Land Use system on Soil Texture and Bulk Density:

Source of variations	Categories	Soil types	DF	Mean square	F-value	Means
Site	Cropland	Clay %	2	0.33	0.02 ns	35.66a
	Fallow					35.33a
	Woodland					35.00a
Depth in cm	00 – 05	Clay %	3	3908.33	241.75***	13.67b
	06 – 30					15.33b
	31 – 60					77.00a
	61- 90					13.67b
Site	Cropland	Silt%	2	0.78	0.44 ns	4.33a
	Fallow					3.66a
	Woodland					3.33a
Depth in cm	00 – 05	Silt%	3	8.44	4.75 ns	4.00a
	06 – 30					5.33a
	31 – 60					2.00b
	61- 90					1.18b
Site	Cropland	Sand %	2	12.11	1.24 ns	57.33
	Fallow					55.00
	Woodland					53.33
Depth in cm	00 – 05	Sand %	3	5910.11	604.44***	82.33a
	06 – 30					79.33a
	31 – 60					4.00b
	61- 90					2.05b
Site	Cropland	BD($g.cm^3$)	1	0.39	22.58**	1.58a
	Woodland					1.14b

*** Very high significantly difference at P<0.001
** High significantly difference at P<0.001
* Significantly difference at P<0.05
Ns not significantly difference at P<0.05
BD: Bulk density

*mean with same letter for the some source in same column are not significantly different at p= 0.5 using Duncan range taste.

The result that in table (1) showed highly significant difference in clay and sand contents within depth at {$P<0.05$}, The percentage of silt content in all land use types is less than clay and sand particles content and the sand content is higher, this indicated that soil is not degraded by erosion. Sand content is increased with changing forest or woodland to crop land this result of removal of silt and adding sand in soil surface is accelerated water erosion. As Moradi and others (2015) mentioned that different land uses and plowing can lead to the destruction of soil structure and reduced performance due to changes in the pores and the pores size distribution, this mean that, sand content is a physical parameter affected by soil erosion and, hence, can be measured and as indicator for evaluating soil degradation under different land use systems. In 2013 Filho *et al*, report that, impact of shifting cultivation causes an alteration of the texture and structure of the soil, as a result of the repeated exposure of the soil, and the deepening of the negative effects is related to the increase of surface runoff and erosion and decrease of water conductivity and the rate of infiltration. Moreover, the result showed that there was no significant difference in amount of the soil bulk density (BD) among depths in two sites. The high value of bulk density in the cropland caused the limitation in the roots improvement, these mean (BD) varied according to land use types. Soil bulk density is influenced by crop and land management practices that affect soil cover, organic matter, soil structure, and/or soil porosity. Cropland tends to have higher soil bulk densities than woodlands. As Gol (2008) stated that the deforestation and subsequent tillage practices increase in bulk density BD and decrease in SOM.

Table (2): The effect of Land Use system on Soil pH value:

Source of variations	Categories	DF	Mean square	F-value	Means
Site	Cropland	2	0.020	0.07 ns	7.84a
	Fallow land				7.83a
	Woodland				7.84a
Depth in cm	00 – 05	3	0.56	1.95 ns	7.9a
	06 – 30				7.8a
	31 – 60				7.8b
	61- 90				7.8a

pH, hydrogen ions, ns indicate not significant difference, different letters within one row indicate a significant difference at $p < 0{\cdot}05$.

Table (2) showed that pH value under fallow land was lower than pH under woodland and cropland but, had not significant difference between fallow land and other land use types. Soil pH value was slightly higher for cropland and woodland as compared with fallow land, that means the soil alkaline range between 7.4 – 7.8 as mentioned in soil manual 2017. Moreover, pH value under cropland and woodland are showed that the soil moderately alkaline which range between 7.9 – 8.4. The positive impacts during conversion of forests to shifting cultivation are mainly related to the increase of soil pH may be due to the increase of basic cations (Mg, Ca, and K). At the beginning of the cultivation phases, which was coincided with sowing, the soil was exposed and impacted are negative for the chemical properties on the pH Filho *et al.,* (2013). Yiming *et al* (2020) reported that soil organic matter (SOM) and pH are critical soil properties strongly linked to carbon storage, nutrient cycling and crop productivity. Land use system was known have a dominant impact on the key soil properties

Electrical Conductivity (EC) and Sodium Adsorption Ratio: (SAR)

Table (3): The effect of Land Use Types on EC and SAR values:

Source of variations	Categories	Variety	DF	Mean square	F-value	Means
Site	Cropland	EC	2	0.0003	0.70 ns	0.14a
	Fallow land					0.14a
	Woodland					0.13a
Depth in cm	00 – 05	EC	3	0.0015	3.32*	30.15a
	06 – 30					0.13a
	31 – 60					0.12b
	61- 90					0.14a
Site	Cropland	SAR	2	0	-	1.0a
	Fallow land					1.0a
	Woodland					1.0a
Depth in cm	00 – 05	SAR	3	0	-	1.0a
	06 – 30					1.0a
	31 – 60					1.0a
	61- 90					1.0a

EC electrical conductivity SAR sodium adsorption ratio, ns indicate not significant difference, different letters within one row indicate a significant difference at $p < 0{\cdot}05$.

Table (3) the results showed that the electrical conductivity (EC) value had significant difference at ($p<0.05$) among all soil depths. In addition to that result as observed in table (3) the EC value is not significant difference in all land use types. The EC value in depth 0.0 – 05 cm is higher than other three depths. The electrical conductivity EC of a saturation paste extract is the standard method for measuring salinity. EC is related to the amount of salts that are more soluble than gypsum in the soil USDA, (2017).

The sodium adsorption ratio (SAR) represents the amount of Na^{+}, relative to Ca^{2+}, Mg^{2+}. The SAR is approximately equal to the exchangeable sodium percentage (ESP) of the soil. As observed in table (3) SAR values had same amount in the three land uses type (cropland, woodland and fallow land) also the same amount observed in the four soil depths.

Cations Exchangeable capacity

Table (4): The effects of land use Types on Cations Exchangeable:

Source of variations	Categories	Variety	DF	Mean square	F-value	Means
Site	Cropland	Na	2	5.070	0.91 ns	0.17a
	Fallow land					0.20a
	Woodland					0.13b
Depth in cm	00 – 05	Na	3	21.163	3.78 ns	0.18a
	06 – 30					0.15a
	31 – 60					0.13a
	61- 90					019a
Site	Cropland	K ($mgKg^{-1}$)	2	5.041	0.87 ns	0.12a
	Fallow land					0.14a
	Woodland					0.13a
Depth in cm	00 – 05	K ($mgKg^{-1}$)	3	25.39	4.40 ns	0.16a
	06 – 30					0.13a
	31 – 60					0.11b
	61- 90					0.13a
Site	Cropland	Ca /Mg	2	5.92	0.38 ns	1.0a
	Fallow land					1.0a
	Woodland					1.0a

Depth in cm	00 – 05	Ca/Mg	3	5.54	0.36 ns	1.0a
	06 – 30					1.0a
	31 – 60					1.0a
	61- 90					1.0a

Na, sodium, K, potassium, Ca/Mg, calcium/magnesium, ns indicate not significant difference and DF , degree of freedom

Soil sodium (Na) was not significantly different across the three LU types. However, the sodium amount is higher in the fallow land than other two land uses type, as indicated in table (4). Biro *et al.* (2013) reported that potassium losses in the clay soil were more than twice as those in the sand soil because of the development of preferential flow in the clay soil. Soil potassium (K) in table (4) showed that hadn't significant different across soil depths and land use types, furthermore, potassium K within depths lesser than potassium within land use types. But, the Calcium and Magnesium (Ca/Mg) in soil depths and LU types had the same values.

Cations exchangeable capacity (CEC) increased by following conversion of forest to field crops as in table (4) Grath *et al,* (2001). When forest was cleared for cultivation, there was a slight decrease in the exchange capacity at all soil depth Watters (1971). When forest is cleared and burned, large losses of nitrogen occur upon burning by volatilization and reduction of organic matter Gol and Dengiz (2008).

Phosphorus and Nitrogen:

Table (5): The effects of land use Types on phosphorus (P_{av}) and Nitrogen value:

Source of variations	Categories	Variety	DF	Mean square	F-value	Means
Site	Cropland	P ($mgKg^{-1}$)	2	0.00000000	-	0.73a
	Fallow land					0.73b
	Woodland					0.73a
Depth in cm	00 – 05	P ($mgKg^{-1}$)	3	0.64000000	99999.99	1.00a
	06 – 30				***	1.00b
	31 – 60					0.20c
	61- 90					0.20c
Site	Cropland	N	2	0.00000000	-	0.0006667a
	Fallow land					0.0006667b
	Woodland					0.0006667c
Depth in cm	00 – 05	N	3	0.00000100	99999.99	0.001000a
	06 – 30				***	0.001000b
	31 – 60					0.00c
	61- 90					0.00c

ns means not significant difference, DF means degree of freedom, different letters within one row indicate a significant difference at $p < 0{\cdot}05$., *** means very high significant, P, phosphorus and N means Nitrogen

In the table (5) the result showed that, there was very high significant difference in Phosphorus value among soil depths at ($P<0.05$) .Moreover, phosphorus (P_{ava}) has not significant difference among land use types. The results observed that land use has significant effects on soil chemical characteristics. Different studies have examined the effects of land use on soil physical and chemical characteristics, as reported by Mhawish (2014) soil changed into agriculture might have negative impacts on soil characteristics and the carbon budget to explore history of land management, and diversely affect soil organic carbon (OC) and Nitrogen (N) levels.

Bicarbonate (HCO_3^-)

Table (6): the effects of land use Types on Bicarbonate (HCO_3) value:

Source of variations	Categories	DF	Mean square	F-value	Means
Site	Cropland	2	1.49	16.34	2.21a
	Fallow land			***	1.73b
	Woodland				1.65b
Depth in cm	00 – 05	3	0.13	1.40 ns	1.95a
	06 – 30				1.95a
	31 – 60				1.80a
	61- 90				1.75a

ns means not significant, *** means very high significant, DF means degree of freedom and different letters within one row indicate a significant difference at $p < 0{\cdot}05$.

The result in table (6) showed very high significant difference in soil bicarbonate value across land use types was achieved, and the amount of bicarbonate in cropland increased more than fallow and woodland. However, high levels of bicarbonates in irrigation water can lead to sodium issues. Bicarbonates in the soil can tie up calcium, making it unavailable to the soil, which can increase sodium concentrations and typically stem from bicarbonates in the irrigation water. High bicarbonates on low CEC soils might be a lesser issue due to good drainage. Soils with high bicarbonates and low sodium may still tie up calcium.

Organic Carbon:

Table (7): the effect of Land Use Types on Organic Carbon value:

Source of variations	Categories	DF	Mean square	F-value	Means
Site	Cropland	2	0.001	1.00 ns	0.13a
	Fallow land				0.13a
	Woodland				0.10a
Depth in cm	00 – 05	3	0.004	4.00 ns	0.100a
	06 – 30				0.100a
	31 – 60				0.167a
	61- 90				0.170a

ns indicate not significant difference, DF, degree of freedom and same letters within one colum indicate no significant difference at $p < 0{\cdot}05$.

The amount of organic carbon are showed in Table (7) is limited and has no significant difference within soil depth and land use types. And this amount disappeared and became zero in sub-depths. The results of statistical analysis and average comparison for both of the 00 – 05 cm and 05 – 30 cm depths observed that the change in usage caused the amount of organic matter decrease. The results of this research showed amount of organic carbon (OC) in cropland and fallow land is more than amount of OC in woodland. Mustafa (2007) stated that in Kordufan and Darfur in western Sudan, cultivation of marginal lands (traditional farming), exhaust soil organic matter, reduce soil fertility, and enhance soil erosion. He also stated that soils with less than 3.5% organic matter could be considered erodible. Particular, lowering of organic matter is the main cause of physical degradation and also affects nutrient supply. Degradation of soil physical structure has substantial affects on plant yield independently of chemical properties Young (2000).

Conclusion:

Land use types (woodland, cropland and fallow land) affected physicochemical characteristics of soil. These effects observed particularly in sand soil used for shifting cultivation in El Salaam locality which is resulted in crops yield reduction and infertile soil. Sand soil loss organic matter easily by runoff water and wind conditions, when farmland disposture by land preparation and crops harvesting. The statistical analysis of the result within both depths 0.0 – 0.5 and 0.5 – 30cm showed that the change of land use types caused significant change in soil organic matter amount.

References:

1.Abd El Magid, H.A.M. (2007). Impact of Land Use Management System on Some Soil Properties. The Case of South Khartoum State, M. Sc. Thesis, Desertification and Desert Cultivation Institute, University of Khartoum, 2007

2.Abad, J.R.S., Khosravi, H., and Alamdarlou, E.H. (2014). Assessment the Effects of Land Use Changes on Soil Physicochemical Properties in Jafarabad of Golestan Province, Iran, Bull. Env. Pharmacol. Life Sci., Vol 3 Spl Issue III 2014, Online ISSN 2277-1808, www.bepls.com, India.

3.Bray, R.H., and Kurtz, L.T. (1945). Determination of Total Organic and Available Forms Phosphorus in Soils, Soils Sci. Pages 59, 39-45

4.Bouyoucous, G.J.A. (1951): Recalibration of the hydrometer for making mechanical analysis of soil. Agro. J., 43, 434-438

5.Bremner, J.M. (1996). Methods of Soil Analysis, Part3, Chemical Methods, Soil Science Society of America, Madison, pp. 1087-1089.

6.FAO, (1970). Physical and Chemical Methods for Soil and Water Analysis, Food and agriculture Organization, Rome.

7.Filho, A., A., R., Adams, C., and Murrieta, R., S., S., et al. (2013). The Impact of Shifting Cultivation on Tropical Forest Soil: a Review, Boletim do Museu Paraense Emílio Goeldi. Ciências Humanas, v. 8, n. 3, p. 693-727, set.-dez. 2013.

8.Gol, C., and Dengiz, O. (2008). Effect of Modifying Land Cover and Long Term Agricultural Practices on the Soil Characteristics in native Forest-land. *Journal of Environmental Biology* 29(5) 677-82.

9.Gol, C., (2008). The effects Land Use Change on Soil Properties and Organic Carbon at Dagdami River Catchment in Turkey, Journal of Environmental Biology, September, 2009, 30(5) 825-830 (2009), ©Triveni Enterprises, Lucknow (India), Website: www. jeb.co.in

10. Hinderson, T. (2004). Analyzing Environmental Change in Semi-Arid Areas in Kordofan, Sudan, PhD Thesis, Lund University, Lund, Sweden.

11. Jimpy, Y.M.I. (2012). Change Detection in Trees Species Composition and Structure in Meidob Hills, Northern Darfur, Sudan, PhD Thesis, SUST, 2012.

12. Jong, B.H.J., de. (2000). Forestry for Mitigating the Greenhouse Effects, an Ecological and Economic Assessment of the potential of Land use to mitigate CO_2 Emissions in the Highland in Chiapas Mexico, ISBN 90-8508-266-0

13. Kendawang, J.J., Tanaka, S., Ishihara, J., Shibata, K., Sabang, J., Ninomiya, I., Ishizuka, S., and Sakurai, K. (2004). Effects of Shifting Cultivation on Soil Ecosystems in Sarawak, Malaysia, Slash and Burning at Balai Ringin and Sabal Experimental Sites and effect on Soil Organic Matter, Journal Soil Sci. Plant Nutr., 50(5), 677-687, 2004.

14. Kiakojouri, A., and Gorgi, M.M.T. (2014). Effects of Land Use Change on the Soil Physical and Chemical Properties and fertility of Soil in Sajadrood Catchment, Agric Eng Int: CIGR Journal, Vol. 16, No. 3, 10 September, 2014, Open Access at http://www.cigrjournal.org

15. Kibet, T.E. (2013). Predictions of Soil Properties for Agricultural and Environmental Applications from Infra and X-Ray Soil Spectral Properties, PhD Thesis, Faculty of Agricultural Sciences, University of Hohenheim, 2013.

16. Matano, A.S., Kanangire, C.K., Anyona, D.N., Abuom, P.O., Gelder, F.B., Dida, G.O., Owuor, P.O., and Ofulla, A.V.O. (2015). Effects of Land Use Change on Land Degradation Reflected by Soil Properties along Mara River, Kenya and Tanzania. *Open Journal of Soil Science*, **5**, 23. http://dx.doi.org/10.4236/ojss.2015.51003

17. Macdonald, S., M., and Partners, (1974). Soil and Vegetation Resources, Southern Darfur Land-use Planning Survey, by Hunting Technical Services LTD, 33 DOVER STREET, LONDON, WI4QU

18. McGrath, D.A., Smith, C.K., Gholz, H.L., and Oliveira, F.D., (2001). Effects of Land-use Change on Soil Nutrient Dynamics in Amazonia, Ecosystem.

19. Mhawish, M.Y. (2014). Effect of Land-Use/Cover Change on Physical and Chemical Soil Properties within an Agricultural Ecosystem of Ajloun Area-Jordan, International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081(Online), Vol. 5(2) May-August, PP. 1-17, 2015, Access at *http://www.cibtech.org/jgee.htm*

20. Mishra, R.R., (2014). Soil Microbiology, the Organic Matter, Page 4, Published by Satish Kumar Jain and Produced by V.K, 2014

21. Mohawesh, Y, Taimeh, A, and Ziadat, F (2015). Effects of Land Use Changes and Soil Conservation Intervention on Soil Properties as Indicators for Land Degradation under a Mediterranean Climate, Solid Earth, 6, 857-868, 2015, www.soild-earth.net/6/857/2015

22. Moradi, A. R, Jafari, M, Arzani, H, and Ebrahimi, M (2015). Effects of Land Use Change on Some Physical and Chemical Properties of Soil in Rangelands of Kerman Province, Journal of Biodiversity and Environmental Sciences (JBES), Vol. 6, No. 5, P. 447-455, 2015

23. Mustafa, M A, (2007). Desertification Processes, Causes of Desertification, P. 18, 19, & 42, Khartoum University Press; 2007

24. Rhoades, J.D. (1996): Methods of Soil Analysis. Part3. Chemical Methods, Soil

25. Science of America and American Society of Agronomy, SSSA Book Series No.5. Madison-USA

26. Richard, H.L. and L.S. Donald (1996): Methods of Soil Analysis. Part3. Chemical Methods, Soil Science of America and American Society of Agronomy, SSSA Book Series No. 5. Madison-USA

27. Nelson, D. W, Sommer, L. E. (1996). Methods of Soil Analysis, Part3, Chemical Methods, Soil Science Society of America, Madison-USA, pp. 995-996.

28. Sumner, M E, and Miller, W P, (1996). Methods of Soil Analysis, Part3, Chemical Methods, Soil Science Society of America, Madison, pp. 1220-1221.

29. UNEP, United Nations Environmental Programme, (2006). Sudan-Post-Conflict Environmental Assessment, United Nations Environment Programme, P.O Box 30552 Nairobi, Kenya, Tel: +254 (0)20 762 1234, Fax: +254 (0)20 762 3927, Email: uneppub@unep.org, Website: www.unep.org.

30. USDA United States Department of Agriculture, (2017). Soil Survey Manual, Soil Science Division Staff, United States Agriculture Handbook No. 18, Issued March 2017.

31. Watters, R F, (1971). Shifting Cultivation in Latin America, FAO Forestry Department Paper No. 17.

32. Young, A., (2000). Land Resources-Now and for the Future-First Published 1998, Cambridge University Press.

33. Yiming, S., Guanlin, G., Huading S., Mensiioo,L., Aidan,K., Hons, L., and KevinE, J.,(2020) Decadal shifts in Soil Ph and Organic Matter differ Between Land Uses in Contrasting Regions in China, Science of the Total Environment, Volume 740, 139904