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Evaluation of Sustainable Agro-forestry Practices for Climate Change Adaptation and Promotion of Organic Agriculture among Farmers in Imo State, Nigeria

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Abstract
Imo State lies in the rain forest region of Nigeria and such area can be vulnerable to climate change impact. Climate change related issues make agricultural activities in the area highly susceptible to climate-related extreme events such as floods. These extreme events have effects on agricultural production. To alleviate the threats from climate change, sustainable agro-forestry practices which are organic in nature provides management practices that can help farmers adapt to climate change, through strengthening farmers' knowledge base to best prevent and confront changes in climate. The study evaluated sustainable agro-forestry practices and the benefits as a mitigation strategy for climate change and for promotion of organic agriculture among farmers in Imo State, Nigeria. Data were collected through the use of questionnaire administered to 180 respondents and analysed using descriptive statistics - percentages, frequency and mean scores. The results revealed that the prevalent agro-forestry practices using multiple responses included improved fallow (98.1%), intercropping (98.8%) and live fence making (100%), among others. The respondents agreed that the benefits of agro-forestry included reduced soil erosion (Mean=3.30), reduced heat stress (Mean=3.01), improved soil fertility using organic manure (Mean=2.98), among other practices. Extension agents should visit farmers for information dissemination, and land should be allocated to enterprising agro-foresters. The government should enact laws protecting agro-foresters, forest reserves, encourage and invest in organic and agro-forestry agriculture-related researches to determine the best combination of forest and crop production practices, best for the environment in order to reduce the effect of climate change.

Keywords: Agro-forestry, Climate change, organic agriculture, Adaptation.

Évaluation des Pratiques D'agroforesterie Durable Pour L'adaptation au Changement Climatique Et la Promotion de L'agriculture Biologique Chez les Agriculteurs de L'état D'imo, au Nigeria

Résumé
L'État d'Imo est situé dans la région de la forêt pluviale du Nigéria et peut être vulnérable aux effets du changement climatique. Les problèmes liés au changement climatique rendent les activités agricoles de la région extrêmement sensibles aux phénomènes extrêmes tels que les inondations. Ces événements extrêmes ont des effets sur la production agricole. Pour atténuer les menaces du changement climatique, les pratiques agro-forestières durables de nature organique fournissent des pratiques de gestion qui peuvent aider les agriculteurs à s'adapter au changement climatique, en renforçant la base de connaissances des agriculteurs pour mieux prévenir et faire face aux changements climatiques. L'étude a évalué les pratiques d'agroforesterie durables et leurs avantages

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en tant que stratégie d'atténuation du changement climatique et de promotion de l'agriculture biologique auprès des agriculteurs de l'État d'Imo, au Nigéria. Les données ont été collectées à l'aide d'un questionnaire adressé à 180 répondants et analysées à l'aide de statistiques descriptives - pourcentages, fréquence et scores moyens. Les résultats ont révélé que les pratiques agroforestières répandues faisant appel à plusieurs réponses comprenaient la jachère améliorée (98,1%), les cultures associées (98,8%) et la fabrication de clôtures vivantes (100%), entre autres. Les répondants ont convenu que l'agroforesterie avait entre autres avantages de réduire l'érosion des sols (moyenne = 3,30), de réduire le stress thermique (moyenne = 3,01), d'améliorer la fertilité des sols avec du fumier organique (moyenne = 2,98). Les agents de vulgarisation devraient rendre visite aux agriculteurs pour diffuser des informations, et des terres devraient être attribuées aux forestiers agricoles entreprenants. Le gouvernement devrait promulguer des lois protégeant les forestiers forestiers et les réserves forestières, encourager et investir dans les recherches sur l'agriculture biologique et agroforestière afin de déterminer la meilleure combinaison de pratiques de production forestière et végétale, mieux adaptée à l'environnement afin de réduire les effets du climat. changement.

Mots-clés: agroforesterie, changement climatique, agriculture biologique, adaptation.

Introduction

A large percentage of population in developing countries depends on agriculture for their livelihood. The practice of agriculture ranges from the primitive subsistence farming to large scale commercial ventures. At either end of the farming practices' spectrum is the continual exposure of the environment to adverse conditions due to degradation of the forest and the exposure of the soil to agents of erosion. Furthermore, the application of farm inputs such as fertilizer creates carbon pollutants in the atmosphere. The release of these carbon pollutants such as CO_2 and methane from farming and other human activities increase atmospheric temperature to an extent of altering the world climate (Intergovernmental Panel on Climate Change – IPCC, 2007a). The need for food security, raw materials and enhancing socio-economic development has influenced the activities implicated in climate change (Ogbeide and Ele, 2016). Therefore, the interacting effects of climate change and agriculture on the farmers and the environment are already being felt in many countries, most times negatively.

Subsistence and industrial agriculture have implication for climate change as both involve land clearing and exposure that lead to warmer surface. As it is important that food, shelter and the environment be maintained in a sustainable manner, agriculture must be practiced in a way that delivers maximum benefit to the general society. Different models of farming have been suggested to ensure mutual relationship between plant and other living organisms in different ecosystem including organic (Rodale Institute, 2014; FAO, 2016) and agroforestry (Neufeldt 2013; Mbow *et al*, 2014).

Agro-forestry is one of the prominent land use systems across many agro-ecological zones in Africa that cater for food production and mitigates the impact of climate change. Sustainable agro-forestry practices are the practices that conserve an ecological balance by avoiding depletion of natural resources. The prevalent sustainable agro-forestry practices include rotational farming, improved fallow, intercropping, forest fencing, as well as soil and water conservation, among others. It is a practical innovative production approach to improve the economic and ecological sustainability of agricultural systems, and at the same time provide a flow of valued ecosystem services (FAO, 2016). Agro-forestry provides assets and income from carbon, wood energy, improved soil fertility using organic matter and enhances local climate conditions; it provides ecosystem services and reduces human impacts on natural forests (Nguyen *et al.*, 2013; Mbow *et al,* 2014).

To alleviate the threats from climate change and overall ecosystem degradation, as reported by FAO (2016), various land use practices have been recommended. FAO (2016) also reported that organic agriculture provides management practices that can help farmers adapt to climate change through strengthening agro-ecosystems, diversifying crop and livestock production, and building farmers' knowledge base to best prevent and confront changes in climate. Similarly, Rodale Institute (2014) noted that there should be a shift in the management of the existing cropland to reflect a regenerative model. Regenerative organic agriculture comprises of organic practices including the use of

cover crops, residue management through mulching, composting and crop rotation (Rodale Institute, 2014). Conservation tillage, while not yet widely used in organic systems, is a regenerative organic practice integral to soil-carbon sequestration. Rodale Institute (2014) reported further that with regenerative organic agriculture, more than 40% of annual emissions could potentially be captured and if at the same time, all global pasture was managed to a regenerative model, an additional 71% of greenhouse gases could be sequestered.

Imo State is in South-east Nigeria and lies within latitudes $4^0$45N and $7^0$15N and longitudes $6^0$50^{0}N and $7^0$25^{0}E with an area of around 5,100sq/km (IMSG, 2010). Imo State lies in the rain forest region of Nigeria and is vulnerable to climate change impact. The IPCC (2007b) noted that climate change-related issues make agricultural activities in Imo State highly susceptible to climate-related extreme events such as floods, severe wind storms, soil erosion, and excessive rise in temperature. These extreme events have effects on agricultural production (IPCC, 2007b). According to Lal (2004), continued growth at a declining rate is expected in land productivity due to decreasing returns from increased use of technology and greater use of marginal land with lower productivity. Agro-forestry systems are a key type of agriculture, that allow for a high level of progressive adaptation from simply increasing structural and temporal diversity of the production system to selling ecosystem services for increased economic diversification (Lin, 2015). Therefore, when well managed, agro-forestry can play a crucial role in improving resilience to the uncertain climate through microclimate buffering and regulation of natural resources like water flow. Management options in agro-forestry such as tree pruning are important measures to reduce below-ground competition, particularly for water such that trees tap into deep groundwater rather than top soil moisture that annual crops rely upon.

It is against background that the study was designed to ascertain the benefits of sustainable agro-forestry practices as a mitigation strategy for climate change, and for promotion of organic agriculture among farmers in Imo State, Nigeria.

Materials and Methods

The study was conducted in Imo State, Nigeria in December, 2016. Purposive sampling technique was used to select agro-foresters only. A list of 1800 agro-foresters from the three forest reserve areas in Imo State was compiled from the Forest Department of the Ministry of Agriculture and Research headquarters, Owerri. From the list, 10% of the foresters were accessed to represent a sample size of 180 respondents. Questionnaire was used to gather the data from the respondents. Data were analysed using percentages, frequency and mean scores. Mean score (M) of the responses to the variables was designed using a 4-point Likert type scale which originally had five points that ranged from Strongly agree (SA), Agree (A), Undecided (UD), Disagree (D) to Strongly Disagree (SD), to find out the agreement response of the foresters based on the listed items under the benefits of agro-forestry. Therefore, the 4-point Likert type scale used ranged from Strongly agree (SA), Agree (A) to Strongly Disagree (SD) with assigned scores of 4, 3, 2 and 1 respectively, where '4' represented 'strongly agree' and '1' indicated 'strongly disagree'; undecided was excluded from the scale. The mean score of each scale item greater than or equal to 2.50 was used to determine the influence of each variable and any mean response below 2.50 was considered to be of no effect.

Results

Sustainable Agro-forestry practices

It was reflected in Table 1 that farmers adopted sustainable agro-forestry practices in the study area. The more frequently adopted practice using multiple responses was making of live fences (100%). This was followed by intercropping trees in farms (98.8%), improved fallow (98.3%), tree planting along boundaries of the farm (96.1%), and home garden establishment (92.7%). Making of live fences being the most frequently adopted agro-forestry practices is an indigenous practice. Oral discussion revealed that in live fences making, there is easy access to the planting materials, less labour requirement and low cost of adoption. Again, practice of tree planting along boundaries of the farm was a common practice for boundary demarcation, claim of ownership, notification of use, and for family security, making these practices to be sustainable.

Table 1: Sustainable Agro-forestry Practices in the Study Area (n =180)

	Adopted Practices	*Frequency	Percentage (%)
I.	Improved fallow	177	98.3
II.	Rotational farming	155	86.1
III.	Alley cropping	133	73.8
IV.	Hedgerow making	125	69.4
V.	Direct tree planting	101	56.1
VI.	Home garden	167	92.7
VII.	Mixed farming/cropping	149	82.7
VIII.	Forest farming	154	85.5
IX.	Maintenance of trees on farm land	128	71.1
X.	Intercropping tree	178	98.8
XI.	Soil and water conservation	165	91.6
XII.	Wind breakers planting	140	77.7
XIII.	Tree planting along boundaries of the farm	173	96.1
XIV.	Taungya	104	57.7
XV.	Orchards	109	60.5
XVI.	Plantain and crop combination	117	65.0
XVII.	Live fence making	180	100

Table 2: Benefits of Sustainable Agro-forestry (n= 180)

	Statement	SA (%)	A (%)	D (%)	SD (%)	Mean	S.D
I.	Slows down water runoff	53 (29.4)	19 (10.6)	33 (18.3)	75 (41.7)	2.58	1.28
II.	Reduces soil erosion	90 (50)	72 (42)	0 (0)	18 (10)	3.30	0.90
III.	Reduction of flood menace	54 (30)	54 (30)	36 (20)	36 (20)	2.70	1.10
IV.	Reduces water pollution	32 (178)	35 (19.4)	55 (30.6)	58 (32.2)	2.62	1.08
V.	Reduces heat stress on crops/animals	54 (30)	90 (50)	18 (10)	18 (10)	3.01	0.89
VI.	Protects crop from wind damage	90 (50)	72 (40)	0 (0)	18 (10)	3.32	0.90
VII.	Reduces cold stress by providing shelter	54 (30)	54 (30)	18 (10)	54 (30)	2.65	1.14
VIII.	Reduces wind speed	90 (50)	36 (20)	36 (20)	18 (10)	3.10	1.05
IX.	Reduces total crop failure	4 (2.2)	140 (77.8)	36 (20)	0 (0)	2.82	0.45
X.	Promotes crop diversity on farmland	6 (3.3)	120 (66.7)	18 (10)	36 (20)	2.53	0.84
XI.	Provision of natural habitat for beneficial soil fauna	34 (18.9)	108 (60)	20 (11.1)	18 (10)	2.88	0.83
XII.	Builds plant resistance/resilience to disease	36 (20)	72 (40)	35 (19.4)	37 (20.6)	2.59	1.02
XIII.	Improves soil fertility	54 (30)	90 (50)	16 (8.9)	20 (11.1)	2.98	0.91
XIV.	Provision of energy needs of rural farmers	55 (30.6)	58 (32.2)	32 (17.8)	35 (19.4)	2.73	1.09
XV.	Improves the exchange of gases in the forest	36 (20)	90 (50)	24 (13.3)	30 (16.7)	2.73	0.96
XVI.	Promotes water use efficiency	18 (10)	36 (20)	108 (60)	18 (10)	2.30	0.78
XVII.	Improves income of farmers	104 57.8)	34 (18.9)	29 (16.1)	7 (3.9)	3.30	0.91
XVIII.	Rich sources of food for rural populace	90 (50)	73 (40.6)	17 (9.4)	0 (0)	3.40	0.65
XIX.	Increase water infiltration	15 (8.3)	46 (25.6)	49 (27.2)	70 (38.9)	2.03	0.99
XX.	Promotes soil porosity	39(21.7)	51 (28.3)	43 (23.9)	47 (26.1)	2.65	1.10
XXI.	Aids soil air aeration/water retention capacity	53(29.4)	19 (10.6)	33 (18.3)	75 (41.7)	2.87	1.27
XXII.	Improves pollination of wild flora	3 (1.7)	106 (58.9)	40 (22.2)	31 (17.2)	2.55	0.79
XXIII	Rich source of medicinal plants	86 (478)	9 (5)	77 (42.8)	8 (4.4)	2.96	1.04
XXIV	Source of forage for animal h/di	115 (63.9)	27 (15)	30 (16.7)	8 (4.4)	3.38	0.9

Source: Field survey data, 2016

This study revealed that agro-forestry systems involved a list of innovative land management practices that allowed for crop diversification, long rotation systems for soil conservation, home-gardens, boundary plantings, perennial crops, hedgerow intercropping, live fences, improved fallows or mixed strata agro-forestry.

Benefits of sustainable agro-forestry

Agro-forestry plays prominent role in climate change adaptation, both at the environment and farm/agricultural level. Agro-forestry makes the environment suitable for organic farming, through the use of manure from decomposed leaves and other plant residues.

Result in Table 2 shows the numerous roles of agroforestry as perceived from the respondent's mean (M) response to the statements. Agro-forestry reduces soil erosion with a mean response of 3.30, reduces heat stress on crop/animal (M=3.30), improves income of farmers (M=3.30), and a source of food for the rural populace (M=3.4). Other roles included slowing down of water run-off (M=2.58), reduction of flood menace (M=2.70), reduces water pollution (M=2.62), reduces cold stress by providing shelter (M=2.65), reduction of total crop failure (M=2.82), promotes crop diversity on farmland (M=2.53), provision of natural habitat for beneficial soil fauna (M=2.88), builds plant resistant/resilience to diseases (M=2.59), and improves soil fertility (M=2.98). It was also revealed that agro forestry practices provides the energy needs of rural farmers (M=2.73), improves the exchange of gases in the forest (M=2.73), increases water infiltration (M=2.73), promotes soil porosity (M=2.65), improves the pollination of field flora (M=2.55) and aids soil aeration/water retention capacity (M=2.87), rich source of medicinal plants (M=2.96), and source of forage for animal growth/production (M=3.38). From the result, agro-forestry practices are of great importance in the improvement of soil fertility in various ways directly and indirectly. The direct effect iswhen leguminous crops that fix nitrogen to the soil are planted with other crops without application of any synthetic substances to the soil while the indirect effect is the provision of natural habitat for soil fauna. The soil fauna aid in the decomposition of plant residues, thereby enhancing the production of organic manure. The use of the manure to enrich the soil and the use of forage from agro-forest to feed the animals help to improve crop and animal productivity respectively, in organic agriculture.

The responses from the survey support the studies of Sen (1991); Neupane and Thapa (2001), that agro-forestry systems are not only a source of timber and fuelwood, but also support crop production throughout the world. Furthermore, the result indicated that the use of trees and shrubs in agricultural systems helps to tackle the triple challenge of improving food security, increasing the adaptability of agricultural systems and mitigating climate change. While trees in the farming system can help increase farm income, they enable diversification of production and spread the risk of crop or market failure.

Conclusion and Recommendations

Based on the findings of the study, the agro-forestry practices in the study area were fully adopted by the farmers. Live fencemaking was the mostly adopted practice by the farmers as a result of its sustainability, in terms of easy access to planting materials, less labour requirement and for security reasons. The study also reveals the benefits of agro-forestry, as it serves as rich sources of food, improves farm income, improves soil health through which suitable environment is provided for organic plant growth, among others. It is recommended that agro-forestry practices that are fully organic based on its economic and ecological advantages, be given more attention, in terms of regular practice; where there should be a policy for its establishment in every agricultural unit, schools and institutes. More research should be carried out to determine the best combination of forest and food crops to yield maximum benefits for the environment in particular, and organic agriculture, in general.

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