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CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH

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PREFACE

There is a growing concern on the adverse impacts of climate on biodiversity. This phenomenon is greatly manifested in form of shifting weather patterns threatening global food security, health and species existence. Humanity is at the receiving end of the consequences of climate change hence there is a need to step up actions on all fronts- overtime, everywhere all at once.

This calls for collaboration, partnership and networking to strengthening synergy among relevant stakeholders in a bid to tackling climate change menace. This forms the basis for the theme of this year world Environmental conservation conference: **CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH.** The theme is conceived with a view to create an interface for information sharing and offer opportunities for participants to refine their commitments and pledges in the quest to achieving Sustainability in the face of climate change.

This year World Environmental Conservation Conference is memorable in the sense that it received overwhelming funding from the host - West African Science Service on Climate Change and Adapted Land use). WASCAL is posed to provide information and knowledge at the local, national and regional level to cope with the adverse impacts of climate change. Thus, this conference will offer opportunities for participants to learn from good practices demonstrated and showcase by WASCAL during the course of the conference. It will also strengthen staff-student exchange and provide prospect for Doctorate Research Doctoral Research in West Africa Climate System Programme (DRP WACS) – WASCAL among others.

Special appreciation goes to the management of The Federal University of Technology, Akure the host institution, National Park Service and African Regional Center for Space Science and Technology Education-English (ARCSSTE-E) that co-host this conference. We equally acknowledge other private, individual and corporate organizations that have contributed towards the success recorded in this event.

All the submitted articles were subjected to strict double blind peer-review process by the reviewers that are experts in the area of the particular submitted manuscript. The accepted manuscripts are published in WECC 2023 proceedings and also available for download on the organization website (www.necorng.org).

The accepted manuscripts fall within the underlisted subthemes:

- Climate change adaptation strategies in Agriculture, Forestry and Other Land Use (AFOLU)
- Climate smart city and architectural landscape design
- Retrofitting and decarbonization in tourism and hospitality industry
- Indigenous knowledge and local innovation in climate change adaptation
- Climate risk management, health, safety and hygiene
- Carbon credit-offset marketing/circular economy
- ICT development in environmental conservation (image processing and acquisition, computer vision, graphics, speed, interface technology, HMD devices, GIS: Body Tracking, AI and IOT, VRT, IVE).

We commend our keynote speaker Prof. Douda Kone Director Capacity Building Department, WASCAL Headquarter, Ghana and other guest speakers Prof. Babatunde Rabiu, Director General, Chief Executive Office, African Regional Centre for Space Science and Technology Education-English (ARCSSTE-E) and Dr. Goni I. M., Conservator General National Park Service.

It is hoped that researchers, students and policy makers will find the papers in this book very useful. Even though all the papers were reviewed and edited, the content and option expressed remain essentially that of the authors and not necessarily that of Netlink Environmental Conservation Organization.

Dr. Oladeji S. O.

President Netlink Environmental Conservation Organization

Convener World Environmental Conservation Conference

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IMPACTS OF SMALLHOLDER FARM PRACTICES ON SOIL CARBON STORAGE POTENTIAL IN AN AGRICULTURAL LANDSCAPE

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ABSTRACT

Ilora farm settlement in Afijio Local Government Area of Oyo State remains a major part of the southwest agricultural sector, as one of the areas prominent with agricultural production owing to its vast number of farms and farmed area. This necessitate the assessment of the contribution of smallholder farm practices to soils capacity to sequester carbon as a means to reduce GHG emissions that may occur from agricultural activities. Eight profile pits were established along two transect from which soil samples were collected and analysed in the laboratory. Data generated were subjected to descriptive statistics and correlation analysis. Results showed that the soils were predominantly loamy sand and sandy loam with low pH values ranging between 4.80 and 6.80. Soil Organic Carbon decreased down the profile pit, ranged between 0.34 and 2.68 %. Carbon sequestered by the different horizons ranged from 9.95- 170.32 g cm^{-2}. It was found that more carbon were stored in the upper than deeper horizons which was contrary to earlier observation. The regression analysis further portray and support this finding by giving a negative relationship between sequestered carbon per centimeter against horizon thickness, indicating decrease in carbon sequestration with increase soil profile depth. Therefore, this study established that more carbon is sequestered in the epipedal portions of the soil profile than in the sub-surface horizons. Therefore, the soils possess high capacity to sequester carbon to mitigate GHGs emissions.

Keywords: *Carbon sequestration, Greenhouse gas, Mitigate, Horizons and epipedal.*

INTRODUCTION

Increased consciousness about climate change and global warming led to the establishment of CO_2 and other greenhouse gas (GHG) emissions as possible sources of climate change, with disastrous consequences for humans, economy, and livelihoods (Poolen and Ryszka 2021). Given this, the Paris Agreement, which became effective in 2016, intends to limit global warming to less than 2.0 degrees Celsius by mid-century in order to attain climate neutrality with the participating countries promise to develop measures to reduce GHG emissions in order to achieve the set long-term goals (United Nations Climate Change n.d.).

However, some industries, among which agricultural industry belongs, produce unavoidable emissions. According to the Intergovernmental Panel on Climate Change (IPCC) (2019), agriculture and other land-use changes are responsible for approximately 23% of net anthropogenic global GHG emissions, which include 13% of CO_2 (carbon dioxide), 44% of CH_4 (methane), and 81% of N_2O (nitrous oxide) which are produced from a diverse range of sources emanating from various agricultural practices from 2007 to 2016 (Sharma *et al.*, 2021). Gingrich *et al.* (2007) and Aguilera *et al.* (2013) reported that CO_2 emissions from fertilizer manufacturing, farm machinery use, and feed imports are the most prominent sources of agricultural CO_2 emissions, while net soil CO_2 emissions are related to the balance between humified organic matter input and mineralization or leaching. Emissions of CH_4 are mainly from livestock manure management and enteric fermentation particularly in ruminants while N_2O emissions comes from the transformation of nitrogen in soils via microorganisms activities during inorganic fertilizer usage, manure applications and other organic substances such as urine and dung deposited by grazing animals(Aguilera *et al.*, 2013 and Springmann *et al.,* 2018)

Increasing agricultural productions through conventional means to satisfy rising food demand of the ever increasing human population globally will emits more GHG, which will in turn have a negative influence on climate change. Thus, players in the agricultural industries are faced with three major challenges that are interconnected viz: meeting an increasing global demand for food as a results of increased population, reducing GHG emissions and adapting production practices to changing climate conditions. This invariably informed the importance of climate-smart agricultural strategies adaptations that lead to sustainable agricultural practices, to avert the growing food insecurity under climate changes while reducing GHG emissions (Verschuuren 2018).

Climate-smart agriculture (CSA) is an approach that helps guide actions to transform agri-food systems towards green and climate resilient practices. It supports reaching internationally agreed goals such as the Sustainable Development Goals (SDG) and the Paris Agreement. It aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible, thus, supporting the FAO Strategic Framework 2022-

2031 that in anchored on four Betters, i.e. better production, better nutrition, a better environment and a better life for all, leaving no one behind.

GHG emissions (especially CO_2) coming from agricultural operations are adjudged to be relatively low compared to industrial emissions. As a result, carbon-credit systems in the agricultural sector have gained wide attention globally in achieving climate neutrality, where agricultural producers can earn extra revenue through selling their surplus of carbon credits to producers who emit higher amounts of GHGs (Shockley and Snell, 2021) and at the same time improve the soil productivity through soil carbon sequestration that improves soil carbon content thereby availing sustainable crop productions through series of holistic integrated farming activities, in which a range of stakeholders are involved to ensure greater efficiency in the use of resources, reduce the pressure on the natural resources and minimize the need for external inputs and more sustainable management of natural and human-created processes in the landscape which is basically the back bone of climate- smart agricultural practices. However, despite the growing popularity of farmer's adoption of Climate smart agricultural practices as a means to enhancing soil productivity, promote climate neutrality in a bid to mitigate against climate change and on the long run serves as another source for increased income to farmers, there is a paucity of research towards its adoption in Nigeria and by extension in the study area. Agricultural soils are among the planet's largest reservoirs of carbon and hold potential for expanded carbon sequestration, and thus provide a prospective way of mitigating the increasing atmospheric concentration of greenhouses gases which can only be achieved by the effectiveness of the best farming practices. Therefore, the objective of this study is to assess the impacts of climate smart agricultural practices in stimulating the accumulation of additional soil carbon with soil fertility improvements, positive land productivity and its environmental effects.

MATERIALS AND METHODS

The Study Area

The study area is Ilora farm settlement in Afijio Local Government area of Oyo State having a land mass of about 800 square kilometres and an average population of 134,173 (NPC, 2007) The 2006 National population census put the average projected increase of 2.5% in population annually in the local government, thus putting the estimated population as at 2022 at the study area at 199,180. The study site is located within the derived savanna zone and part of the region underlain by the Precambrian Basement complex rocks in Southwestern Nigeria. Agriculture is the main land use in the area, and the major agricultural crops are cacao, maize, cassava, yam, water melon, varieties of pepper and livestock production. The area is characterized by equatorial climate with dry and wet seasons and relatively high humidity. The dry season lasts from November to March while the wet season starts from April and ends in October supporting longer term crop productions. Average daily atmospheric temperature ranges between 25 °C and 35 °C almost throughout the year which is moderately high with a low range between the monthly mean minimum and maximum temperatures (FMANR, 1990). The vegetation pattern in Oyo State is that of rainforest in the south and derived savanna in the north where the study site is located. (http://www.oyostate.gov.ng/about-oyo-state/the-state/).

Soil Sampling Procedure

Two toposequences were established on an expanse of land comprised of different pattern or land cover at the study site. The area is basically a farming zone planted to Maize (*Zea mays*), cassava (*Manihot esculenta*), at the upper, middle and lower slope positions and fallow land area with trees and shrubs. Guided by transect sampling technique with observation based on soil landscape relationship as established by Smyth and Montgomery (1962). Random sampling was carried out across the study area within each of the physiographic unit to assess the fertility status of the top and sub soils and examine the soil morphology which in turn guided in citing profile pits. Eight (8) standard profile pits were then established in line with the number of soil units and physiographic positions observed at the location and soil samples were collected from the identified genetic horizons.

Laboratory and Data analyses

The soil samples collected were air-dried, crushed gently and passed through 2 mm sieve to separate gravel content from other soil components. The less than 2 mm fraction was retained for physical and chemical analyses. The bulk density was determined by the core method (Blake and Hartge, 1986), particle size distribution was evaluated by the Bouyoucos hydrometer method (Bouyoucos, 1965), soil pH was determined in both water and 1.0 M KCl solution employing a 1:1 soil/solution mixture (Thomas, 1996) Total exchangeable acidity and Al were determined by titration using 1.0 M KCl solution for extraction (Sims, 1996) and titrated with 0.05N NaOH solution (Sims, 1996). Exchangeable cations were determined by extracting with 1.0 N ammonium acetate (NH_4OAc) solution (Thomas, 1982). Ca, Na and K concentrations in the extract were determined using a flame photometer while that of Mg was determined using atomic absorption spectrophotometer (AAS). The soil organic carbon was determined by the Walkley-Black method (Nelson and Sommers, 1996), moisture content by (Obi, 1990), Carbon stored (gCm^{-2}) in each horizon was determined by multiplying bulk density (gcm^{-3}) x organic carbon (gkg^{-1}) x horizon depth (cm) (Batjes, 1996). Carbon storage - horizon depth ratio was obtained by dividing carbon stored in each horizon by the corresponding horizon depth. Generated soil data were subjected to mean and standard deviation analyses from which coefficient of variation (in percentage) was computed. Variability among selected soil properties of the different horizons of each profile pit was ranked using Wilding, (1985).

RESULTS AND DISCUSSION

Eight profile pits were established from which soil samples were collected for analyses. The sand content ranged from 61 to 90% and decreased with increasing depth except at certain depths where the BC-horizon contained more of sand as in Pedons 03 and 04. The soils have low to moderate silt content at the surface, this characteristic is in line with the findings of Fasina*et al.* (2007), and it distinguished the soils of granite and gneiss rock complex origin from other soils of southwestern Nigeria. The silt content ranged from 03 to 19%, although the value fluctuated within all the pedons with increasing depth. The clay content ranged from 02 to 27%, the clay content increased generally with depth to a maximum (probably due to illuviation/ eluviation interplay) and then decreased in the BC horizon. The lower clay content in the surface horizon could be attributed to the sorting of soil material by biological and agricultural activities, clay migration or surface erosion by run-off or a combination of these (Malgwi *et al.*, 2000). Soil bulk density values increased from 1.06 g cm^{-3} in the Ap horizon to 1.68 g cm^{-3} in the subsoil horizon. The textural class of the soils studied comprised generally of loamy sand and sandy loam. The bulk density values of the investigated soils are within the predicted range for tropical soils (Landon, 1991). Generally the soil has low moisture contents from the results of the analysis with the values ranging between 10.4 to 12.5%. This is indicated by the nature of the soil texture (Sandy), and as a result has a limited ability to retain enough moisture except at the valley bottom where the water table is high.

The pH of the soils studied fall within the neutral to very strongly acid class (Landon, 1991), with pH (H_2O) values ranging from 4.8 to 6.8 and the pH (1M KCl) from 3.5 to 5.3. Generally, the pH decreased with increasing soil depth except pedon06 where sudden increase in pH was observed at the sub soils and followed no definite pattern. The surface horizons of all the pedons were medium to slightly acid (pH 5.1 – 6.0), while B and C-horizon were strong to very strong acid with pH values ranging from 4.8 - 5.8. Generally, there was higher accumulation of bases in the surface horizon of the soils with the values from 2.39 – 2.85 cmol(+)kg^{-1} and decreased with soil depth except in some cases owing to nutrient biocycling (Ajiboye and Ogunwale, 2010), and could also be due to differential weathering that had taken place or as a result of plant uptake and leaching losses.

Soil organic carbon and carbon sequestration

Organic carbon contents of the soils under investigation presented in Table 1 indicated that diagnostic surface horizons of the soils had more soil carbon content in all the pits.

Table 1: Physical and Chemical properties of soils along transect 1

Horizon	Depth (cm)	pH		Exchangeable Bases				Org. C (%)	Exch. Acidity		Moisture Contents	Carbon/ Horizon	Sand	Silt	Clay	Bulk Density (g/cm^3)	Textural Class
		H_20	KCl	Ca^{2+}	Mg^{2+}	K^+	Na^+		Al	H							
									Profile 01 (Upper slope)								
Ap	0-25	5.9	4.1	1.43	0.38	0.11	0.47	2.68	0.4	0.2	10.40	71.02	88	08	04	1.06	Sand
AB	25-45	6.1	4.8	1.90	0.43	0.13	0.43	0.34	0.2	0.3	10.65	10.47	86	08	06	1.54	Loamy sand
Bt1	45-90	6.1	4.8	1.19	0.77	0.19	0.72	0.6	0.3	0.3	11.08	42.93	84	06	10	1.59	Loamy sand
Bt2	90-130	5.9	4.8	1.43	0.28	0.19	0.47	0.4	0.7	0.3	12.65	25.92	81	06	13	1.62	Sand
BC	130-185	5.8	4.7	1.66	0.36	0.23	0.47	0.4	1.4	0.6	11.00	36.30	73	07	20	1.65	Sandy clay
									Profile 02 (Mid slope)								
Ap	0-20	5.1	4.1	1.43	0.48	0.19	0.54	1.68	0.4	0.2	10.95	33.94	90	06	04	1.01	Sand
AB	20-60	4.8	3.5	1.67	0.39	0.15	0.47	1.41	0.4	0.3	11.02	88.55	76	04	20	1.57	Sandy loam
Bt	60-95	4.8	3.6	1.90	0.05	0.21	0.47	1.27	0.1	0.4	12.11	72.45	67	06	27	1.63	Sandy clay loam
BC	95-160	5.2	3.6	1.67	0.36	0.09	0.40	1.41	0.4	0.3	12.25	153.97	61	14	25	1.68	Sandy clay loam
									Profile 03 (Lower slope)								
Ap	0-15	5.8	5.2	1.67	0.36	0.09	0.40	2.01	0.4	0.3	11.40	40.4	90	08	02	1.34	Sand
AB	15-50	5.5	5.0	2.60	0.54	0.15	0.43	2.01	0.3	0.3	11.58	42.81	86	10	04	1.42	Loamy sand
Bt	50-90	6.0	5.0	2.14	0.70	0.27	0.47	1.34	0.2	0.2	12.06	77.72	90	04	06	1.45	Sand
BC	90-160	5.1	4.3	1.43	0.49	0.11	0.47	1.01	0.2	0.3	11.04	116.66	73	03	24	1.65	Sandy clay loam
									Profile 04 (Valley bottom)								
Ap	0-11	5.1	4.9	1.66	0.34	0.07	0.40	1.66	0.3	0.2	12.06	28.12	75	19	06	1.54	Sandy loam
AB	11-35	5.6	4.8	1.66	0.43	0.15	0.47	1.27	0.3	0.2	12.19	45.11	80	14	06	1.48	Loamy sand
Btg	35-60	5.4	4.9	1.44	0.39	0.11	0.40	1.01	0.5	0.3	12.23	32.83	92	06	02	1.30	Sand

Table 2: Physical and Chemical properties of soils along transect 2

Horizon	Depth (cm)	pH H_2O	pH KCl	Exchangeable Bases Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Org. C (%)	Exch. Acidity Al	Exch. Acidity H	Moisture Contents	Carbon/ Horizon	Sand	Silt	Clay	Bulk Density (g/cm^3)	Textural Class
Profile 01 (Upper slope)																	
Ap	0-11	5.8	4.9	1.66	0.36	0.17	0.47	0.87	0.4	0.2	10.24	9.95	88	10	02	1.04	Sand
B1	11-50	5.8	4.6	1.90	0.59	0.17	0.47	0.94	0.2	0.3	10.88	37.03	88	08	04	1.51	Sand
B2	50-95	5,6	3.9	1.90	0.57	0.38	0.47	0.94	0.3	0.3	11.02	66.83	78	04	18	1.58	Sandy loam
BC	95-170	5.6	3.9	1.90	0.46	0.17	0.40	1.01	0.7	0.3	12.01	119.69	65	09	26	1.58	Sandy clay loam
Profile 02 (Mid slope)																	
Ap	0-20	6.0	5.3	1.66	0.51	0.13	0.43	1.93	0.4	0.2	10.40	39.37	88	08	04	1.02	Sand
B1	20-60	5.6	4.7	1.43	0.43	0.13	0.40	1.27	0.4	0.3	10.45	74.17	88	07	05	1.46	Sandy loam
Bt	60-95	5.3	4.1	1.43	0.34	0.07	0.43	2.15	0.1	0.4	11.65	119.65	71	05	24	1.59	Sandy clay loam
BC	95-160	5.2	4.1	1.41	0.34	0.06	0.26	1.22	0.4	0.3	11.85	130.85	75	10	15	1.65	Sandy clay loam
Profile 03 (Lower slope)																	
Ap	0-15	5.9	4.8	1.90	0.33	0.15	0.47	1.88	0.4	0.3	11.08	36.38	90	08	02	1.29	Sand
AB	15-50	4.8	3.6	1.66	0.56	0.17	0.43	1.07	0.3	0.3	12.50	50.18	88	08	04	1.34	Loamy sand
Bt1	50-90	5.3	3.6	1.43	0.51	0.13	0.40	0.95	0.3	0.2	12.44	53.58	86	10	02	1.41	Sand
Bt2	90-160	5.1	3.6	1.43	0.49	0.14	0.20	1.54	0.3	0.3	11.04	170.32	86	10	04	1.58	Sandy clay loam
Profile 04 (Valley bottom)																	
Ap	0-15	5.7	4.5	1.66	0.31	0.13	0.40	0.94	0.7	0.4	10.65	21.29	86	12	02	1.51	Sandy loam
AB	15-60	5.7	4.3	1.43	0.34	0.11	0.43	0.74	0.8	0.3	11.97	47.95	86	10	04	1.44	Sandy clay loam
Bt1	60-100	5.8	4.1	2.38	0.31	0.21	0.36	1.01	0.7	0.2	12.22	57.77	82	12	06	1.43	Sandy clay
Btg	100-120	5.8	4.5	1.22	0.46	0.38	0.36	0.54	0.9	0.4	11.05	15.01	82	14	04	1.39	Sandy clay

The values ranged from 0.34 to 2.68% and it decreased with increasing soil profile depths. Horizontally, it was observed from the results as shown in Table 1 (Carbon/ Horizon) that horizon with greater depths sequestered more carbon. Therefore, carbon storage increased with increased profile depths and horizon thickness down the profiles.

Traditionally, workers all over the world have studied carbon sequestered in the soil profile from the approach of carbon stored per horizon depth. Using this approach, they have concluded that carbon sequestered in the soil profile increases with increase in soil depth. For instance, Batjes (1996), Mba and Idike, (2011), Aticho, (2013) and Ahukaemere, (2015) observed that as sampling depth of soils increased, organic carbon storage also increased; they noted that deep soil profile allows more carbon accumulation than shallow depths. This reflection was based on the horizon depth (thickness). In as much as horizon depth is high, carbon sequestered will definitely be high since horizon depth is one of the functions of carbon sequestration calculation. In calculating carbon storage in soil, organic carbon is multiplied by bulk density and horizon depth. If carbon sequestration is therefore based on this, one is bound to have more carbon stored in the deeper horizons since as depth of soil increases, horizon thickness also increases. These was based on the facts that higher horizon thickness will definitely yield higher carbon sequestration and thus the reason carbon appeared to be increasing with a rise in horizon depth. Unlike the previous observation, this study discovered that more carbon is stored in the upper horizons than in the deeper horizons. The soil analysis results clearly demonstrate this. This observation in which higher amounts of carbon is sequestered in the upper portions of the profile pits than in the deeper layers can be substantiated. The top soil happened to be the first beneficiary of the organic matter deposition where decomposition and humification process begins. It is also the point of the photosynthetic extraction of carbon into the terrestrial environment from the atmosphere through phyto-mechanisms. Despite the fact that the distance travelled by carbon down the soil profile that is normally captured by plants from the atmosphere is determined by soil type in relation to the parent material from which the soil was formed, the nature of the soil separates, ambient weather conditions of the place, and land disturbances such as cultivation, land-use changes, and other soil management practices; it is important to note that as carbon moves down the soil, there is replacement through the soil and the rate of movement down the soil pedons is usually slower than the rate of replacement from the atmosphere. This therefore, further justifies the reason why more carbon is sequestered in the epicedial layers. Although cultivation and other soil disturbances can lead to loss of carbon from the soil (Schlesinger and Litcher, 2001), findings from this study however, suggests that more carbon were sequestered in the upper layers of the soil than in the inner portions. However, soil management and land-use strategies that promote the deposition of organic materials at the soil's surface should be implemented. As a result, in order to continue reducing carbon in the atmosphere as a means of preventing or moderating global warming (Tieszer, 2000), all sorts of vegetative growth that ensures soil cover should be strongly encouraged. This way, the soil's carbon sinking ability might be possibly exploited, thereby reducing global warming.

CONCLUSIONS

In this study, soil carbon sequestration capacity was measured using regression technique, and it was discovered that sequestered carbon in the soil profile decreased with increasing soil depth. Based on the result, it was concluded that the epipedal parts of soil pedons sequester more carbon than deeper horizons. To maintain this carbon sequestration, soils should be kept covered and with little or no tillage; and other management practices that encourage the deposition of organic residues on the soil surface, such as those highlighted in climate smart agricultural practices, should be implemented to reduce the possibility of more CO_2 escaping into the atmosphere and thus mitigating global warming.

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