PATTERN OF SOIL CONSERVATION PRACTICES IN ARABLE CROP FARMING SYSTEM IN DERIVED SAVANNAH ZONE OF ENUGU STATE, NIGERIA: IMPLICATION FOR CLIMATE CHANGE

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Abstract: The study examined patterns of soil conservation practices employed by arable crop farmers and their implications for climate change in Derived Savannah Zone of Enugu State, Nigeria. One hundred and twenty randomly selected arable crop farmers were interviewed. Data were analysed by use of descriptive statistics and standard deviation. The most frequently used soil conservation practices were organic manure (M=3.63), inorganic manure (M=3.36), planting of cover crops (M=2.93), mulching (M=2.73) and crop rotation (M=2.52). Organic manure was either applied by braodcasting before cultuvation (82.5%), alternated with inorganic manure after planting (76.7%), applied at the base of crops (70.8%). The respondents applied inorganic manure mainly by top dressing (60.0%), broadcasting (42.5%). Similarly, the major cover crops used for soil conservation were groundnut (50.0%); crop rotation was carried out indiscriminately (42.2%), while mulching was by covering tilled soil with dry grasses (76.7%). The most effective soil conservation practices were organic manure (M=4.13), mulching (M=3.93), use of cover crops (M=3.81), crop rotation (M=3.69). Both conservation practices have great potential for climate change adaptation and mitigation, however the pattern of application either limit the potential or increase their contribution to climate change and vulnerability of community. Therefore, the study recommends that extension services should increase efforts to educate and promote use of the most environmental friendly pattern of soil conservation to maximize the effectiveness both for food production, adaptation, mitigation and environmental sustainability. Also stringent policy instrument to promote and ensure adherence to environmental sound practices should be enacted by the government.

Keywords : Adaptation, Degradation Mitigation, Sequestration, Vulnerable.

Introduction: One of the major obstacles to achieving agricultural production and development is soil infertility problem which is caused by land degradation [1]. Global food production is being undermined by land degradation and shortages of farmland and water resources, making feeding the world's rising population – projected to reach nine billion by 2050 – a daunting challenge [2]. Reference [3] defines land degradation as is a major concern for at least two reasons namely: it affects global climate through alteration in water and energy balances and disruption in the cycles of nitrogen, sulphur and other elements; and undermines the productive capacity of an ecosystem. It is a concept in which the value of the biophysical environment is affected by one or more combination of human induced processes acting upon land. Land degradation is a long – term reduction of the capacity of land to supply benefits to humanity, which essentially arises from bad land management that encourages soil erosion by wind and water, bad irrigation management leading to salinization, excessive use of fertilizer that leads to soil acidification and formation of acid sulfate soil resulting in barren soil, over grazing of rangeland and more widely and insidiously through a loss of soil organic matter and loss biodiversity [4].

Reference [5] reports that according to a study conducted for the International Food Policy Research Institute, each year an estimated 10 million hectares of cropland worldwide are abandoned due to soil erosion and diminished production caused by erosion. Another 10 million hectares are critically damaged each year by salinization, in large part as a result of irrigation and/or improper drainage methods. According to World Bank report of 1990, the long term loss to Nigeria from environmental degradation was estimated to be about $5 million annually [6]. The report further shows that gullies occupied 4% of the land area of Anambra, Imo, Abia, and Enugu States. gullies occupied 4% of the land area of Anambra, Imo, Abia, and Enugu States. Reference [7] shows that the situation of soil degradation that requires immediate soil conservation attention is more precarious in the southeastern states of Nigeria especially in Enugu State.

The challenge of soil degradation to agricultural production and food security is expected to increase with increasing evidence of climate change in Nigeria. Climate change is expected to alter the patterns of temperature, precipitation and river flows upon which the world's food production systems depend and the problem could be more acute in developing countries, where quality land, soil nutrients and water are least abundant [2]. There are

reported cases of flooding and numerous gully erosion sites in southeast states of Nigeria,
which have resulted to loss of arable farmlands, farm stead, economic tree, biodiversity and others [8]. Also [9] observed that signs of desertification and savanalization are now becoming evident in Oyo, Osun, Ondo and some other parts of the south-western states of Nigeria which hitherto fell within rainforest. These confirm report by [10] that there is evidence that the hydroclimate is changing in ways that could increase erosion by water. Ironically, agriculture is widely reported to significantly contribute to climate change through burning of fossil fuel and land use practices including conservation practices employed by farmers in the face of decreasing soil nutrient and carrying capacity of some ecosystem. Agricultural land use was responsible for approximately 15% - 20% of all anthropogenic green house gas (GHG) emissions [11], [12].

Soil conservation is a set of management strategies for prevention of soil from being eroded from the earth's surface or becoming chemically – altered by overuse, acidification, salinization or other chemical soil contamination. In the opinion of [13] soil conservation efforts of farmers promote minimum disturbance of the soil by tillage, balance application of chemical inputs which are only required for improved soil quality for healthy crop and animal production with careful management of residues and wastes. Effective soil conservation practices reduce land and water pollution; reduce long-term dependency on external inputs which often times lead to increased cost of production, enhance environmental management, improved water quality and water use efficiency, reduced emission of green house gases through lessened use of fossil fuel and finally improved agricultural productivity with minimum cost [14]. However, with increasing concern on the attendant consequences of changing global climate, a critical examination of the use of these practices is apt. Some of the practices have been identified and promoted as adaptive or mitigation measures to climate change and building resilience of farming communities. But in practice, it is possible that farmers overuse some to the neglect of others, notwithstanding their portent for climate change adaptation and mitigation. The pattern of application is even of more concern since the method of use largely determine the effect whether negative or positive to mitigation or adaptation to climate change.. Thus, the questions are: what are the most frequently soil conservation practices used by arable crop farmers?. What are the pattern of use of these practices?. What are the climate implication of the use and methods applied?. What are the perceived effectiveness of these methods?. The study aimed to;

1. determine the most frequently conservation practices used;
2. examine the pattern of conservation practices used by farmers and their implication for climate change and
3. Determine the effectiveness of the conservation practices used.

Methodology: The study was conducted in derived savannah zone of Enugu State conventionally known as Enugu – North Agricultural Zone. The zone comprised eight (8) blocks which includes: Nsukka 1, Nsukka II, Igbo-Eze I, Igbo-Eze II, Udenu, Igbo-Etiti, Uzo-Uwani I, and Uzo-Uwani II. Arable crop farmers in the zone constituted the population for the study. Multistage random sampling technique was used. The first stage involved random selection of six blocks from the zone by simple random sampling technique. In the second stage, two cells from each block were selected using simple random selection techniques, giving a total of twelve cells for the study. Lastly, ten arable crop farmers were selected from the list of arable crop farmers provided by extension agents using simple random selection technique . A total sample size of 120 respondents was used. Data were collected by the use of structured interview schedule. Respondents were asked to indicate the frequency of use of listed soil conservation practices on four point Likert type scale of rarely (1), sometimes (2), often (3), always (4). The respondents indicated the patterns of application employed in the use of the practices (mulching, planting of cover crops, conservation-tillage crop rotation, organic manures, inorganic manure and others). Information on the perceived effectiveness of the conservation practices were elicited on a four point Likert-type scale of very effective (4), effective (3), not very effective (2), and not effective (1). The data were analysed using mean and standard deviation and presented in percentage. Mean scores ≥ 2.5 were considered effective or most frequently used, while <2.5 were regarded not effective or less used.

Results and Discussion:

Frequency of use of soil conservation practices: The soil conservation practices most frequently used by arable crop farmers were organic manure (M =3.63), inorganic manure (M= 3.36), planting cover crops (M= 2.93), mulching (M= 2.71) and crop rotation (M= 2.52) (Table 1). Other practices less used included terracing (M= 2.36), contour bond (M= 2.03), planting windbreak (M=1.48) and zero- tillage (M=1.20). The extent of use of soil conservation practices could be attributed to interaction of personal, socio-economic and technical factors. A study on socio-economics of soil conservation in

Kericho distinct Kenya revealed that some factors influence the utilization of different soil conservation practices by farmer [15]. Such factors according to the author include security of land tenure, household income, sex of the farm decision maker, level of education of farm household head, perception of profitability, extension visits, farm size and farm's biophysical features. Besides, the comparative advantage of the practices with regards to mitigating and adapting to effects of climate change on agricultural production and the environment might have influenced the use particularly in highly vulnerable ecosystem. Generally, both conservation practices have great potential for reducing vulnerability of farming communities and increasing resilience for enhanced production of food and fibre. Reference [16] reported that The agronomic soil conservation practices (cover crops,mulching,crop rotatio, fallowing and others) explore the effect of surface covers to reduce erosion by water and wind in order to conserve the soil, protect the soil from direct sun rays and enrich soil by the decay of their fallen leaves; and some reduces the risk of serious pest and disease outbreaks. Also highlighting on its importance, [21] pointed out that the crop residues released reduce the soil temperature by some degree in the upper centimetes of the top soil and priovide better moisture conservation by reducing the intensity of radiation, wind velocity and evaporartion. Invariably the conservation practices boost adaptation to erosion, effect of direct sun rays on the soil, increase pest and diseases, loss of soil biomass and reduce soil fertility associated with climate change. Application of organic manure also contribute to soil carbon sequestration (carbon uptake from the atmosphere) through increase organic matter content of the soil. On the contrary, both organic and inorganic soil management practices aids climate change through release of the major greenhouse gases (CO_2 and methane). They are the two main sources of nitrous oxide [11].

The less frequently used conservation practices might be due to limited tecchnical knowledge and location specific feature of some like terracing, contour bond, planting wind break and zero-tillage. However, their use particularly zero tillage mitigate against release of CO_2 and N_2O caused by intensive tillage and burning of fossil fuel. Furthermore, tree planting is beneficial for carbon sequestration, reduce wind erosion and improve soil biomass.

Patterns of soil conservation practices: Table 2 shows that only (5.0%) of the respondents adopted mechanical cutting of grasses as a zero- tillage operation, while 1.7% practiced bush burning as a zero-tillage soil conservation practice. None of the respondent used herbicide and dragging chain perhaps due poor accessibility and cost. Generally, zero or no tillage is a way of growing crops from year to year without disturbing the soil through any mechanical manipulation [17] and thus can increase the amount of water in the soil since structural soil properties are maintained or enhanced and soil water transmission improved to reduce runoff and soil loss. Additional benefits derivable from conservation tillage are enhanced soil fertility as the contents of organic nitrogen are raised and increase in the activity of soil organisms due to a favourable soil climate. Invariably it is a veritable practice for adaptation and mitigation of climate change. However, the use of slash and burn is not very appropriate because it releases CO_2 and N_2O into the air which has been identified as one of the major causes of climate change. Though mechanical cutting of grasses and use of herbicides may not be cost effective in terms of time, labour and cost especially for a considerable farm size but it seems to be the most appropriate in the face of threatening impact of climate change and need for sustainability of agro-ecological system.

Application of organic manure: Majority (82.5%) of the respondents broadcasted organic manure before cultivation, 76.7% alternated with fertilizer on the base of plant after cultivation, while 70.8% applied on the base of crop stand. Only 66.7% of the respondents indicated the application of organic manure after planting at little space away from the plants. Use of organic manure for soil conservation has implications for the changing climate based on the type of organic materials applied. There may not be any threat in the use of farmyard manure, compost and green manure except in the decomposition process for large quantity which could release gases like CO_2. On the other hand, use of animal dung from poultry or ruminants could increase the volume of N_2O and CO_2 in the atmosphere. A ten percent rise in N_2O emission between 1999 and 2005 in United States is traced in part to change in the poultry industry, including overall increase in the domestic stock of birds used in meat and egg production [18]. Worse still is the combination and/or alternation of organic and inorganic manure which could have positive and complementary effects for soil management, but leave a multiple effects on the climate. The [12] attributed the doubling of green house gas (GHGs- CH_4, CO_2, N_2O) production during the last 35 years to increase in nitrogen and phosphorus fertilizers. Broadcasting, applying at the base or away from the base of plant exposes organic manure (animal dung) to direct contact with water which triggers decomposition and subsequent emission of gasses to the atmosphere, except if properly managed before use. According to reference

[19] increasing storage period and covering manure storage structure or direct application to the soil could be appropriate for reduced nitrous oxide emission. In other words manure storage method and the amount of exposure to oxygen and moisture can affect how these greenhouse gases are produced [20].

Mulching: Majority (76.7%) of the respondents covered the tilled soil with dry grasses, 59.2% with dry materials, while 44.2% left crop residue on soil surface. Only 10% of the respondents covered the soil with sawdust. Traditionally, different types of material such as residues from the previous crop, brought-in mulch including grass, perennial shrubs, farmyard manure, compost, byproducts of agro-based industries could be utilized for mulching. The practice has benefits for climate change mitigation and adaptation, irrespective of pattern employed in application. Firstly, mulching materials protect the soil from erosion and excessive evaporation, reduce the soil temperature by some degrees in the upper centimeters of the topsoil and provide better moisture conservation by reducing the intensity of radiation, wind velocity, and evaporation [21]. its impact in reducing the splash effect of rain, decreasing the velocity of runoff, and hence reducing the amount of soil loss has been demonstrated in many field experiments conducted on several Nigerian research stations[22], [23]. Secondly, the decomposition of mulching materials particularly green or dry grasses increases the organic content of the soil which is useful for carbon sequestration and improves soil structure.

Cover crops: Table 2 shows that majority (76.7%) of the respondents used groundnut, 54.2% used sweet potatoes, while 18.3% used soya beans as cover crops. Only 4.2% of the respondents used velvet bean (*Mucuna pruien*) as a cover crop. Cover cropping is a soil conservation practice or method by which cover crops are planted to protect soil surface from excess heat from the sun, reduce erosion effects and improve the soil through root nodules for leguminous cover crops or through the decay of fallen parts of the cover crops. This is substantiated by [16] who stated that cover crops are mainly planted to protect the soil from direct sun rays, reduce erosion and enrich the soil by the decay of their fallen leaves. In other words it positively influence physical soil properties such as the infiltration rate, moisture content and bulk density and increase the organic matter content, nitrogen (N) levels by the use of N_2-fixing legumes and hence crop yields [24]. Above all, cover crops could be useful for the suppression of common weeds in Nigeria and subsequently reduce disease multiplication and spread. All these contribute to it's potential for adaptation to varying effects of climate change and mitigation challenges. However the use of cover crops like legumes could be more beneficial to mitigation and adaptation because of its additional advantage of nitrogen fixation.

Pattern of crop rotation practice: A greater proportion (42.2%) of the respondents indicated that crop rotation was carried out indiscriminately, 36.2% practiced crop rotation at one year interval, while 14.2% practiced within 4 years interval (Table 3). About 5% of the respondents practiced crop rotation within the interval of two years. Traditionally, crop rotation is important for efficient and economic use of cultivable soil year after year, reduction of risk of serious pest and disease outbreak, checking erosion and improve soil fertility and balance nutrients remover from the soil. In essence, it is beneficial for improved physical, chemical, and biological properties of soil and increased crop production [25]; and additional advantages of decrease risk of total crop failure and the secession of weed. It is therefore an adaptation strategy against disease, pests and soil erosion. However, indiscriminate rotation may debar optimal profit for adaptation to climate change. Based on the availability of land crop rotation should be planned to allow sufficient time and appropriate choice of crops between rotations for eradication of disease and pest strain and improvement of soil capacity for crop production.

Contour bond: Majority (83.3%) of the respondents made ridges during contour farming, while 33.3% planted in rows and used strip cropping (Table 2). None of the respondents indicated the use of small dams. Research on contour bonds was conducted by [26], who considered these measures to be useful to prevent gully erosion, the most spectacular type of erosion, in southeastern part of Nigeria. The record states that permanent structures of these kinds are effective soil conservation technologies as excessive soil loss and silting up of the field are reduced. It is thus adaptation measures in controlling the effect of erosion in vulnerable, erosion prone areas. The patterns of used however, depend largely on the landscape of the farm land.

Windbreak planting methods: Table 3 shows that majority (50.0%) of the respondents affirmed planting around farm/homestead and planting at the edge of field as methods used in planting wind breaks, respectively, while the remaining 33.3% indicated planting in rows of ever green type tree as a method in planting wind break. Generally, planting of trees at different locations in the farm has great portent for mitigation and adaptation to climate change effects. Generally, it traps Carbon from the atmosphere thereby reducing the rate of depletion of the ozone layer. Planting of fast growing trees at home/ farmstead particularly where there is concentration of livestock/poultry house is strongly recommended for mitigation of green house gases release from livestock production. Furthermore, trees planted at the edge of fields and in rows within the farms also perform similar function; and reduce the effect of wind erosion, direct impact of sunrays and increase biomass/organic content of the soil. Choices of trees and concentration should be such that could provide maximum economic and environmental benefits.

Pattern of terracing: Table 3 shows that greater proportion (54.2%) of the respondents used bags filled with sand, 48.3% used earthen embankment, while 44.2% used big truck of wood in terracing. Only 3.3% practiced planting of creeping grasses like bahama. Terracing is an adaptation measure used to control erosion cause by climate change mostly in erosion prone farm lands. According to [31] as filters, they may not reduce the runoff amount but retard its velocity and hence encourage sedimentation, increase infiltration, and facilitate the formation of natural terraces. The application of the different type depends on the location, landscape, and purpose of the land. Terracing with bags of sand, earthen embankment and big truck of wood are more common in hilly farm lands, while creeping grasses are common in fields and living environment. Reference [25] report that they are effective soil conservation technologies but the installation and maintenance is usually labor-intensive. Also [26] reported that high labor intensity, time-consuming, regular inspections, high consumption of scare farmland, and the large amounts of construction material required hinder farmers from installing or maintaining terrace.

Inorganic manure: Majority (60.0%) of the respondents applied inorganic manure using top dressing method, 42.5% used broadcasting, while 32.5% used band placement (Table 3). The remaining 26.7% and 24.2% used row application and ring method, respectively. Use of fertilizer contributes immensely to global food supply and at the same time has been identified as one of the main anthropogenic sources of nitrous oxide estimated at 24% annual N_2O [29]. it is estimated to contribute about 2,5% of the total global emission and much occur at the point of application (Farm level) [30]. In a study conducted in Irish grassland, Reference [29] reported that a reduction in N fertilizer could mitigate emission of N_2O. the amount of exposure during application and distribution largely affects the emission of greenhouse gases. Thus, use of deep placement methods may be more environmentally sound than the popular traditional methods indicated by the respondents (broadcasting, top dressing and others). And again, fertilizer application to crops requires that it should be applied at the right time and right quantity for crop productivity to improve.

Perceived effectiveness of soil conservation practices. Table 3 indicates that the respondents perceived some of the soil conservative practices to be more effective than others perhaps based on the importance in crop production. The soil conservation practices perceived effective were use of organic manure (M= 4.13), mulching (M= 3.93), planting cover crops (M=3.81), crop rotation (M= 3.69), use of inorganic manure (M= 3.53) and terracing (M= 3.14,). This could be based on their values for enhanced productivity, long term nutrient value, accessibility and management of environmental problems.(erosion). Empirically these practices have been reported to be effective in combating different soil degradation problems. For example field trials on bonds and terraces made by [31] in Ibadan showed that the mean soil loss from a catchments without any erosion control measures was 2.3 t ha-1 and from a terraced catchments, 0.7 t ha-that terracing helps to prevent gully erosion and decrease effective sediment pollution in water. Also Mulching was considered as an effective soil conservation practice probably because it helps in conserving soil water through reduced runoff, better infiltration and reduced surface erosion. Furthermore, [25] reported in a study conducted in Ibadan that 3.3 t soil ha-1 were eroded from plots cultivated with sole maize and 1.8 t ha-1 from plots with the cover crop (*P. phaseoloides).* However the high standard deviation suggested that the experience of the respondents with the various conservation practices defers.

Conclusion: The study revealed that some conservation practices are more common and perceived more effective than others. These include use of organic manure, inorganic manure, mulching, cover crops and crop rotation. There are varying patterns employed by farmers in the use of the conservation practices. The practices have far reaching positive and negative implication for climate change mitigation and adaptation. Also the pattern of application in farms either accelerate climate change or ameliorate the effects of climate change particularly in highly vulnerable ecosystem. Ideally, boosting adaptation and mitigation to climate change should be the driver of land use and management. Therefore, the study recommends re-orientation and training of farmers by extension agents for increase environmental consciousness in the use and pattern of application of conservation practices. This will ensure optimal benefits for food production, adaptation and mitigation of climate change and environmental sustainability.

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Table 1. Distribution of respondents according to frequency of use of soil conservation practices

Conservation practices	Mean	S.D
Zero- tillage	1.20	0.50
organic manure	3.63*	0.70
Mulching	2.71*	1.02
Inorganic manure	3.36*	1.05
Planting cover crops	2.93*	1.06
Crop rotation	2.52*	0.83
Contours bonds	2.03	1.51
Terracing	2.36	0.93
Planting windbreak	1.48	0.78

* **Most frequently used conservative practices**

Table 2 Percentage distribution of respondents based on pattern zero tillage, organic manure, mulching and cover crop application

Conservation practices	% (n=120)
Zero-tillage	
Use of herbicide	-
Mechanical cutting of grasses	5
Dragging chain	-
Bush burning	1.7
***Organic manure**	
Broadcasting before cultivation	82.5
After planting away from base of plant	66.2
On the base of plant	70.8
Alternate with fertilizer	76.7
***Mulching**	
Use of dry materials	59.2
Sawdust	10
Green crop residues on soil surface	44.2
Use of dry grasses	76.7
***Cover crops**	
Sweet potatoes	35.0
Velvet beans ()Mucuna pruien	3.0
Groundnut	50.0
Soyabeans	12,0

*Multiple response

Table 3 Percentage distribution of respondents based on pattern of crop rotation, contour bonds, tree planting and inorganic manure application.	
Soil conservation	**% (n=120)**
Crop rotation	
One year	36.2
Two years	5
Three year	2.4
Four years	14.2
Indiscriminate rotation	39.2
***Contour bonds**	
Planting in rows	33.3
Making ridges	83.3
Constructing dams	12.7
Strip cropping	33.3
Wind break or tree planting	
Around home/farmstead	50.0
In row using ever-green plants	0
Planting at the edges of field	50.0
***Inorganic manure**	
Ring method	24.2
Band placement	32.5
Top dressing	60.0
Broadcasting	42.5
Row application	26.7

Table 4: Mean distribution of respondents on the effectiveness of the soil conservation practices.		
Variable	**Mean**	**S.D**
No tillage	2.11	1.57
Animal manure	4.13*	0.77
Mulching	3.93*	1.17
Inorganic manure	3.53*	1.08
Planting cover crops	3.81*	1.22
Crop rotation	3.69*	1.14
Contours bonds	2.53	0.87
Terracing	3.14*	1.70
Planting windbreak	1.71	0.78

***Most effectively practiced soil conservation**

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