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ASSESSMENT OF SOIL MANAGEMENT WITH POTENTIALS OF MITIGATING GREEN HOUSE GASES IN DUTSE LOCAL OVERNMENT, JIGAWA STATE

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Abstract

The release of greenhouse gas from soils has global implications because it occurs in ecosystems worldwide and its magnitude is such that it contributes significantly to the greenhouse effect**.** This research aimed to assess the soil-management strategies espoused by the intergovernmental panel for climate change (IPCC) with the potential of mitigating greenhouse gas emission while, the specific objectives are, to observe and examine how the management practices identified can mitigate the greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC) has identified a number of soil management practices that can be implemented to reduce greenhouse gas emissions. However, before examine how some soil management can mitigate greenhouse gas emissions it is important to observed and identify specific soil management practices in the area. To mitigate the greenhouse gas emission from the soil, the potentiality of some soil management for mitigating greenhouse gas emission were evaluated. The methodologies adopted in this research are direct observations and questionnaire survey, hundred questionnaire were administered in the study area in which the respondents were identified accidently in their farms. Nutrient management (42%), crops management (18%) residue management (17%), soil restoration (14%) and water management (9%) were identified as soil management practice with potential of mitigating greenhouse gases emission in the study area. Planting trees, use of organic manure and minimum tillage were recommended to reduce the greenhouse gas emission from the soil of the study area.

Keywords: Climate change, Greenhouse gas emission, Soil management and Carbon

INTRODUCTION

Soil carbon is the foundation of soil quality, and a healthy soil is essential for sustainable global biofuel/bioenergy and food production systems. While soil management improves soil quality, increases biodiversity and sequesters carbon, it is also environmentally beneficial and economically viable for agriculture and should be supported and endorsed through policy mechanisms so that worldwide adoption is increased and global benefits are realized (Davidson *et al.*, 2006). Soils are the fundamental foundation of our food security, global economy and environmental quality(Lal, 2007).Soil quality is largely governed by soil organic matter (SOM) content, which is a dynamic pool and responds effectively to changes in soil management, primarily tillage and carbon inputs resulting from biomass production (Betjes, 1998). Maintaining soil quality and soil health can reduce problems of land degradation, decreasing soil fertility and rapidly declining production levels that occur in large parts of the world which lack the basic principles of good farming practices. In view of the rapidly expanding global population and, therefore, the pressure on the finite amount of land available for agricultural production, we must learn and communicate the importance of protecting our soils and natural resources. Lal (2004), reported that soil, and specifically sound soil management, is essential in our continued quest to increase the production of food, feed, fiber, and fuel while maintaining and improving the environment, and mitigating the effects of climate change. Being the essence of all terrestrial life and ecosystem services, we cannot take the soils for granted. Soil is the basis of survival for present and future generations." So it’s important to minimized further loss of carbon stock by more judicious soil management such as avoiding land degradation (Bellamy *et al.*, 2005).

The essence of soil conservation is carbon management. By properly managing the carbon in agricultural ecosystems, we can have less erosion, less pollution, clean water, fresh air, healthy soil, natural fertility, higher productivity, increased biodiversity and sustainability(Bellamy *et al*., 2005). Dynamic soil quality encompasses properties that can change over relatively short time periods (like SOM, labile SOM fractions, soil structure components, and macro porosity) in response to human use and management with agronomic practices. The SOM is both inherent, as total SOM related to particle size distribution, and dynamics, as it is related to ongoing inputs of organic matter to the soil. A dynamic part of soil carboncycling is directly related to the “biological carbon” cycle(Lal, 2004).

There is general agreement that although soil is part of the climate change problem, it also can be an integral part of the solution. The extent to which soil emits greenhouse gases (GHGs) and to what extent the processes leading to these emissions can be reduced will need further work to be better understood and quantified. However, it is clear that reduction of emissions from agricultural activities can be addressed by restoring degraded/desertified ecosystems, adopting appropriate soil management practices, including conservation agriculture, maintaining carbon in soil and, if at all possible, by increasing soil carbon and reducing GHG emissions and the use of emission-creating inputs. Enabling and encouraging broader adoption of conservation agriculture practices through market-based mechanisms will create the catalyst necessary to elevate agriculture’s role as a key part of a global approach to mitigating climate change.

The adoption of the Kyoto Protocol in December 1997 was a significant step towards tackling the problem of global climate change at the dawn of the 21st century. The Protocol states that sinks and sources of carbon must be accounted for “taking into account uncertainties, transparency in reporting, and verifiability.” Included are three carbon market-based mechanisms that allow credits for projects aimed at reducing anthropogenic emissions from sources or enhancing anthropogenic removals by sinks of greenhouse gases. The three mechanisms are: Emissions Trading (ET), the Clean Development Mechanism (CDM) and Joint Implementation (JI).Soil carbon sequestration currently does not fit under ET, CDM or JI and neither Article 3.3 nor 3.4 of the Kyoto Protocol specifically include soil carbon as an option. Yet, this is precisely what is needed to commodify soil carbon and create another income stream for resource-poor and small size land holders (Metz *et al*., 2006).

Indeed, this is an essential pre-requisite to widespread adoption of recommended management practices in the developing countries where the problems of food insecurity and soil degradation are extremely severe.The potential of soil management from improvement of soil quality on small farm to the mitigation of global climate change – is too incredible to ignore. More work is needed – through research, application and policymaking – to expand the current understanding and adoption of soil management. With increasing concerns for global food and energy security, economic stability and environmental sustainability, the time for action is now.

Campbell (2008) stated that "The time is ripe for refocusing on soil stewardship as a key to improving water and energy productivity, and food security while reducing net greenhouse gas emissions from agriculture. It was estimated that, out of the global carbon content of 1.500 Gt, soil represent the largest carbon sink on our planet and about 99% of the world's food and fibres are produced on soil (Amundsen, 2001). If that is the case, thorough assessment and understanding of how soil can be manipulated to increase carbon sequestration is crucial for mitigating greenhouse gas (GHG) emissions. By considering the role played by the soil in mitigating greenhouse gas, this study is essential.

This paper aimed to assess the extent of various soil management that lead to GHG emission while, the objectives are to assess the soil disturbances with potential of greenhouse gases emission and management practice with the potential of reducing GHG emission in the soil of the area.

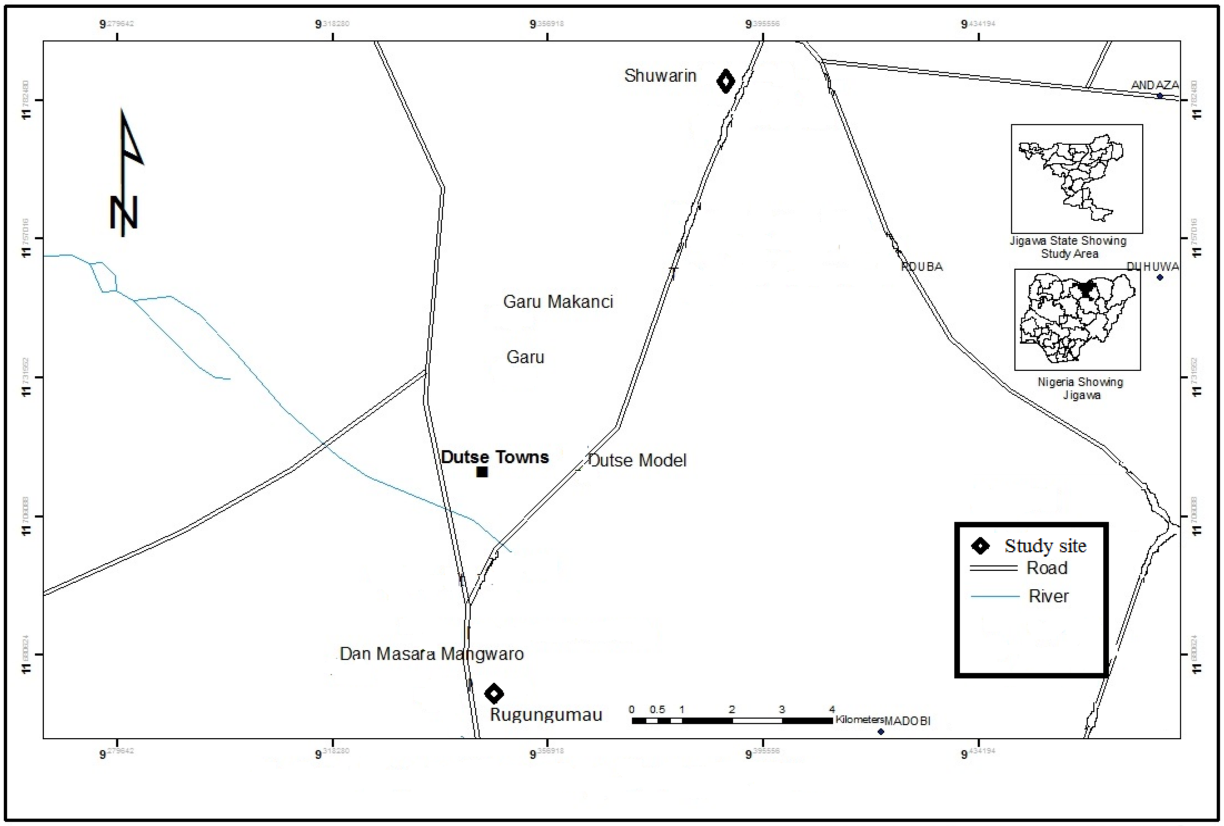
POLICY CHANGES REQUIRED FOR CLIMATE CHANGE MITIGATION THROUGH SOIL CARBON MANAGEMENT

A policy framework is needed to address the economic, social and technical issues related to environmental quality and sustainability. To some, extent carbon in the atmosphere is a problem because of its contribution to global warming; while limited carbon in the soils is a problemleading to environmental degradation. Soil carbon sequestration in conservation agriculture offers the opportunity to bring these two concerns together and provide a mutually beneficial solution. New integrated policies are required to encourage acceptance and application of new technology related to soil carbon benefits.Being very dynamic, soil carbon can change drastically as a result of inversion tillage and low-diversity cropping systems. While technology is improving, the total carbon changes may be relatively small for many agricultural management practices and thus long periods may be required to quantify small differences in carbon accumulation (Amundsen, 2001).In addition, the recent visionary action taken by U.S. Senator Sherrod Brown and several colleagues in the U.S. Senate of the 110th Congress to pass Senate Resolution 440 on June 23, 2008, helped to usher in legislation that recognizes soils as an "essential" natural resource. This resolution recognizes the importance of soil and the importance of soil professionals in managing our nation's soil resources. It also places soil on par with water and air. For the first time, soil is recognized as impacting climate, water and air quality, human health, biodiversity, food safety and overall agricultural production.

METHODOLOGY

Study area

Dutse Local Government is located between latitudes $11^0$14” and $11^0$73”N and longitudes $9^0$17” and $9^0$29’E and lies within the low latitude as Sudan Savanna type (Strahler 1969). The soil of the area is ferrugineous type which is well drained and is often fine sand texture, sandy loam and very permeable, it was formed through several alternating wet and dry condition (Olofin 1987 and Oguntoyinbo 1978). Two villages were purposively selected in Dutse local government area one located in the western part of Dutse town called Rugungumau and the other one in the eastern part of the Dutse called Shuwarin, they are selected because of their homogeneity in crops grown and agricultural practices (Fig.1). Fifty copies of questionnaire were administered to the farmers in each of the village selected. The respondents were selected accidently since the questionnairewas administered to farmers found in the farm.



Source: Cartography Lab Geography Department B.U.K 2015

Figure 1. Dutse local government showing study locations

RESULTS AND DESCUSSION

The sum total of all tillage operations, cropping practice, fertilizer, lime and other treatments conducted on or applied to a soil for the production of plant is regarded as soil management (Brady and Weil, 1999). However, IPCC (2007); identified a number of soil management practice that can mitigate GHG emission. A successful soil management practice that significantly sequesters carbon will maximize carbon inputs, minimize carbon outputs and achieve an economic balance that will favor the farmers in the area. The reduction of carbon outputs is achieved by reducing mechanical soil disturbance, which leads to increased mineralization and soil carbon loss, as much as possible.

Soil Management Practices with the Potential of Mitigating Green House Gases

Five soil management practices with the potential of mitigating GHG were identified in the area through questionnaire, (Table 1).

Based on the analyses of questionnaire administered to the farmers in the study area, nutrient management, crops management and residue management are the major soil managements identified in the two study area

Nutrient management is the major management practice in the study area followed by crop management and residue management. However, the farmers in the areas paid less attention to water management (Table 1). Due to the homogeneity in climate, soil types, topography, vegetation and land uses among the study areas, soil management practices with potential of mitigating greenhouse gases were considered equal in the two location.

Crops management

Rigungumau and Shuwarin villages were characterized by a wet and dry climate (Strahler, 1969) thereby several ways to improve crop management for greenhouse gases mitigation were assessedsuch as planting leguminous crops, crop rotations, crops residue, use of high yield crops and cover crops, as shown in figure 2. Crops management recorded 18% and 16% for Shuwarun and Rugungumau area respectively, this indicated that it's the second dominant soil management practice in the after nutrient management (table 1)

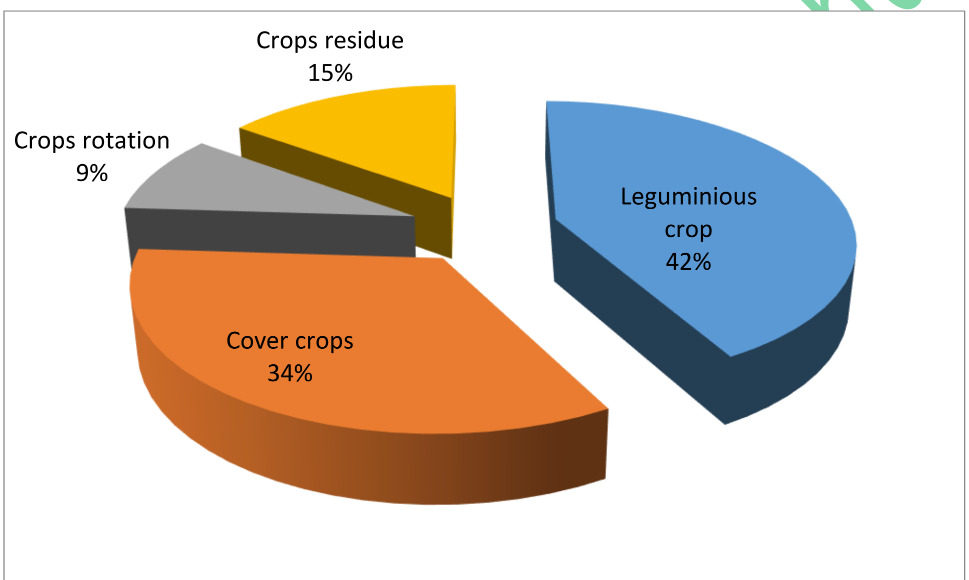


Figure 2. Crops management

Leguminous crops

From the questionnaire leguminous crops, 42% of the respondent shows that, use of leguminous crops is the best way to increase the soil fertility and has the potential to mitigate GHG emission, such crops like beans and groundnut, has the potential to reduce greenhouse gas emissions primarily because they enhance Nitrogen to the soil thereby reduce the need for N-fertilization and consequently save 50-200 kg N/ha depending on the crop they replace (FAO, 1991). Furthermore, leguminous crops have a pre-crop effect of 10-100 kg N/ha on the subsequent crop. Estimates of greenhouse gas emissions from inorganic fertilizer production and application show that total greenhouse gas emissions range from 0.8 to

10.0 kg CO_2-eq per kg fertilizer-N produced and from 0.8 to 6.7 kg CO_2-eq per kg N applied in the field.This means that for every 100 kg fertilizer-N saved, the emission of as much as 1.7 t CO_2-eq is potentially avoided. Some leguminous crops have a higher demand for water than other crops, whereas other leguminous crops have lower demand, so the net effect on water resources is likely to be zero (FAO 1991).

Cover crops

Based on the respondents, cover crops cultivation is the second dominant crop management practice covering about 30% among the soil management in the area. The beneficial effect of using soil conservation for enhancing soil organic carbon concentration are noticeable when used in conjunction with cover crops and planting more trees (Batjes 2002). This is supported by Mohammed and Mukhtar, (2014) who reported that cover crops are identified as a way of soil carbon sequestration in dry land environment because they enhance soil organic matter, improve soil structure, prevent the soil from exposure to leaching and erosion. It was observed and comfirmed from the study site that some trees such as parkia species normally enhance the fertility of their soil and the crops planted around the trees grow rapidly and produce more than those far away from the tree.

Crop rotation

Crop rotation account for 9% of crop management in the study area (figure 2) and can sequester carbon by increasing the fraction of perennial crops like cassava.

Crops residue

This is a situation whereby farmer leave their crops residue with intention to decompose in to organic matter. Fifteen percent (15%) of the respondents show that they leave their crop residue in their farm to enhance their soil fertility while many of them shows that they are using the crop residue to feed their livestock and some use it for fuel. This is adduced by Mohammed (2004, 2014) who reported that crops residue increase soil organic matter thereby enhancing the soil quality and reduce greenhouse gas emission.

3.1.2 Nutrient Management

Nutrient management is the dominant soil management practice in the study area which cover the 42% and 54% of the respondent for Shuwarin and Rugungumau area respectively table 1.However, their nutrient management centered on the application of inorganic and organic fertilizer figure 3.

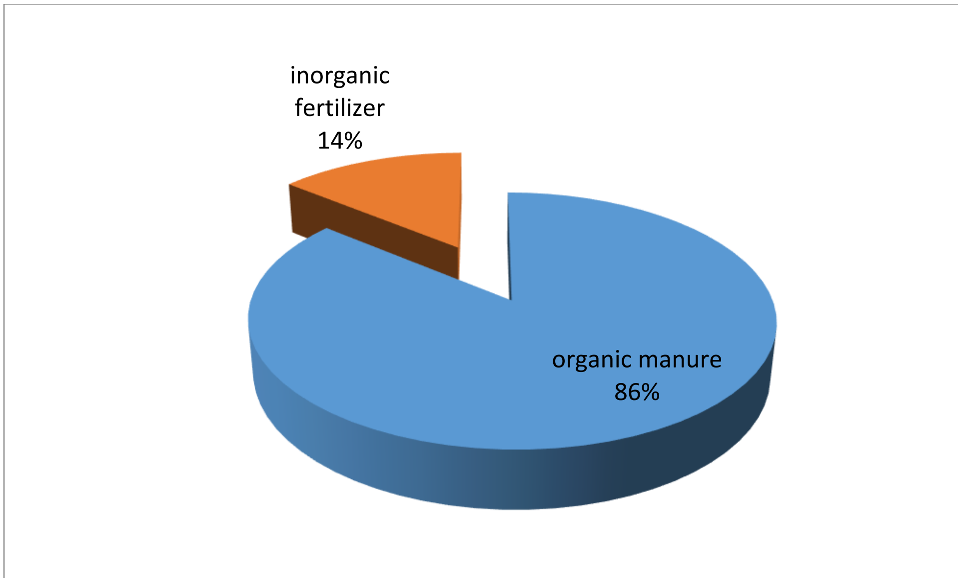


Figure 3: Nutrient management in the area

Figure 3, shows that 86% of the respondents increase their soil fertility by the use of organic manure which include application animal dung, small ruminant manure, poultry manure, ashes manure and crop livestock integration considered as source of manure in the area, this is adduced by Yusuf (1996, 2010) that the intensified farming system in the area is by the use of manure, other soil management and crops livestock integration. However, use of inorganic fertilizer is very rare due to inadequate supply and high cost in the market, this necessitated the farmers to use organic manure, while some farmers believed that organic manure is more useful, productive and can last for years and have less or no environmental problem. This is adduced by Ekschmitt *et al.*(2004) that applications of NPK (Nitrogen, Phosphorous, Potassium) fertilizers result in GHG emissions ranging from 0.8 to 10.0 kg CO_2-eq per kg of fertilizer-N depending on fertilizer production plant design and efficiency, emission control mechanisms, and raw-material inputs and contended by Smith *et al.* (1997) that the application of inorganic fertilizers in the field is estimated to emit from 0.25 to 2.25 kg N_2O per 100 kg N.Increasing fertilizer efficiency and reducing fertilizer inputs are the two primary ways to optimize nutrient management for reducing GHG emissions. Fertilizer efficiency can be increased by adjusting fertilizer amount, placement, and timing to minimize losses and meet actual crop demand.

The use of organic manure in the study area have the potential to mitigating the greenhouse gas in the area, which is in line with Intergovernmental Panel for Climate Changereport which stressed that the mean estimate of the greenhouse gas-mitigation potential of improved nutrient management range from 0.33 to 0.62 t CO_2-eq/ha^{-1}/yr^{-1} in dry climatic zones (Smith *et al.*, 2007).

Estimates show that the production of inorganic fertilizers consumes approximately 1.2% of the world's energy and is responsible for approximately 1.2% of global GHG emissions (Kongshaug 1998).

Residue Management

Residue management constituted 17% and 14% in Shuwarin and Rigungumau area respectively among the soil management practiced in the area. Crop residues may have significant synergistic effects on water resources, as the resulting improved soil structure, increases the water-holding capacity of the soil and leaves the soil less prone to leaching and erosion (Eschmitt *et al.*, 2008).The IPCC mean estimate of the GHG-mitigation potential of improved residue management range from 0.17 to 0.35 t CO_2-eq/ha^{-1} yr^{-1} in wet and dry climatic zone from which the stud area is belong to (Smith *et al.*, 2007). Maximizing residue management increase the buildup of soil organic matter and thereby mitigate GHG emissions, especially if combined with the retention of crop residues (Holland, 2004).

Soil Restoration

soil restoration is the lowest soil management practice in the area with 4 and 9 percent for Shuwarun and Rugungumau area respectively. Soil degradation has adverse impacts on all soil functions, like production and soil-filter function (Smith *et al.*, 2007), some part of their agricultural land are affected by erosion. Soil restoration practice in the area is low because the areas were not well degraded by erosion due to inadequate rainfall and vegetation scattered over the area. As summarized in Smith *et al.* (2007), a large proportion of agricultural lands have been degraded by erosion and organic matter loss. The combination of applying organic manures, reducing tillage, retaining crop residues, and conserving water is the primary mitigation measure for degraded land.

Water Management

Water management account for 9 and 7 percent of soil management in the area through early matured crop like beans called *Dan'eka*, ground nut called *Yar Dakkar*and sorghum called *Yar Dandalama*while some farmer store water during rainy season in shallow depression to augment the inadequate water in the season.

Conclusion and recommendations

There are many soil-management strategies that can be used to reduce GHG emissions but in the study area crop rotations, appropriate crop choices, nutrient management and the introduction of efficient water management systems are dominant and frequently use as their management practicesin the study area. It is recommended that planting trees, use of organic manure and minimum tillage be employed as soil management practice with potentiality of mitigating greenhouse gas emission from the soil of the study area.

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Table 1: Soil Management Practises in the Study Area

		Study area	
S/N	**Soil management**	**Shuwarun (%)**	**Rugungumau (%)**
1	Crops management	18	16
2	Nutrient management	42	54
3	Residue management	17	14
4	Soil restoration	14	9
5	Water management	9	7

Source: Field survey, 2014