GEROLD RAHMANN, VICTOR OLOWE, TIMOTHY OLABIYI, KHALID AZIM, OLUGBENGA ADEOLUWA (Eds.) (2018) Scientific Track Proceedings of the 4TH African Organic Conference. "*Ecological and Organic Agriculture Strategies for Viable Continental and National Development in the Context of the African Union's Agenda 2063"*. November 5-8, 2018. Saly Portudal, Senegal

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

[1]Anyoha, N.O., [2]Chikaire, J.U. and [3]Atoma, C. N.

[1&2]Federal University of Technology, Owerri.
[3]Delta State Polytechnic, Ozoro.

Corresponding author:
ndypaschal2004@yahoo.com

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

Abstract

The study ascertained 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 instrument administered to 180 respondents and analyzed using descriptive statistics - percentages, frequency, mean scores. The results revealed that the prevalent agro-forestry practices using multiple responses included rotational farming (86.1%), improved fallow (98.1%), intercropping (98.8%), live fence making (100%) and soil and water conservation (91.6%) among others. The respondents agreed that the benefits of agro-forestry included reduced soil erosion (Mean=3.30), reduced heat stress (Mean=3.01), protection of crops from wind damage (Mean=3.32), improved soil fertility using organic manure (Mean=2.98), reduction of wind speed (Mean=3.10), among others 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.

Introduction

A large percentage of the population in developing countries depends on agriculture for their livelihood. The practice of the 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 trapping of these carbon pollutants such as CO_2 and methane from farming and other human activities causes the atmospheric temperature to rise to an extent of altering the world climate (Intergovernmental Panel on Climate Change - IPCC 2007a). The need for food security, raw materials and to enhance socio-economic development has influenced the activities implicated in climate change (Ogbeide and Ele 2016; Abeygunawardena *et al*. 2003). 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 and 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 2011). Agro-forestry provides assets and income from carbon, wood energy, improved soil fertility using organic matters 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 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. 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) and Van Oost, Govers, Quine and Heckrath (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 in line with this 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.

Methodology

The study was conducted in Imo State. Purpose sampling techniques was used for the study 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 was obtained to give a sample size of 180 respondents. Questionnaire was used to gather the data from the respondents. The data were analyzed using percentages, frequency and mean. Mean score (M) of the responses to the variables designed as a 4-point Likert type scale items was used to find out the agreement response of the foresters based on the listed items under the benefits of agro-forestry. The scale ranged from Strongly agree (SA), Agree (A), D (Disagree) to Strongly Disagree (SD) with assigned scores of 4, 3, 2 and 1 respectively, where '4' represented 'strongly agree' and '1' indicated 'strongly disagree'. 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 of no effect.

Results

Sustainable Agro-forestry practices

Table 1 shows that farmers adopted sustainable agro-forestry practices in the study area. The more frequently adopted practice using multiple response 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 reveals that in live fences making, there is easy access of the planting materials, less labour requirement and low cost of adoption. Again, practice of tree planting along boundaries of the farm is 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 Study Area. (n =180)**

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

This study revealed that agro-forestry systems comprised 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. Making the environment suitable for organic farming through the use of organic manure from decomposed leaves and other plant residues.

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

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

Field survey data, 2016

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), building plant resistant/resilience to diseases (M=2.59), and improves soil fertility (M=2.98). The Table revealed also 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), increase 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, when leguminous crops that fix nitrogen to the soil are planted with other crops without application of any synthetic substances to the soil and indirectly, as in 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 organic 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 response from the survey supports Sen (1991); Neupane and Thapa (2001) and FAO (2011) 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

Based on the findings of the study, the agro-forestry practices in the study area were fully adopted by the farmers. Live fences making 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 security reasons. The study also reveals the benefits of agro-forestry as it serves as rich sources of food, improves farm income, improve soil health through which suitable environment is provided for organic plant growth among others. It is recommended that agro-forestry based on its economic and ecological advantages be given more attention in terms of regular practice and policy making for its establishment in every agricultural unit, schools and institutes. More researches should be done to determine the best combination of forest and food crops to yield maximum benefits for organic agriculture, the environment and agriculture in general.

References

Abeygunawardena, P., Vyas, Y., Knill, P., Foy, T., Harrold, M., Steele, P., Tanner, T., Hirsch, D., Oosterman, M., Rooimans, J., Debois, M., Lamin, M., Liptow, H., Mausolf, E., Verheyen, R., Agrawala, S., Caspary, G., Paris, R., Kashyap, A., Sharma, R., Mathur, A., Sharma, M. & Sperling, F. (2003). Poverty and climate change—reducing the vulnerability of the poor through adaptation. World Bank Press.

FAO, (2016). Organic Agriculture and Climate Change. Retrieved from http://www.fao.org/organicag /oa-specialfeatures/oa-climatechange/en/

IMSG, (2010). Education in Imo State. Imo State, Nigeria: Ministry of information, Owerri, Imo State Government.

IPCC (2007a). Climate Change 2007: Impacts, Adaptation and Vulnerability. Summary for Policymakers, IPCC AR4 WGII, Cambridge University Press, Cambridge, UK.

IPCC (2007b). Climate Change: Fourth Assessment Report. Retrieved from IPCC, www.ipcc.ch/

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

Lin, B.B. (2015). Agroforestry adaptation and mitigation options for smallholder farmers vulnerable to climate change. Retrieved from http://aciar.gov.au/files/node/13992/agroforestry_ adaptation_ and_mitigation_options_for_10868.pdf , 2015.

Mbow, C., Smith, P., Skole, S., Duguma, L. & Bustamante, M. (2014). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability, 6*, 8-14.

Neufeldt, H. (2013). Agroforestry and Climate Change Adaptation and Mitigation. Retrieved from http://www.fao.org/climatechange/36174-0552b1d21a0dd865ae3a3eda6acc8a3a0.pdf

Nguyen, Q., Hoang, M.H., O¨born I. & Noordwijk, M. V. (2013). Multipurpose agroforestry as a climate change resiliency option for farmers: an example of local adaptation in Vietnam. Climatic Change 2013, 117:241-257. Ogbeide, O.A. & Ele, I. (2016). Consumer Attitude, Socio-demographics and Adoption of Climate Change Measures. *Mayfair Journal of Agriculture Development in Emerging Economies 1*(2), 12-31.

Rodale Institute (2014). Reversing Climate Change Achievable by Farming Organically. Retrieved from http://rodaleinstitute.org/reversing-climate-change-achievable-by-farming-organically/

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O'Mara, F., Rice, C., Scholes, B. & Sirotenko, O. (2007). Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.