Soil carbon management practices, knowledge of climate change and CO_2 emission of some land use types in Ogbomoso Agricultural Zone, Oyo State, Nigeria

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Abstract

The design and implementation of land use management types that would minimize degradation and sustain productivity will require an understanding of the soil dynamic processes that prevail under the different land use types and different ecological zones. This paper investigated four land use types, farmer's soil management practices, knowledge of climate change and effects of land use types on soil carbon and CO_2 emissions in Ogbomoso Agricultural Zone, south-western Nigeria. Multistage sampling techniques were used to select 200 respondents from five Local Government Areas (LGAs) in 20 villages. Information on socio-economic factors, current cropping practices, knowledge of soil types, properties, climate and crop and soil management history was elicited from the respondents. Soil samples from the various land use system were evaluated, while land use system and CO_2 emission were determined. Data were collected with the use of structured questionnaires and described using frequency counts and percentages while Pearson's Product Moment Correlation (PPMC) was used to test the existence of relationships between the pairs of variables. Majority of the respondents were married and had basic education. Fertilizer usage was at the following level, inorganic fertilizers (59%), Manure (27%), compost (14%) and 44% of them have used at least compost, manure or inorganic fertilizers once. Forty-six percent (46%) relied on personal observation as source of climate change knowledge while 91% had ploughed their farm once and 55% had burnt their land once. Sex (r = 0.356**), age(r = 0.383**), education (r = 0.265**) and source of climate change knowledge (r = 0.216*) had decisive influence on the knowledge of climate change among the respondents. On average, maize farms across the two LGAs showed SOC stock deficits of 174,296 kg ha^{-1} corresponding to an emission of about 639,084.68 kg CO_2e ha^{-1}. Effective land management practices should be adopted for enhanced carbon sequestration, climate change mitigation, sustained fertility status and increased agricultural productivity.

Introduction

Numerous studies abound on the impacts of climate change over the past 30 years, indicating its diverse potentials to affect agriculture in different parts of the world (Parry et al., 1999; Tol, 2002a, Tol, 2002b). The effects depends on variables like climatic and soil conditions; type of farming system; direction of change and ability to cope with change, given the infrastructure and resources available to individuals (Olesen and Bindi, 2002).

Emission of greenhouse gases (GHGs) is a major agricultural activity which effects are of global concerns. It results in global warming and climate change (MacCarthy, 2018). The extent to which many developing countries contribute to GHG emissions has not been adequately documented. The problem of CO_2 emission has escalated due to the conversion of forests to agricultural production, urban development and adoption of unconventional practices (Nwite and Alu, 2017). Agricultural land can sequester at least 10% of the current annual emissions of 8-10 Gt/ year (Hansen et al., 2013). Many researchers have proposed the idea that the concentration of CO_2 in the atmosphere can be minimized by sequestering it in terrestrial ecosystems, (Guo et al., 2002, Lal, 2004, Stockmann et al 2013). Kirschbaum (2000) also reported that mineralization of only 10% of the Soil organic carbon (SOC) pool globally can be equivalent to about 30 years of anthropogenic emissions; therefore, there is need to prevent carbon loss (emission) from the soil resource. Stockmann et al. (2013) asserted that carbon sequestration in soils can be a short term solution of reducing CO_2 concentration in the atmosphere until when more effective strategies are found. Soil carbon sequestration reduces the concentration of greenhouse gases (GHGs) in the atmosphere and also complements efforts geared at improving land productivity because all strategies that sequester carbon in soil also improve soil quality and land productivity by increasing soil organic matter (Lal, 2004).

The importance of soil and SOC in soils cannot be overemphasized. Research has shown that soil can reduce the concentration of carbon dioxide (CO_2) in the atmosphere through sequestration of organic carbon in the soil and also through the release of this CO_2 back into the atmosphere by mineralization of soil organic matter (Kirschbaum, 2000). Soil organic carbon sequestration in agricultural soils as climate change mitigating strategy in relation to soil management has become the area of focus. Researchers (Blair et al., 1995; Carter, 2002; Lal, 2014; Nwite and Okolo, 2017) have shown that SOC influences soil physical fertility; chemical and biological properties; improves quality, crop productivity and sustains agricultural soils. Therefore, there is need to preserve the SOC pool since organic matter is the sole indicator of soil degradation (Obalum et al., 2017). Most agricultural soils are degraded (Batjes 2013, IPCC, 2014). They are estimated to have the potential of sequestering up to 1.2 billion tonnes of carbon per year (IPCC, 2014).

The major goal of Sustainable Land Managements (SLMs) is to stabilize or increase the soil organic matter (SOM), which is considered as the “life blood” of tropical soils. The SOM is critical in any soil-plant ecosystem. With respect to soil physical properties, the SOM is a binding agent that improves soil structure (Tisdale et al., 1985; Emerson et al., 1995) and the water holding capacity (Greenhalgh and Sauer 2003). With regard to soil chemical properties and fertility, the SOM is a repository of nutrients such as nitrogen, phosphorus and sulphur (Hudson, 1994). It also contributes to the cation exchange capacity. Lal (2004) also asserted that organic matter improves soil structural stability, water holding capacity, nutrients availability and provide favourable environment for soil organisms. Therefore, it is important to keep healthy and productive soil which can influence the soil to function optimally to increase agricultural production with appropriate soil amendment and crop management practices (MacCarthy et al., 2013). Management practices like reduced tillage, erosion control, diversified cropping systems, improved soil fertility programmes and efficient land use systems ensure soil carbon storage and conform to principles obtainable under sustainable agriculture (Velasco et al., 2016) and should be encouraged as carbon sink practices. No till system is one of the agricultural management systems that has been reported to increase soil carbon and relies on specialized planting equipment, chemical herbicides and genetically modified seed to reduce or eliminate the need for tillage equipment. Several researchers (Cambardella and Elliot, 1992; West and Post, 2002; Grandy and Robertson, 2007; Six et al., 2016) have reported an increase in soil carbon and aggregation. It is also important to note that the effectiveness of a given SLM will vary from one ecological zone to another, since ecological zone reflects the response of vegetation to the type of climate and soils present.

Land use and land–cover change is one of the most common human alterations of the earth's land surface (Foley et al., 2005). Conversion or over-utilization of land by processes such as cultivation, excessive removal of vegetation, burning, tree plantation, and other forms of degradation and restoration can add or remove GHGs from the atmosphere and thereby impact on the global carbon cycle (Pielke, 2005). Some of these land use types experience diverse tillage practices such as periodic slash and burn and/or conventional tillage. The design and implementation of land use management types that would minimize degradation and sustain productivity will require an understanding of the soil dynamic processes that prevail under the different land use types and different agricultural zones. These types of studies are lacking in Nigeria. It is therefore, the purpose of this paper to investigate the effects of four land use types on soil carbon, CO_2 emission, management practices and knowledge of climate change in Nigeria, with a focus on Ogbomoso Agricultural Zone, in the south-western part of the country as the case study.

Materials and Methods

Study sites

This study was carried out in Oyo State, located in the south west geopolitical zone of Nigeria. Ogbomoso Agricultural Zone was adopted in this study. There were five Local Government Areas (LGAs) in this zone namely: Ogbomoso North, Ogbomoso South, Ogo-Oluwa, Surulere and Orire LGAs. The climate of Ogbomoso area can be described as fairly hot, tropical, with marked wet and dry seasons, usually with a short period of harmattan in between. Mean annual rainfall is about 1400 mm while the mean annual temperature is about 27°C. The vegetation can be referred to as Southern Guinea Savannah. The population of the study comprised all registered farmers with the State Agricultural Development Programme in the study area. A multistage random sampling procedure was used to select the respondents. The first stage involved purposive selection of two out of the five LGAs with rural outlook. The second stage involved the random selection of ten villages from each LGA, making a total of twenty villages.

The villages randomly selected from Surulere LGA included Adekunle, Balogun, Idi Opele, Alapata, Baba Egbe, Idi Iyin, Abegunrin, Onikoko, Iresa apa while the ten villages randomly selected from Ogo-Oluwa LGA were Otamokun, Ladanu, Idi-Araba, Opete, Alasunko, Ologburo, Aba Omo Oba, Olugboyepe, Ajaawa and Olukunle. The last stage involved random selection of ten farms from each village making a total of two hundred farmers.

Land use systems and soil sampling

Data on socio-economic characteristics, land use systems and farmers' understanding of soil carbon climate change nexus were collected with the aid of structured questionnaire. Four land use types, namely, maize cropping, cassava cropping, plantations (cashew, mango, plantain and oil palm) and natural forests were selected. Two hundred (200) farms, across the twenty villages were selected and visited from June to August, 2018. Soil samples were taken from each land use type at 0-20 cm soil depth.

At each site, at least 3 maize and 3 cassava farms were sampled in triplicates and bulked to obtain a composite sample for each farm. In addition, soils were sampled in triplicates from plantations and the natural forests and bulked to obtain composite samples. The disturbed top soil (0-20 cm) and separately sampled undisturbed soil cores taken from each land use were taken to the laboratory for analysis. The bulk density was determined on the soil cores. Disturbed soils were air-dried, crushed and sieved through 2-mm sieve for the determination of texture, pH and total soil carbon. Soil texture determination followed the procedure of Bouyoucous (1951) as modified by Day (1965) using sodium hexametaphosphate as the dispersant. Soil pH was determined in 1:1 soil to water ratio using a MV88 Praitronic pH meter and electrode. Total soil carbon was determined using TruMac Carbon, Nitrogen and Sulphur analyzer. The soil carbon content was converted to stocks (C_{st}) following equation from Solomon et al., (2002)

$$C_{st} = A \times \rho_b \times z \times SOC \quad (1)$$

where *A* is the land area (1 ha = 10^4 m^2), ρb is the soil bulk density (kg/m^3) and *z* is the soil depth (0.20 m).

Carbon emission estimation

The soil organic carbon of the pristine forest sites at each sampling location was assumed to represent the maximum or saturation SOC. Therefore, the difference between the forest SOC (SOC_f) and the actual SOC under a given land use system (SOC_a) constituted the carbon lost, which was attributed largely to emissions. The equivalent CO_2 lost by emission was calculated following equation from (IPCC, 2003 and Hairiah et al 2011)

$$CO_2 \text{ emitted} = (SOC_f - SOC_a) \times 44/12 \quad (2)$$

Data analysis

The analytical technique employed for the data collected with the aid of questionnaire included descriptive statistics and Pearson's Product Moment Correlation (PPMC) was used to test the existence of relationships between the pairs of variables. Analysis of variance was used to assess the differences between land use and the soil parameters measured, and LSD post hoc test was carried out at 5% level of significance.

TABLE 1

Socio-economic characteristics of the respondents (N=200)

Variable	Frequency	Percentage
Type of crop planted		
Maize	59	29.5
Cassava	61	30.5
Cashew	60	30.0
Forest	20	10.0
Age (yrs)		
20-40	26	13.0
41-60	108	54.0
61 – 80	66	33.0
Gender		
Male	195	97.5
Female	5	2.5

TABLE 1 *cont.*
Socio-economic characteristics of the respondents (N=200)

Variable	Frequency	Percentage
Marital status		
Married	200	100
Highest education		
Basic	98	49.0
JHS	50	25.0
SHS	38	19.0
Diploma	14	7.0

Source: Field survey 2018

Results

Socio-economic characteristics of the respondents

Thirty percent (30%) of the respondents were cashew farmers, 30.5 % were cassava farmers, 29.5% were maize farmers and only 10 % owned forests. More than half (54%) of the farmers age ranged between 41 and 60 years, 13% were between the age range of 20-40 years while 33% were between the age range of 61-80 years. All the respondents were married. Majority (97.5%) of the farmers were male while only 2.5% were female. Forty nine percent (49%) of the respondents have basic level of education; 25% attended Junior High School, 19% attended Senior High School and 7% had Diploma level of education (Table 1).

Farmers' understanding of soil carbon climate change nexus

The respondents' knowledge of climate change is presented in Table 2. The climate change knowledge of the respondents is low (6.5%). Low proportions of the respondents reported fellow farmers (33.5%) and personal observation (46%) as sources of information on climate change. Some of the farmers had some indigenous knowledge of climate change which they attributed to angry gods and signs of the last days. Their main source of information was via observation of rainfall patterns and the hotness of the environment over time. Climate change knowledge diffusion is from farmer-to farmer, although 8% of farmers indicated some exchange of knowledge and education by agricultural extension officers.

Relationship between farmers selected demographic characteristics and their climate change knowledge level

For the test of significant relationship between the demographic characteristics of the farmers and their climate change knowledge level, the study employed Pearson Product Moment Correlation (PPMC) (Table 3). The results

TABLE 2
Climate change knowledge of the respondents (N= 200)

Climate change knowledge	Frequency	Percentages
High	13	6.5
Medium	115	57.5
Low	72	36.0
Source of climate change knowledge		
Extension officer	16	8.0
Farmer to farmer	67	33.5
Personal observation	92	46
Other (Radio programme)	25	12.5

Source: Field survey 2018

revealed that some of the selected demographic variables such as age (0.383** p≤0.01) sex (0.3456**), Marital status (0.203*), Education (0.2645**), Type of land use (0.268**), Source of climate change (0.524**), Year of experience (0.2680**), exhibited significant positive relationship with the climate change knowledge level of the farmers in the study area.

Soil management and tillage practices of the respondents

About 62% applied inorganic fertilizers to boost crop growth, 29% applied animal manure and 9% used compost (Table 4). The results revealed that majority of the respondents had applied mineral, compost or manure once. Thirty-four percent (34%) and 29% of the respondents used hoeing and ridging, respectively while 26.5% used

TABLE 3

Test of significant relationship between the variables using Pearson correlation analysis

Demographic variables	Correlation coefficient	P-value	Result	Decision
Sex	0.3456**	<0.0001	S	Reject HO
Age	0.383**	<0.0001	S	Reject HO
Marital status	0.203*	0.043	S	Reject HO
Education	0.2645**	0.008	S	Reject HO
Type of land use	0.268	0.005	S	Reject HO
Land tenure	0.062	0.539	NS	Accept HO
Sources of climate change	0.524**	<0.0001	S	Reject HO
Association of membership	0.038	0.705	NS	Accept HO
Year of experience	0.2680**	0.005	S	Reject HO

Source: Field survey 2018

** - Correlation is significant at 0.01 level

* - Correlation is significant at 0.05 level

S- Significant

NS- Significant

TABLE 4

Farmers fertilizer application practices in the study area (N = 200)

Soil management practices	Frequency	Percentage
Inorganic fertilizer		
50 – 100 kg/ha	124	62.0
Manure		
120 – 150 kg/ha	58	29.0
Compost		
200 – 250 kg/ha	18	9.0
Frequency of application		
Once	120	60
Twice	49	24.5
Thrice	19	9.5
Occassionally	12	6.0

Source : Field survey 2018

slash and burn method, and only 10% used tractor on their farms (Table 5). None of the respondents used animal drawn implement but rather preferred the use of normal labour. The table further represents the frequency in which the farmers engage in those tillage practices. Majority (74%) carried out slash and burn and hoeing (60%) once. Table 6 shows that majority (73%) of the farmers used hoe to control weeds while a few respondents (27%) used slash and burn and herbicides. The major (76%) methods of weed control was slash and burn during land preparation; and 18% used herbicides and 6% ploughed their farm to control weeds. More than half (51%) of the respondents had burnt their farmlands at least once to control weeds while a frequency of bush burning of about 10% was carried out by 26% of the respondents and only 23% have >10% frequency of burning. Eighty four percent have once used contact herbicide and 92% have once used residual herbicide.

Land use effects on soil carbon storage

The soil carbon stocks varied with land use type and LGAs. The forests, which were the oldest land use systems, had the highest SOC generally, ranging from 31,174 to 69,964 kg C ha^{-1} for Ogo-Oluwa LGA (Table 7) and 18,988 to 28,428 kg Cha^{-1} for Surulere LGA (Table 8). The general observation showed that except for Idi-araba, Ladanu and Opete in Ogo-Oluwa LGA and Alapata in Surulere LGA, SOC stock declined in the order: forest > plantation >cassava farm >maize farm. The SOC stock also varied with LGAs, with Ogo-oluwa LGA having higher (73%) values than Surulere LGA (43%). Continuous cropping

TABLE 5

Farmers fertilizer application practices in the study area (N = 200)

Management practices	Frequency	Percentage
Tillage practices		
Hoeing	69	34.5
Ridging	58	29.0
Slashing and burning	53	26.5
Tractor	20	10.0
Animal drawn implement	-	-
Frequency of ploughing		
Once	17	8.5
Twice	12	6.0
Thrice	2	1.0
Occasionally	169	84.5
Slash and burn		
Once	149	74.5
Twice	22	11.0
Thrice	51	5.5
Occassionally	18	9.0
Hoeing		
Once	120	60.0
Twice	45	22.5
Thrice	15	7.5
Occassionally	20	10.0

Source: Field survey 2018

TABLE 6
Farmers weed control methods in the study area (N = 200)

Weed control	Frequency	Percentage
Hoeing	146	73.0
Manual	44	22.0
Slashing	1	0.5
Herbicide	9	4.5
Method of weed control		
Slash and burn	152	76.0
Plough	12	6.0
Herbicide	36	18.0
Frequency of bush burning		
0%	102	51.0
10%	52	26.0
>10%	46	23.0
Tree growth control		
Burning	100	50.0
Slash and retain residue	48	24.0
Graze with animals	52	26.0
Herbicide type (contact)		
Once	168	84.0
Twice	26	13.0
Thrice	4	2.0
Occassionally	2	1.0
Herbicide (residue)		
Once	184	92.0
Twice	8	4.0
Thrice	4	2.0
Occassionally	4	2.0

Source: Field survey 2018

TABLE 7
Land use effects on soil carbon storage at Ogo Oluwa Local Government Area

Village	Land use	% C	Total Soil Carbon kg C/ha	Bulk Density (g/cm^3)
Alasunko	Forest	2.25	54942	1.22
	Plantation	0.64	22186	1.72
	Maize	0.56	19973	1.76
	Cassava	0.59	19370	1.64
Idi Araba	Forest	0.81	31174	0.84
	Plantation	0.59	18501	1.74
	Maize	0.65	27900	1.71
	Cassava	0.86	22746	1.51
Ladanu	Forest	2.15	61001	1.42
	Plantation	1.24	37172	1.57
	Maize	1.02	37482	1.83
	Cassava	0.64	23268	1.94

TABLE 7 *cont.*

Land use effects on soil carbon storage at Ogo Oluwa Local Government Area

Village	Land use	% C	Total Soil Carbon kg C/ha	Bulk Density (g/cm^3)
Opete	Forest	2.10	66789	1.59
	Plantation	0.60	21252	1.74
	Maize	1.06	39491	1.85
	Cassava	0.64	22952	1.80
Otamokun	Forest	2.01	69964	1.74
	Plantation	0.84	28049	1.67
	Maize	0.87	27518	1.58
	Cassava	0.88	29240	1.66
Land use LSD 0.05		0.274**	8597.8**	0.11*
Village LSD 0.05		0.306*	9612.6*	0.12*
Land use * Village LSD 0.05		0.611*	19225.3ns	0.24**

TABLE 8

Land use effects on soil carbon storage at Surulere Local Government Area

Village	Land use	Bulk density (g/cm^3)	Total Soil Carbon Kg C/ha	%C
Adekunle	Forest	1.16	23803	1.023
Adekunle	Plantation	1.31	22654	1.003
Adekunle	Cassava	1.11	20968	0.94
Adekunle	Maize	1.34	16167	0.607
Alapata	Forest	1.41	18988	1.176
Alapata	Plantation	0.79	16877	1.067
Alapata	Cassava	1.31	17238	0.658
Alapata	Maize	1.40	15643	0.629
Baba Egbe	Forest	1.02	27042	1.685
Baba Egbe	Plantation	1.21	25029	1.042
Baba Egbe	Cassava	1.49	24808	0.834
Baba Egbe	Maize	1.38	19548	0.706
Balogun	Forest	0.91	25934	1.659
Balogun	Plantation	1.10	23199	1.053
Balogun	Cassava	1.39	20101	0.94
Balogun	Maize	1.13	14996	0.664
Idi Opele	Forest	0.90	28428	1.47
Idi Opele	Plantation	1.28	24847	1.184
Idi Opele	Cassava	1.20	15249	0.643
Idi Opele	Maize	1.36	15056	0.999
Landuse LSD 0.05		0.05699**	5173.6*	0.2396*
Village LSD 0.05		0.06371**	5784.3 ns	0.2679 ns
Land use*village LSD 0.05		0.12742**	11568.5 ns	0.5358 ns

TABLE 9

Soil Carbon Loss and Estimated CO_2 Equivalent Emission in Surulere Local Government Area

Village	Land use	Mass of Carbon loss (kg C/ha)	Equivalent CO_2 Emission (Kg CO_2 e/ha)
Adekunle	Plantation	1152	4224
Adekunle	Cassava	2838	10406
Adekunle	Maize	7639	28009.67
Alapata	Plantation	2111	7740.33
Alapata	Cassava	1750	6416.67
Alapata	Maize	3345	12265
Baba Egbe	Plantation	2013	7381
Baba Egbe	Cassava	2234	8191.33
Baba Egbe	Maize	7494	27478
Balogun	Plantation	2735	10028.33
Balogun	Cassava	5833	21387.67
Balogun	Maize	10938	40106
Idi Opele	Plantation	3581	13130.33
Idi Opele	Cassava	13179	48323
Idi Opele	Maize	13372	49030.67

Mass of carbon loss = $TSC_{forest} - TSC_{actual\ land\ use}$

Equivalent CO_2 Emission Kg CO_2 e/ha = Mass of carbon loss X 44/12

with cassava and maize had negative effects on the SOC stocks. At Ogo-Oluwa LGA Farms, maize farming reduced the SOC stock to 39,491 kg Cha^{-1}, which was about 43.5% of the forest SOC stock. For Surulere LGA, continuous maize cropping reduced the SOC stock by 27.7 % of that of the forest. The Cashew plantation farms had higher SOC stock compared to arable farms. At Alasunko in Ogo-Oluwa LGA, Cashew plantation had SOC stocks which were around 60% of the forest SOC.

Carbon Emission and Losses

If the forest SOC represents the upper limit of the soil carbon storage, and reduced carbon stocks in croplands assumed to be largely due to emission losses, then continuous cropping is a major driver of these emissions. Continuous maize cropping, at Idi Opele village farms, resulted in carbon deficit of 13,372 kg ha^{-1} or a corresponding emission of 49030.67 kg CO_2e ha^{-1} (Table 9). Similarly, large emissions were calculated for all the sampling locations under maize cropping except Baba Egbe and Alapata villages. On average, maize farms across the two LGAs showed SOC stock deficits of 174,296 kg ha^{-1} corresponding to an emission of about 639,084.68 kg CO_2e ha^{-1} (Tables 9 & 10). In contrast, Cashew plantation systems narrowed lower SOC deficits and may also have sequestered atmospheric carbon over time. The carbon stock gap analyses show that most of the cultivated soils in the two LGAs

TABLE 10
Soil carbon loss and estimated CO_2 equivalent emission in Ogo Oluwa Local Government Area

Village	Land use	Mass of Carbon lost (kgC/ha)	Equivalent CO_2 Emission (Kg CO_2 e/ha)
Alasunko	Plantation	32756	120105.33
Alasunko	Cassava	35572	130430.67
Alasunko	Maize	34969	128219.67
Idi Araba	Plantation	12673	46467.67
Idi Araba	Cassava	8428	30902.67
Idi Araba	Maize	3274	12004.67
Ladaanu	Plantation	23829	1187373
Ladaanu	Cassava	37733	138354
Ladaanu	Maize	23519	86236.33
Opete	Plantation	45537	166969
Opete	Maize	27298	100092.67
Opete	Cassava	43837	160735.67
Otamokun	Plantation	41915	153688.33
Otamokun	Cassava	40724	149321.33
Otamokun	Maize	42448	155642.67

Mass of carbon loss = TSC_{forest} - $TSC_{actual\ land\ use}$
Equivalent CO_2 Emission Kg CO_2 e/ha = Mass of carbon loss X 44/12

were highly degraded. The cultivated soils held less than 45% of the forest SOC which showed that a large amount of carbon has been lost over time.

Discussion

The study surveyed soil carbon, management practices, knowledge of climate change and CO_2 emission of farmers in Ogbomoso Agricultural Zone of Oyo State, Nigeria. The observed proportion of the respondents interviewed that had basic education is an indication of educational exposure (level of literacy) on farmers' practical field knowledge and level of adoption of farm technologies. The literates could have had access to many extension materials and more knowledge on carbon and CO_2 emission. This position agrees with the findings of Oladosu and Okunade (2006) in Nigeria who reported that farmers' level of literacy can improve farmer's right perception of agricultural problems and how to proffer solution to them. Chirwa (2005) also reported that in southern Malawi, literacy level had positive relationship with the level of adoption of fertilizer technology among smallholder farmers. The sampled farmers were still in their active years and this active age is likely to make them more responsive to adoption of new innovations. The observed major source of information on climate change being farmer to farmer and personal observation, calls for a need for availability of reliable sources of information to acquaint farmers with the numerous dimensions of climate change. The low organic carbon in arable lands may be due to the fact that the soils under forest and plantation land use were always covered, which had not been subjected to intense cultivation as compared to the arable land use types (Senjobi and Ogunkunle, 2010). The low carbon stocks also suggest that there were opportunities to increase SOC, not only to mitigate climate change, but also improve soil productivity. The extent to which a community is aware of climate change reflects its level of exposure to climate risks. Lack of sufficient knowledge about climate change and impact on agricultural production is an impediment to long term sustainable agriculture in most developing countries. In this research work, SOC was impacted differently by the different combinations of soils and farming practices and these can be corrected through changes in agronomic practices (Robertson et al., 2015, Zhao et al., 2013). Use of inorganic fertilizer and incessant use of chemical fertilizers have been reported to result in depletion of soil micronutrients, environmental and health hazards (Ramesh et al 2005). Though the use of inorganic fertilizers is positively correlated to increased agricultural productivity (Cameron et al., 2013), their continuous use can have detrimental effects on soil quality, such as soil acidification and subsequent reductions in crop yield (Ogunwole et al., 2010; Cameron et al., 2013, Gilbert et al., 2014,). Besides, the production of inorganic fertilizers often incurs environmental consequences. Cherkadov et al. (2015) reported that about 60% of chemicals used in agriculture with respect to N, are produced using the Haber Bosch process which consumes large quantities of energy and produce concomitant quantities of CO_2. Also, only few farmers used compost and animal manure which are alternative sources of plant nutrients that can enhance soil fertility without adverse effects on the soil (Thomas et al., 2019). Onunwa et al. (2018) asserted that use of amendments in the tropics has the potential to increase production because the soils are highly weathered; hence it is a core strategy in restoring soil fertility as well as raising crop productivity. It was also reported that the amount of organic matter (OM) in the soil as well as the rate of OM turnover were influenced by agricultural management practices and because OM is composed of a series of fractions, management practices also influence the distribution of organic carbon among SOM pools (Godde et al., 2016). Adeoye et al. (2005) also asserted that decline in soil fertility due to inherent fragile characteristics of the tropical soils have resulted to progressive decrease in capacity of tropical soils to grow food and fibre. Moreover, the quantity and quality of litter falls and field layers, different temperature condition and soil management may be responsible for the increase in high organic carbon stocks of forest and plantation land uses. Maintaining soil organic matter is critical to tackling climate change because soil organic matter is rich in carbon. Soil carbon is also the keystone element controlling soil health, which enables soils to be resilient as droughts and intense rainfall events increasingly occur. Agricultural practices that truly mitigate climate change cannot sequester SOC, but must at the same time limit emissions of other GHGs. In this study, plantation and forest land uses recorded low CO_2 emissions. This was despite the high organic matter content of their soils. This could be attributed to the low level of soil disturbance in the two land use types.This implies that maintaining forest reserves and promoting agroforestry and plantation crops is highly desirable for mitigating climate change.

Conclusion and recommendation

In this study, we investigated the impact of four land uses, namely: (i) maize farms (ii) cassava farms (iii) plantations and (iv) natural forests at different locations within Ogbomoso Agricultural Zone of Oyo State, Nigeria. Land use, soil and tillage practices affected soil organic carbon. Most of the cultivated soils are highly degraded, have low carbon stocks which was assumed to be due to emission losses because of continuous cropping. Farmers' knowledge on climate change needs to be improved through taking steps like extension media contact; training, organizational participation and raising the level of adoption of the farmers. Establishment of more organizations, more training facilities and greater farmers' involvement with those that will increase their knowledge on climate change can also be helpful. Extension agents should also increase their contact period with farmers; more training and demonstration programmes should be organized for farmers. Government policies should be initiated to improve household access to extension services and access to credits and information which would improve and diversify farmers' knowledge.

References

Adeoye, G. O., Sridhar M. K. C., Adeoluwa O. O. and Akinsoji N. A. (2005). Evaluation of naturally decomposed solid wastes from municipal dump sites for their manurial value in southwest Nigeria. *Journal of Sustainable Agriculture* **26**, 143-152.

Batjes, N. H. (2013). Reader for the soil carbon benefits module. In: *Proceedings of the ISRIC Spring School*; April 22-26, Wageningen University Campus, The Netherlands. pp. 1-16.

Blair, G. J., Lefroy, R. B. D. and Lisle, L. (1995). Soil carbon fractions based on their degree of oxidation and the development of a carbon management index for agricultural systems. *Australian Journal of Soil Research* **46**, 1459-1466.

Bouyoucous, G. H. (1951). A recalibration of the hydrometer for making mechanical analysis of soils. *Agronomy Journal* **43**, 434-438.

Cambardella, C. A. and Elliott, E. T. (1992). Particulate Soil Organic-Matter Changes across a Grassland Cultivation Sequence. *Soil Science Society of American Journal* **56(3)**, 777–783.

Cameron, K. C., DI, H. J. and Moir, J. L. (2013). Nitrogen losses from the soil plant system a review. *Annals of applied biology* **162**,145-173.https://doi.org/10.1111/aab.12014

Carter, M. R. (2002). Soil quality for sustainable land management: organic matter and aggregation interactions that maintain soil functions. *Agronomy Journal* **94**, 38 - 47.

Cherkasov, N., Ibhadon, A. and Fitzpatrick, P. (2015) A review of the existing and alternative methods for greener nitrogen fixation. *Chemical Engineering and Processing*. **90**, 24-30.https://doi.org/10.1016 /j. cep. 2015.02.004.

Chirwa, E. W. (2005). Adoption of fertilizer and hybrid seeds by smallholder maize farmers in Southern Malawi. *Developing Southern Africa* **22 (1)**, 1-12.

Day, P. R. (1965). Particle fractionation and particle size analysis. In: Black et al. (Eds) Methods of soil analysis, Part I. *Agronomy* **9**, 545-567.

Emerson, W. W. (1995). Water retention, organic carbon and soil texture. *Australian Journal of Soil Research* **33**, 241–251.

Foley, J. A., Defries, R., Asner, G.P. et al (2005). Global consequences of land use . *Science* 309, **5734**:570-574. Doi: 10.1126/science.1111772.

Grandy, A. S. and Robertson, G. P.

(2007). Land-Use Intensity Effects on Soil Organic Carbon Accumulation Rates and Mechanisms. *Ecosystems* **10**, 9–74. https://doi.org/10.1007/s10021-006-9010-y.

Greenhalgh, S. and Sauer, A. (2003). Awakening the Dead Zone: An investment for Agriculture, Water Quality and Climate Change. World Resources Institute. Available at:<http://www.wri.org/publication/awakening-dead-zone-investment-agriculture-water-quality-and-climate-change>Last accessed Sep 2, 2009.

Gilbert, P., Alexander, S., Thornley, P. and Brammer, J. (2014). Assessing economically viable carbon reductions for the production of ammonia from biomas gasification. *Journal of Clean Production* **64**,581-589.https://doi.org/10.10.1016/j.fcr.2011.01.014.

Godde, C. M., Thorburn, P. J., Biggs, J. S. and Meier, E. A.(2016). Understanding the impacts of soil, Climate, and farming practices on soil organic carbon sequestration: A simulation Study in Australia. *Frontiers Plant Science* **7**, 661 http.//.,doi.org/10.3389/fpls.2016.00661.

Guo, L. B., Gifford, R. M. (2002). Soil carbon stocks and land use change: A meta analysis. *Global Change Biology* **8**, 345-360.

Hairiah, K., Dewi, S., Agus, F., Ekadinata, A., Rahayu, S. and van Noordwijk, M. (2011). Measuring carbon stocks across land use systems: a manual, Bogor, Indonesia, World Agroforestry Centre (ICRAF), SEA Regional Office, Brawwijaya University and ICALRRD (I ndonesian Centre for Agricultural Land Resources Research and Development), pp 1-154

Hansen, J., Sato, M., Kharecha, P., Beerling, D., Berner, R., Masson-Delmotte, V., Pagani, M., Raymo, M., Royer, D.L. and Zaches, J. C. (2013). Target atmospheric CO2: Where should humanity aim? *The Open Atmosphere Science Journal* **2**, 217-231.

Hudson, B. D. (1994). Soil organic matter and available water capacity, *Journal of soil and water conservation* **49**, 189-194.

Intergovernmental Panel on Climate Change (IPCC) (2003). Good practice guidance for land use, land use change and forestry, in Penman, J., Gytarsky, M. Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K.., Ngara, T., Tanabe, K. and Wagner, F. (Eds), IPCC National Greenhouse Gas Inventories Programme, Institute for Global Environmental Strategies (IGES), Kanagawa

Intergovernmental Panel on Climate Change (IPCC). (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, R. K. Pachauri and LA. Meyer (eds.) IPCC, Geneva, Switzerland, 151pp.

Kirschbaum, M. U. F. (2000). Will changes in soil organic carbon act as a positive or negative feedback on global warming? *Biogeochemistry* **48**, 21-51.

Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. *Science* **304**, 1623-1627.

Lal, R.(2014). Societal value of soil carbon. *Journal of Soil and Water Conservation* **69(6)**,186-192Adoi:10.2489/jswc.69.6.186A

MacCarthy, D. D., Agyare, W. A., Vlek, P. L.G. and Adiku, S. G. K. (2013). Spatial variability of some soil chemical and physical properties of an agricultural landscape. *West African Journal of Applied Ecology* **21(2)**, 47-61.

MacCarthy, D. S., Zougmore, R. B., Akponikpe, P. B. I., Koomson E., Savadogo P. and Adiku, S. G. K. (2018). Assessment of Greenhouse Gas Emissions from different land use systems: A case study of CO_2 in the southern zone of Ghana. *Applied and Environmental soil science.* 2018: 12 pages. https//doi.org/10.1155/2018/1057242.

Nwite, J. N., Okolo, C. C. (2017). Organic carbon dynamics and changes in some physical properties of soil and their effect on grain yield of maize under conservative tillage practices in Abakaliki, Nigeria. *African Journal of Agricultural Research* **12**, 2215 -2222.

Nwite, J. N. and Alu M. O. (2017). Carbon Sequestration and Assessment of fertility status of soil under different land uses for agronomic potentials in Abakaliki South Eastern Nigeria. *African Journal of Agricultural Research* **12(11)**, 871-880.

Obalum, S. E., Chibuike, G., Peth, S. and Ouyang, Y. (2017). Soil organic matter as sole indicator of Soil degradation. *Environmental monitoring and assessment* **189(4)**, 176. Doi:10.1007/s10661-017-5661-y.

Ogunwole, J. O., Iwuafor, E. N. O., Eche, N. M. and Diels, J. (2010). Effects of organic and inorganic soil amendments on soil physical and chemical properties in a West African savanna agro-ecosystem. *Tropical and Sub Tropical Agroecosystems* **12**, 247-255.

Oladosu, I. O., Okunade, E. O., (2006). Perception of village extension agents in disseminating agricultural information in Oyo Agricultural zone of Oyo State. *Journal of Social Science* **12 (3)**,187- 191.

Olesen, J. and Bindi, M. (2002). Consequences of climate chage for European agricultural productivity, land use and policy. *European Journal of Agronomy* **16(4)**, 239-262.

Onunwa, A. O., Igwe, C. A. and Mbonu, O. A. (2018). Tillage and Residual effect of some organic amendments on aggregate associated soil carbon of an Ultisol, growth and yield of maize and cowpea intercrop. *Nigerian Journal of Soil Science* **28 (2)**, 31-41

Parry, M. L., Rosenweig, C., Iglesias, A., Livermore, L. and Fisher, G. (1999). Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change* **14**, 53-67.

Pielke, R. A. (2005). Land use and climate change. *Science* **310**, 1625-1626.

Ramesh, P., Singh, M. and Subbaro, A. (2005). Organic farming: Its relevance to the Indian context. *Current Science* **88**, 561-569.

Robertson, F., Armstrong R., Partington D., Perris,R., Oliver, I., Aumann, C., et al., (2015). Effects of cropping practices on soil Organic carbon: Evidence from Long Term Field Experiments. (Victoria: CSIRO Publishing) **53 (6)**, 36-64. Doi.1071/SR14227.

Senjobi, B. A. and Ogunkunle, A. O. (2010). Effects of land use on soil degradation and soil productivity decline on Alfisols and Ultisols in Ogun State in South Western Nigeria. *Agriculturae Conspectus Scientificus* **75 (1**), 9-19.

Six, J., Frey, S. D., Thiet, R. K. and Batten, K. M. (2006). Bacterial and Fungal contributions to Carbon Sequestration in Agrosystems. *Soil Science Society of America* **70(2)**, 555-569.

Solomom, D., Fritzsche , F., Lehmann, J., M. Tekalign and Zech W. (2002). Soil Organic Matter Dynamics in the Subhumid Agroecosystems of the Ethiopian Highlands. Evidence from natural 13C Abundance and particle size fractionation. *Soil Science Society of American Journal* **66**,969-978. https://doi.org/10.2136/ssaj2002.9690.

Stockmann, U., Adams, M., Crawford, J. W., Field, D. J., Henakaarchchia, N., Jenkins, M., Minasnya, B., McBratneya, A.B., de Courcelles, V. D., Singha, K., Wheeler, I., Abbott, L., Angers, D. A., Baldock, J., Birde, M., Brookes, P. C., Chenug, C., Jastrow, J. D., Lal, R., Lehmann, J., O'Donnell, A. G., Parton, W., Whitehead, D. and Zimmermann, M. (2013). The knowns, known unknowns and unknowns of sequestration of soil organic carbon. *Agriculture, Ecosystems and Environment.***164**, 80-90

Thomas, E. Y., Adiku, S.G.K., Atkinson, C. J. Omueti, J. A. I. and MacCarthy, D. S. (2019). Evaluation of CO2 Emission From RiceHusk Biochar and Cowdung Manure Co-compost preparation. *Journal of Agricultural science* **11 (17)**, 158-166.

Tisdale, S. L. , Nelson, W. L. and Beaton, J. D. (1985). Soil Fertility and Fertilizers (Fourth ed.). Macmillian: New York, NY: Collier Macmillian London. 754pp.

Tol, R. S. (2002a). Estimates of the damage costs of climate change: Part 1- Benchmark Estimates. *Environmental and Resource Economics* **21(1)**, 47-73.

Tol, R. S. (2002b). Estimates of the Damage Cost of Climate Change: Part 2 - Dynamic Estimates. *Environmental and Resource Economics* **21(2)**, 135-160.

Velasco, E, Roth, M. Norford, L. and Molina, L.T. (2016.) "Does urban Vegetation enhance/sequestration. *Landscape and Urban Planning* **148**, 99-107.

West, T. O. and Post W. M. (2002) Soil Organic Carbon Sequestration Rates by Tillage and Crop Rotation. *Soil Science Society of America Journal* **66**, 1930-1946.

Zhao, G., Bryan, B. A., King, D., Luo, Z., Wang, E., Song, X., et al. (2013). Impact of agricultural management practices on soil organic carbon: Simulation of Australian wheat systems. *Global Change Biology* **19**, 1585-1597. Doi: 10.1111/gcb. 12145.