Adoption of Sustainable Farming Practices amidst Climate Change Incidence by Crop Farmers in Ebonyi State, Nigeria

Osuji, E.E.[1], Igberi, C.O.[1], Odor, A.H.[2], Anah C.O.[2], Abana, P.C.[2], Agunanne, U.T.[3] and Iheanacho, R.A.[3]

1Department of Agriculture, Alex Ekwueme Federal University Ndufu-Alike Ebonyi State, Nigeria
2Department of Agricultural Technology, Federal Polytechnic Nekede Owerri Imo State, Nigeria
3Department of Agriculture and Extension Management, Imo State Polytechnic Omuma Oru-East, Imo State, Nigeria.

K E Y W O R D S

Sustainable Agriculture,
Climate Change,
Crop Farmers,
Yield and Output

*C O R R E S P O N D I N G A U T H O R

osujiemeka2@yahoo.com

A B S T R A C T

Sustainable agriculture amidst climate change incidence in Ebonyi State, Nigeria was examined. A multi-stage sampling was used to select 140 crop farmers who were administered with questionnaires. Data collected were analysed using descriptive statistics, logit model and the local average treatment model. Results shows that the crop farmers were married (72.1%), more of males (70.7%), relatively educated (Mean = 12) and were in their productive age (51) years. Crop rotation (94.3%), bush fallowing (76.4%), shifting cultivation (98.6%), multiple cropping (100%), and erosion control measures (69.3%) were some of the sustainable agricultural practices adopted by the crop farmers in the State. About (94.3%) of the crop farmers adopted these practices against 6% that did not adopt. Age, sex, education, farm size, extension contacts, and farming experience were the major determinants of sustainable agricultural practices of the farmers. The adoption and use of sustainable farming practices increased land yield and output by (910.03%) and (1211.02%) amidst climate change manifestations. Farmers were recommended to adopt and practice sustainable farming practices to improve crop yield, output and land productivity in the State. This will ensure increased food production and security in the State.

INTRODUCTION

The challenge for agriculture to meet the World's increasing demand for food in a sustainable way is still far-fetched. This could be credited to the adverse effects of climate change and declining agricultural farm practices among the crop farmers. Climate change is one of the most serious threats to Nigeria agricultural sector and food security; arising from its sensitivity (Warsame, Sheik-Ali, Ali, and Sarkodie, 2021). For instance, higher temperature lowers the yield of the desirable crops, while encouraging weeds and pests' proliferation and changes in precipitation patterns increase the likelihood of short-run crop failure and long-run production declines, thus its variability create a huge challenge for crop production (Zhai, Song, Qin, Ye, and Lee, 2017). All over the world, issues related to climate change have become a major concern especially as it relates to sustainable agriculture. This is because climate change is seen to be causing serious challenges to the development of agriculture, food security and biodiversity (Osborne and Wheeler, 2013). Farming activities especially those dependent on rain-fed, rely on favourable climate conditions to be productive and are at risk under a changing climate especially if it comes with adverse conditions. Climate change affects food availability, access, and nutritional quality (Raju, 2019). As long as agriculture remains a soil-based industry, climate change will continue to cause major havoc in relation to farm yield, crop output and land productivity. However, increases in farm productivity are likely to be attained through sustainable farming practices (SFP) which ensures increase crop growth, and land productivity of the farmers (Onyeneke, Amadi, Njoku, and Osuji, 2021).

Understanding the principles of SFP can help farmers improve on their farm operations and maintain productive and profitable soil both now and for future generations. SFP is the application of soil management techniques that support plant growth without degrading the soil for further use. It involves the application of soil management practices that sustain food crop production in the midst of climate change and adverse atmospheric weather conditions. The relevance of SFP to agriculture includes the maintenance of soil productivity and economic viability over time without been depleted while maintaining and meeting the food demands of the present and future generations along changing climates and weather conditions (Onyeneke, Nwajiuba, Tegler, and Nwajiuba, 2020). It is the adoption of proven land use and crop management strategies that enable crop farmers to maximize the economic and social benefits of the soil, enhance ecological support and maintain a balanced soil ecosystem. Managing our soils sustainably is very crucial for agricultural production and post harvest of crops as climate change occurs (Adeagbo, Ojo, and Adetoro, 2021). SFP improves the fertility of degraded and marginal soils for long term benefits and protects the soil from degredation, increases its nutrients (with locally sourced products from farm, such as recycled crop residue and animal waste products) used for crop growth. SFP includes the use crop rotation, organic manure, and minimum tillage, erosion control, avoiding traffic on wet soils and maintaining soil cover with plants and/or mulches. It also involves the combination of soil fertility treatment such as application of mineral and organic fertilizers with soil and water conservation measures such as implementation of agronomic principles, soil management and physical measures such as contour ridging, terracing, tied ridges or providing ground cover through mulching, use of leguminous plants and crop residues (Agovino, Casaccia, Ciommi, Ferrara, and Marchesano, 2019). However, considering the interplay of climate change and sustainable agriculture in Ebonyi State in recent past, crop production in the State has fared poorly and unproductive exacerbating the farmers economic returns, yield, output and productivity of the land. This has created a huge gap in knowledge and empirical literature. The objectives of the study include; identify the socio-economic characteristics of the farmers, types of sustainable farming practices, examine the adoption levels of sustainable farming practices, determinants of sustainable farming practices, and impact of sustainable farming practices on land yield and output of farmers.

MATERIALS AND METHODS

The study was conducted in Ebonyi State, Nigeria. The State is made up of 13 Local Government Areas with Abakaliki as its capital. According to the National Population Commission, the State population was estimated to be 2,176,947 people in 2006 (National Population Commission, 2007). The total land area is about 5,533 km^2 with *Latitude*: 6°10' 40.7028" and *Longitude*: 7°57' 33.4296". Temperature ranges around 17^{0c} while precipitation is about 2000mm. Multi-stage sampling technique was employed for sample selection. In the first stage, four local government areas (LGA's) were randomly drawn from each of the agricultural zones of the state; (Ebonyi North, Ebonyi South, and Ebonyi Central), to make 12 LGA's. In the second stage, two communities were randomly selected from the LGAs, making a total of 24 communities. In the third stage, two villages were randomly picked from the selected communities giving 48 villages. The fourth stage had 4 crop farmers randomly selected, giving a total of 192 farmers. Primary data was collected for the study. The survey instrument (questionnaire) was used for primary data collection. It was prepared following the specific objectives of the study and was administered in person to the sampled respondents, but only 140 questionnaires were found useful for data analysis. Data were analysed using mean, frequency and percentage, Logit model and Local Average Treatment Effect (LATE Model). The Logit model is expressed as follows;

Log (P/1-P) = F (X_i, B) + e --- --- --- eqn. 1

Where:

P = Probability of adoption of SFP, while (1− P) is the probability of non-adoption of SFP.

B = Vector of estimated parameter

X_i = Independent variables considered, which include;

X_1 = Age of farmer (Years)

X_2 = Sex of farmer (Male =1, 0 = Female)

X_3 = Education (No of years spent in school)

X_4 = Household size (No. of persons)

X_5 = Net farm income (Naira)

X_6 = Farm size (Ha)

X_7 = Return from off farm activities (Naira)

X_8 = Distance of farm (Km)

X_9 = Labour supply (Mandays)

X_{10} = Cost of land improvement practices (Naira)

X_{11} = Extension contacts (No. of visits)

X_{12} = Farming experience (No. of years spent on crop production)

e = error term

The LATE model was specified as follows;

$E\ (y_1 - \frac{y_0}{d_1} = 1) = LATE = \frac{cov(y,z)}{cov\ (d,z)}$ --- --- -- eqn. 2

$$= \frac{E\left(\frac{y}{z}=1\right) - E(\frac{y}{z}=0)}{E\left(\frac{d}{z}=1\right) - E(\frac{d}{z}=0)}$$

$$= \frac{E(y_i * (z - E(z_i)}{E(d_i * (z - E(z_i)}$$

$$= \left(\frac{\sum_{i=1}^{n} y_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} y_i (1 - z_i)}{\sum_{i=1}^{n} (1 - z_i)}\right) \text{X} \left(\frac{\sum_{i=1}^{n} d_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} d_i (1 - z_i)}{\sum_{i=1}^{n} (1 - z_i)}\right) \text{-----} \quad \text{eqn. 3}$$

Specifying LATE model components,

$\text{ATE} = \frac{1}{n} \sum_{i=1}^{n} i \, \frac{(d_i - p(X_i) y_i}{p\,(X_i)(1 - p(X_i)}$

$\text{ATE1} = \frac{1}{n1} \sum_{i=1}^{n} i \, \frac{(d_i - p(X_i) y_i}{(1 - p)(X_i)}$

RESULTS AND DISCUSSION

Socio-economic Characteristics of Farmers

The socio-economic characteristics of the farmers are presented in Table 1. The mean age of the farmers is 51 years. This implies that the crop farmers were in their productive age. This could have a tremendous positive influence on crop production and efficiency of resource utilization. According to the Table, 70.7 percent of the farmers were males while the remaining 29.3% were females. This implies that Nigeria agriculture is still male dominated based on the fact that men are bread winners and takes full responsibility in providing for their love ones and families at every given time (Ahmad, Jiang, Majeed, and Raza, 2020). Majority of the farmers, 72.1 percent were married with children which is a significant indication of high family labour availability utilized in the farming business (Agovino *et al*., 2019). The mean household size was 7 persons. This implies that the household size was relatively large and therefore could enhance production efficiency of the crop farmers since rural households rely more on members of their households than hired labourers who charge outrageous wages (Ahsan, Chandio, and Fang, 2020). The mean years of educational attainment were 12 years. This implies that majority of the farmers had secondary education which depicts that the farmers could read and write and able to understand farm production principles and takes critical decisions concerning their farming enterprises (Osuji, Okwara, Essien, Agu, and Oguegbuchulam, 2019). Majority of the farmers 70.7% had farming experience ranging from 11-20 years and the mean farming experience was 17 years. This means that the farmers were experienced in the farming enterprise which might considerably reduce inefficiency in production. Farming experience of a farmer increases his production efficiency and helps him in overcoming climate change incidence and adoption of improved production techniques. The mean extension contact of the farmers was 6.2; this implies that the farmers were visited 6 times in the cropping season. This implies that the household farmers were exposed to improved farm agricultural practices, innovations and their resultant benefits (Zhai *et al*., 2017). The mean farm size was 3.06; this implies that majority of the farmers in the area cultivated on relatively large scale farmlands which is known to improve yields, outputs, land productivity and income of the farmers. Large farm size also accommodates climate change adaptations and adoption of new farming practices (Osuji *et al*., 2019). The Table reveals that majority 92.9 percent of the farmers made use of family labour compared to 4.3 percent of the farmers who used hired labour in their farm operations. This finding shows that a greater percentage of the respondents used family labour due to the high costs charged by most labourers.

Table 1: Socio-economic characteristics of farmers

Variables	Frequency	Percentage	Mean
Age			51.0
20 – 29	5	3.6	
30 – 39	19	13.6	
40 – 49	16	11.4	
50 – 59	83	59.3	
60 – 69	12	8.6	
70 – 79	5	3.6	
Sex			
Male	99	70.7	
Female	41	29.3	
Marital Status			
Married	101	72.1	
Single	8	5.7	
Separated	2	1.4	
Divorced	10	7.1	
Widow/Widower	19	13.6	
Household Size			7.2
1 – 5	52	37.1	

6 – 10	81	57.9	
11 – 15	7	5.0	
Education			12.0
0	10	7.1	
1 – 6	44	31.4	
7 – 12	70	50.0	
13 – 18	16	11.4	
Farming Experience			17.0
1 – 10	11	7.9	
11 – 20	99	70.7	
21 – 30	10	7.1	
31 – 40	16	11.4	
41 – 50	4	2.9	
Extension Contact			6.2
1 – 4	6	4.3	
5 – 9	131	93.6	
10 – 14	3	2.1	
Farm Size			3.06
0.01 – 1.00	5	3.6	
1.01 – 2.00	2	1.4	
2.01 – 3.00	2	1.4	
3.01 – 4.00	131	93.6	
Sources of Labour			
Family labour	129	92.9	
Hired labour	6	4.3	
Both labours	5	3.6	

Source: Field survey data, 2022

Types of Sustainable Farming Practices of Farmers

The various types of sustainable farming practices of the farmers are shown in Table 2. The Table showed that all the crop farmers adopted organic manure and multiple cropping. Organic manure is largely practiced by arable crop farmers to improve the fertility of the soil and productivity of the land. On the other hand, multiple cropping is mainly practiced to avert the risks of total crop failure occasioned by climate change (Roco, Bravo-Ureta, Engler, and Jara-Rojas, 2017). Multiple cropping is further practiced to accommodate one type of crop or the other per cropping season. Similarly about 98.6, 76.4, and 94.3 percent of the farmers adopted shifting cultivation, bush fallowing and crop rotation respectively. Shifting cultivation and bush fallowing are soil sustainable farming practices used to improve the fertility of the soil and enhance crop productivity of the farmers. However these soil management techniques are rarely practiced by crop farmers due to land scarcity and tenure systems available to the farmers (Samuel, Seth, and Edward, 2021). Consequently, a cross section of the farmers adopted mulching 91.4 percent, planting of leguminous/cover crops, 77.9 percent, erosion control measures, 69.3 percent and minimum/zero tillage, 80.7 percent respectively. These sustainable farming practices are generally used to control soil erosion, mitigate climate change and reduce water run-off in most farmlands (Saalu, Oriaso, and Gyampoh, 2020). Again, another section of the famers adopted alley cropping 62.9 percent, crop residue recycling 86.4 percent and mixed farming, 97.1 percent respectively. These practices help in increasing the farm productivity of the farmers, thus leading to an increase in income of the crop farmers. Furthermore, the farmers in the area adopted liming 42.1 percent, taungya farming 32.1 percent, contour cropping 26.4 percent and strip cropping 18.8 percent respectively. Liming is practiced by most crop farmers to reduce the acidity of the soil. Taungya farming improves soil fertility which enhances crop yield and productivity of the farmers (Roco *et al*., 2017). Contour and strip cropping on the other hand are used by crop farmers on slope farmlands to reduce the risks of water run-off and soil loss.

Table 2: Types of sustainable farming practices of farmers

Types of SFP	Frequency	Percentage
Contour Cropping	37	26.4
Strip Cropping	26	18.8
Crop Rotation	132	94.3
Planting of Cover crops	109	77.9
Crop Residue Recycling	121	86.4
Use of Organic Manure	140	100
Use of Mulching	128	91.4
Alley Cropping	88	62.9
Erosion Control Measures	97	69.3
Multiple Cropping	140	100
Minimum/Zero Tillage	113	80.7
Mixed Farming	136	97.1
Liming	59	42.1
Taungya Farming	45	32.1
Bush Fallowing	107	76.4
Shifting Cultivation	138	98.6

Source: Field survey data, 2022

Adoption of Sustainable Farming Practices

The adoption of sustainable farming practices of farmers is shown in Table 3. The Table shows that about 94.3 % of the farmers adopted the sustainable agricultural practices introduced to them as against the 6% that did not adopt. This implies that majority of the farmers practiced the agricultural practices exposed to them thus, leading to increased farm yield, output, land productivity and income of the farmers (Osuji *et al*., 2019). The lesser percentage that did not adopt may be due to ignorance and unwillingness to adopt such sustainable practices.

Table 3: Adoption of sustainable agricultural practices

Adoption of SFP	Frequency	Percentage
Adopted	132	94.3
Non-Adopted	8	5.7

Source: Field survey data, 2022

Determinants of Sustainable Agricultural Practices of Crop Farmers

The estimated determinants of sustainable farming practices of crop farmers are presented in Table 4. The chi (χ^2) was highly significant at 1 percent and this confirms the fitness of the model. The coefficient of age was positive and highly significant at 1 percent level; implying a direct relationship with sustainable farming practices of farmers. This implies that young farmers are more receptive and eager to try out new practices and in responding to climate change (Khanal, Wilson, Hoang, and Lee, 2018). The coefficient of sex was positive and significant at 5 percent level; implying a direct relationship with sustainable farming practices. The positive value denotes that male farmers have greater probabilities of engaging in sustainable farming practices compared to their female counterparts. The coefficient of education was positive and highly significant at 1 percent level indicating a direct relationship with sustainable farming practice. This implies that education increases the ability of the farmers to adopt new technologies. Thus, the level of farmers' education has profound effect on technology adoptions and climate change mitigations (Lenis, Liverpool-Tasie, and Charuta, 2020). The coefficient of net farm income was positive and significant at 5 percent probability level, indicating a direct relationship with sustainable farming practices. This implies that any increase in net farm income increases the adoption of sustainable farming practices. Increase in net farm income empowers farmers to adopt more sustainable soil practices and procurement of agricultural inputs (Mahmod and Beeching, 2018). The coefficient of farm size was positively related to sustainable farming practices and was significant at 1 percent level. This implies that a unit increase in farm size of the farmers will lead to a corresponding increase in the adoption of sustainable farming practices. Larger farm sizes drive farmers to adopt sustainable agricultural practices and purchase of more production inputs. The coefficient of cost of land improvement practices was negatively related to sustainable farming practices and significant at 5 percent probability level. Thus, this indicates an inverse relationship with sustainable farming practices. This implies that any increase in the cost of land improvement practices will lead to a decrease in the adoption of sustainable agricultural practices. High cost of land management practices deters farmers especially those in rural areas from adopting improved soil practices (Mulinya, 2017). The coefficient of the extension contacts was positive and highly significant at 1 percent level, indicating a direct relationship with sustainable farming practices. This implies that a unit increase in extension contacts will lead to a unit increase in the adoption of sustainable farming practices. Extension contacts engender innovative effectiveness, knowledge transfer, information dissemination and adoption drive of the farmers (Samuel *et al*., 2021). The coefficient of farming experience was positively related to sustainable farming practices and significant at 1 percent level. This implies that an increase in farming experience of farmers will lead to a corresponding increase in the adoption of sustainable farming practices. Experience farmers are generally better and knowledgeable enough to access the relevance of new of technologies through interaction with other farmers and the outside world (Mupakati and Tanyanyiwa, 2017).

Table 4: Determinants of sustainable farming practices of crop farmers

Variables	Parameters	Coefficients	t-values	Std Error
Constant	b_o	0.0725	2.5008**	0.0289
Age of farmer	b_1	0.7550	4.0012***	0.1886
Sex of farmer	b_2	0.8923	2.0406**	0.4373
Education	b_3	0.7411	3.7111***	0.1997
Household Size	b_4	-0.9791	-0.0503NS	19.465
Net farm income	b_5	0.5702	1.8881**	0.3019
Farm size	b_6	0.0991	3.0019***	0.0330
Return from off farm activities	b_7	0. 4402	1.1116NS	0.3960
Distance of farm	b_8	0.9044	0.5019NS	1.8019
Labour supply	b_9	0.1883	1.2091NS	0.1557
Cost of land improvement practices	b_{10}	- 0.6065	-2.0905**	0.2901
Extension contacts	b_{11}	0.9121	3.7110***	0.2457
Farming experience	b_{12}	0.7738	4.9529***	0.1562
LR (χ^2)		171.07***		
Log likelihood		186.03		
Pseudo (R^2)		0.8710		
N		140		

Source: Field survey data, 2022 Significant at ***1% and **5%

Impacts of Sustainable Farming Practices on Land Yield and Output of Farmers

The impact of sustainable farming practices on land yield and output of farmers is presented in Table 5. The table reveals that the propensity score matching (PSM) and the inverse propensity score weighing (IPSW) estimates gave 42.6401 and 22.0100 respectively. These estimates fail to identify the actual casual effect of the adoption and use of sustainable agricultural practices. Hence, they are declared inconclusive and imply the existence of non-compliance. The non-compliance here means that there are farmers who will never adopt or use sustainable agricultural practices. Thus the LATE model becomes an appropriate tool in reducing non-compliance issues. From the results, the LATE (WALD) and LATE (IV) estimates gave 9.1003 and 12.1102 and were highly significant. This implies that the adoption and use of sustainable agricultural practices amidst climate change excesses increased land yield and output by 910.03% and 1211.02% (Dokic, Matkovski, Jeremic, and Duric, 2022). This further implies that the higher the adoption and use of sustainable agricultural practices, the higher the increase in land yield and output of the farmers (Prihandiani, Bella, Chairani, Winarto, and Fox, 2021). Again, the ATE 1, estimate was positive and significant, implying that the adoption and use of sustainable farming practices amidst climate change incidence yielded a positive increase of 990.04% in land yield and output. While, the ATE 0 was negative and not significant.

Table 5: Impacts of sustainable agricultural practices on land yield and output of farmers

PARAMETER	LATE (WALD)	LATE (IV)	ATE (IPSW)	PSM
ATE	9.1003	12.1102	22.0100	42.6401
	(15.52)***	(16.90)***	(10.01)***	
ATE 1			9.9004	
			(8.50)***	
ATE 0			-4.0880	
			(-0.75)	

Source: Field survey data, 2021. Significant at ***1%

CONCLUSION AND RECOMMENDATION

The findings of the study showed that the crop farmers were in their productive age, more of males, married, and relatively educated. A range of sustainable agricultural practices such as contour cropping, mulching, crop rotation, liming, bush fallowing, etc were adopted by the crop farmers. Age of the farmer, sex, education, farm size, extension contacts and farming experience were the major determinants of sustainable agricultural practices in the State. The adoption and use of sustainable agricultural practices increased land yield, and output in the State amidst climate change occurrences. Farmers were recommended to extensively adopt and practice sustainable farming practices to enhance yield increase, farm output and land productivity; this will boost food and crop production in the State.

REFERENCES

Adeagbo, O.A.,Ojo, T.O., and Adetoro, A.A. (2021).Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. Heliyon, 7, 2, e06231. https://doi.org/10.1016/j.heliyon.2021.e06231

Agovino, M., Casaccia, M., Ciommi, M., Ferrara, M., and Marchesano, K. (2019). Agriculture, climate change and sustainability: The case of EU-28. Ecological Indicators, 105, 525–543. https://doi.org/10.1016/j.ecolind.2018.04. 064

Ahmad, M., Jiang, P., Majeed, A., and Raza, M.Y. (2020). Does financial development and foreign direct investment improve environmental quality? Evidence from belt and road countries. Environmental Science and Pollution Research, 27, 23586–23601. https://doi.org/10.1007/s11356-020-08748-7

Ahsan, F., Chandio, A.A, and Fang, W. (2020). Climate change impacts on cereal crops production in Pakistan. International Journal of Climate Change Strategies and Management, 12, 257–269.

Dokic, D., Matkovski, B., Jeremic, M., and Duric, I. (2022). Land productivity and agri-environmental indicators: A case study of Western Balkans. Land, 11(12), 2216.

Khanal, U., Wilson, C., Hoang, V. N. and Lee, B. (2018). Farmers' adaptation to climate change, its determinants and impacts on rice yield in Nepal. Ecological Economics, 144, 139–147.

Lenis, S., Liverpool-Tasie, O. and Charuta, M. P. (2020). Climate risk and technology adoption in the midstream of crop value chains: evidence from Nigerian maize traders. Journal of Agricultural Economics, 3, 1-22. https:doi: 10.1111/1477-9552.12394

Mahmod, N., and Beeching, J. (2018).Correlation of scopoletin-induced fluorescence with visible PPD symptoms in greenhouse cassava. Postharvest Biological Technology, 145, 10–14.

Mulinya, C. (2017). Factors affecting small scale farmers coping strategies to climate change in Kakamegacounty in Kenya. Journal of Humanities and Social Sciences, 22(2),100-109.

Mupakati, T., and Tanyanyiwa, V. I. (2017). Cassava production as a climate change adaptation strategy in Chilonga ward, Chiredzi District, Zimbabwe. Jamba, 9(1), 348-370. https://doi.org/10.4102/jamba.v9i1.348

NPC, (2007). Reports of National Population Commission Abuja, Nigeria.

Onyeneke, R.U., Nwajiuba, C.U., Tegler, B., and Nwajiuba C.A. (2020). Evidence-based policy development: National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN). Springer, MRW, 1-18

Onyeneke, R.U., Amadi, M.U., Njoku, C.L. and Osuji, E.E. (2021).Climate change perception and uptake of climate smart agriculture in rice production in Ebonyi State, Nigeria. Atmosphere, 12, 1503.

Osborne, T.M and Wheeler, T.R. (2013). Evidence for a climate signal in trends of global crop yield variability over the past 50 years. Environmental Research Letters, 8, 024001, 1-9.

Osuji E.E., Onyeneke R.U., Balogun O.L., Tim-Ashama A.C., Onyemauwa C.S., Praise N.C., Azuamairo G.C., Amadi M.U., Obi J.N., Ibekwe C.C., Obasi I.O., Njoku C.L., Izuogu C.U., Ebe F.E., and Ugochukwu G.C. (2021). Econometric analysis of agricultural intensification techniques of household farmers in Nigeria. Universal Journal of Agricultural Research, 9(6), 289- 299.

Osuji, E.E., Okwara, M.O., Essien, U.A., Agu, C.G., and Oguegbuchulam, M.N. (2019). Sustainability of Climate Change Adaptation Measures in South-South, Nigeria. Agriculture and Food Sciences Research, 6(1), 120-126.

Prihandiani, A., Bella, D.R., Chairani, N.R., Winarto, Y., and Fox, J. (2021). The tsunami of pesticide use for rice production on Java and Its consequences, The Asia Pacific Journal of Anthropology, 22(4), 276-297.

Raju, G. (2019). Assessing the impact of climate change on Indian agriculture: Evidence from major crop yields. Journal of Public Affairs, 20, e2040, 1-7.

Roco, L., Bravo-Ureta, B., Engler, A. and Jara-Rojas, R. (2017). The impact of climatic change adaptation on agricultural productivity in central Chile: a stochastic production frontier approach. Sustainability, 9, 1648.

Saalu, F., Oriaso, S. and Gyampoh, B. (2020), "Effects of a changing climate on livelihoods of Forest dependent communities: Evidence from Buyangu community proximal to kakamega tropical rain Forest in Kenya". International Journal of Climate Change Strategies and Management, 12 (1), 1-21.

Samuel, M., Seth, A.M., and Edward, D. (2021).Gender perceptions on the causes of climate variation and its effects on cassava production among farmers in Ghana. Cogent Food and Agriculture, 7: 1911398, 6 -14.

Warsame, A.A., Sheik-Ali, I.A., Ali, A.O. and Sarkodie, S.A. (2021). Climate change and crop production nexus in Somalia: Empirical evidence from ARDL technique. Environmental Science and Pollution Research, 28:1–13.

Zhai, S., Song, G., Qin, Y., Ye, X., and Lee, J. (2017).Modeling the impacts of climate change and technical progress on the wheat yield in inland China: an autoregressive distributed lag approach. PLoS One, 12(9), e0184474.