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Comparative analysis of the sustainable dimensions of food security with COVID-19 and climate change: A case study

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ABSTRACT

This study examined the comparative analysis of the sustainable dimension of food security with COVID-19 and climate change in the Ebonyi State of Nigeria. It is aimed at developing a scientific response to the basic dimensions of food security in this era of COVID-19. This study employed purposive and random sampling techniques to select 180 respondents from the area using a structured questionnaire. ANOVA technique was used to validate the quantitative statistics of the results. Results showed that the COVID-19 era caused more harm to agricultural production leading to a drastic reduction in agricultural yields, food supply chain, and agricultural inputs and materials in the area. There was a forceful drop in availability, affordability, accessibility, stability, and utility of agricultural inputs and materials in the area as compared to the period prior to the pandemic which showed significant increases in agricultural yields and the food supply chain. The perception of respondents to climate change was recorded as a major threat affecting food security in the area. Government subsidization of agricultural inputs and materials, as well as the adoption of proven climate change adaptation and mitigation strategies, were overtly recommended.

1. Introduction

Climate change action is imposing a continuous challenge to the growth of agriculture all over the world. Its extreme effect is threatening the achievement of Sustainable Development Goal number two aimed at zero hunger by 2030. The effect of climate change in different regions of the world has a direct influence on food security thereby significantly causing major distortion in people's livelihoods'(IPCC, 2015; Olufemi et al., 2020; Pokhrel et al., 2021; Oti et al., 2021; Onyeneke et al., 2018; Onyeneke, 2016a; 2016b; Brida et al., 2013; Singh et al., 2013; FAO, 2020), etc. Further, climate change has distorting effects on the cost and availability of micronutrients to the fact that it is mostly associated with rising temperature and erratic rainfall patterns (Onyeneke et al., 2018; Onyeneke, 2016b; Prasanna, 2014). Indeed, according to (OECD, 2014) and (OECD, 2015), the agricultural sector contributes 17 percent share of the greenhouse gas (GHG) emissions and in Sub-Saharan Africa, climate change is set to hit the agricultural sector the most severely. It would cause suffering particularly for smallholder farmers, (BNRCC, 2011; NEST, 2011; FAO 2021, Arora, 2019; Amare et al., 2020; Ortiz-Bobea et al., 2021).

Agriculture has a direct relationship with food security. Food security can be said to exist when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for active and healthy life (Laborde et al., 2020) and (FAO, 2021). The role of food security in human development cannot be over-emphasized. The number of people who die from hunger in a year is more than that of AIDS, Malaria, and Tuberculosis combined (WHO, 2020). The sudden emergence of COVID-19, in Wuhan, China on December 31, 2019, has put food security in jeopardy (WHO, 2020). The COVID-19 outbreak and its attendant control measures such as quarantine and lockdown impacted human activities and economic growth, not excluding its many adverse effects on agriculture, see e.g., UNPB (2020), Andam et al. (2020), Okonkwo

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et al. (2021), and Obayelu et al. (2021) for details. One can see also (Pakravan-Charvadeh et al., 2021).

The impact of climate change and the COVID-19 pandemic have hampered the state of food security globally and in Nigeria in particular, (Shankar, 2018; Babatunde et al., 2011; Nelson et al., 2010; Barros et al., 2014; Nwajiuba et al., 2011). Though, there are ample articles on the impact of climate change on different dimensions of food security such as the works of (Schmidhuber et al., 2020; Mondal and Reddy, 2018; Shankar, 2018; Zhang, 2020) there are many obvious changes taking place over time as a result of COVID-19 pandemic. These changes in the food sector require in-depth investigation so as to compare the current effect with the already existing facts for proper policy direction in order to simplify the farmers' burden of food insecurity. This study fills this gap in knowledge by using data from Ebonyi State to compare the effect of climate change in addition to the COVID-19 pandemic on food security. Again, little or no research on the above direction seems to have been carried out in Ebonyi State, hence the objective of this study is to carry out a comparative analysis of the sustainable dimension of food security with the COVID-19 pandemic and climate change in Ebonyi State, Nigeria. Specific objectives are to analyze the effect of COVID-19 and climate change on food access during the pandemic and secondly to ascertain the effect of COVID-19 and climate change on the availability of food supply and access. It is also the intention of this study to answer the following.

1.1. Research questions

The following two main questions will be answered by this research: Were the agricultural inputs available, accessible, affordable, and stable in supply during COVID-19? Were different categories of food items available, accessible, affordable, and stable in supply during COVID-19.

1.2. Hypotheses of the study

To statistically validate the answers to the questions above, the following null hypotheses will be tested at a 5% degree of freedom.

$H0_1$: The mean availability, affordability, accessibility, stability, and food supply chain of basic farm inputs before and during the COVID-19 pandemic era in the area is insignificant.
HA_2: The mean availability, affordability, accessibility, stability, and food supply chain of basic farm inputs before and during the COVID-19 pandemic era in the area is significant.

2. Methods

2.1. Description of the study area

The study area is Ebonyi State, one of the states in the Southeast geopolitical zones of Nigeria. It is made up of twelve Local Government Areas. According to the National Bureau of Statistics, the 2016 population estimate of the area is 3,490,383 persons (NBS, 2006).

2.2. Sampling technique

This study employed purposive and random sampling techniques. In each of the six LGAs identified with the highest agricultural population, communities with the poorest food sources, mostly hit by COVID-19, increase flooding, and single-source agricultural farmers were also compiled. Then, two communities were randomly selected from each LGA, resulting in a total of twelve communities for the survey. Finally, from the list of the community leadership, fifteen farmers were picked at random from each of the communities resulting in a total of one hundred and eighty farmers for the final survey.

2.3. Data collection and analysis

The researchers employed a survey instrument questionnaire developed by them and administered face-to-face to rural farming households in Ebonyi State using a group farmers' approach. The contents of the questionnaire were read and interpreted by the researchers in the farming households and their responses were recorded. A pilot survey was first conducted in Ikwo to checkmate the inadequacies of the questionnaire using twenty farmers. Descriptive statistics are applied to analyze the collated data while the hypotheses are decided with the aid of ANOVA analysis. This method is in agreement with the approach of (Ladapo et al., 2020; Shrestha et al., 2021).

3. Results and discussion

The trends of availability of agricultural inputs were studied to find the difference in inputs before and during COVID-The frequency of affirmative responses on availability of major inputs to both crop and livestock farmers were considered and analyzed in Table 1.

Table 1: Distribution of the respondents according to availability of agricultural inputs and materials

Inputs and materials	Before the pandemic	During COVID-19
Labour	110	22
Planting materials	151	34
Fertilizer	140	18
Pesticides	141	35
Day old chicks	138	23
Poultry feed	155	23
Mean	835	155

From Table 1, there is an upward increase in the availability of agricultural inputs and materials before the pandemic and less during the Covid 19. For instance, labor utilization rose up to 110 before the pandemic and dropped to 22 during the Covid 19. Planting materials and fertilizer were recorded at 151 and 140 before the pandemic and drastically dropped to 34 and 18 during the COVID-19 pandemic. Again, there was a tremendous increase in pesticide use, 141, day old chicks, 138 and poultry feed, 155 with overwhelming reductions of these agricultural inputs and materials during the Covid 19 pandemic. However, the mean agricultural inputs and materials before the pandemic recorded a high value of 835 relative to 155 during the pandemic, which implies that these agricultural inputs and materials were more readily available before the pandemic than in the COVID-19 era. These available inputs and materials increased agricultural production which in turn led to an increase in the income of the household farmers.

From Tables 1 and 2, we observe that the mean affirmative response for "before and during the pandemic" is 835 and 155 respectively. Moreover, the F statistic of 258.67 is greater than the F critical of 4.96. We, therefore, conclude that the mean difference between the affirmative and negative responses is significant. Furthermore, the computed P-value is less than a 0.05 confidence interval and we thus reject the null hypothesis and conclude that the difference in mean availability of the inputs is significant. We infer that the agricultural inputs had more availability rate before the COVID-19 pandemic.

Table 2: ANOVA table for availability

ANOVA						
Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	38533.33333	1	38533.33	258.6708	1.79E-08	4.9646027
Within Groups	1489.666667	10	148.9667			

The distribution of the affirmative responses according to the affordability of agricultural inputs and materials is shown in Table 3. The results in Table 2 further confirmed the results obtained in Table 1. Results from Table 2 showed that the agricultural inputs and materials such as labor, planting materials, fertilizers, pesticides, day old chicks, and poultry feed were readily affordable before the pandemic relative to the pandemic era. This could be attested to base on the high values recorded in each of these agricultural inputs and materials before the pandemic as compared to the COVID-19 era which brought about the scarcity of these agricultural inputs and materials. It could be further seen from Table 2 that the mean affordability of agricultural inputs and materials during the COVID-19 era was interestingly less when compared with before the pandemic. The mean estimated value of 114 showed that these agricultural inputs and materials were really affordable before the pandemic. It was generally obvious that the COVID-19 era brought about the relative scarcity of these inputs and materials and drastically led to a significant drop in agricultural production and productivity of the household farmers which interfered with food security.

Table 3: Distribution of the respondents according to Affordability of agricultural inputs and materials

Inputs and materials	Before the pandemic	During COVID-19
Labour	104	10
Planting materials	152	30
Fertilizer	85	8
Pesticides	98	15
Day old chicks	126	26
Poultry feed	119	18
Mean	114	17.83

From Tables 3 and 4, we observe that the mean affirmative response for "before and during the pandemic" is 114 and 17.83 respectively. Moreover, the F statistic of 86.9493 is greater than the F critical of 4.96. We, therefore, conclude that the mean difference between the affirmative response and negative response is significant. Furthermore, the computed P-value is less than a 0.05 confidence interval and we thus reject the null hypothesis and conclude that the difference in mean affordability of the inputs is significant. We infer that the agricultural inputs had more affordability rate before the COVID-19 pandemic.

Table 4: ANOVA table for affordability

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	27744.08333	1	27744.08	86.94933	3.01E-06	4.964603
Within Groups	3190.833333	10	319.0833			

The distribution of the affirmative responses according to the accessibility of agricultural inputs and materials is shown in Table 5. The results from Table 5 further confirmed the results obtained from Table 3. It could be further seen from Table 3 that the high values recorded in each of these agricultural inputs and materials before the pandemic significantly indicated the accessibility of these

agricultural inputs and materials before the pandemic than during the pandemic period. That is, there is increasingly over 90 percent accessibility of these agricultural inputs and materials prior to the pandemic era as compared to the COVID-19 era. This could equally be seen from the notable drop in values recorded during the COVID-19 era. Again, the estimated mean of accessibility of these agricultural inputs and materials before the pandemic was 126.17 as against 21.50 during the pandemic era. This further implies the overall accessibility of these agricultural inputs and materials prior to the pandemic era. Furthermore, the accessibility of these agricultural inputs and materials is consequent upon their availability and affordability.

Table 5: Distribution of the respondents according to the accessibility of agricultural inputs and materials

Inputs and materials	Before the pandemic	During COVID-19
Labour	95	12
Planting materials	153	25
Fertilizer	148	15
Pesticides	137	32
Day old chicks	94	28
Poultry feed	130	17
Mean	126.17	21.50

From Tables 5 and 6, we observe that the mean affirmative response for "before and during the pandemic" is 126.17 and 21.50 respectively. Moreover, the F statistic of 89.98 is greater than the F critical of 4.96. We, therefore, conclude that the mean difference between the affirmative response and negative response is significant. Furthermore, the computed P-value is less than a 0.05 confidence interval and we thus reject the null hypothesis and conclude that the difference in mean accessibility to the inputs is significant. We infer that the agricultural inputs had more availability rate before the COVID-19 pandemic.

Table 6: ANOVA table for accessibility

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	32865.33333	1	32865.33	89.98448	2.57E-06	4.964603
Within Groups	3652.333333	10	365.2333			

The distribution of the affirmative responses according to the stability of agricultural inputs and materials is shown in Table 7. It could be seen that the results in Table 7 are notably consistent with the previous results in Tables 1, 3, and 5. This is because the stability of agricultural inputs and materials is dependent upon their availability, affordability, and accessibility. There could not be stability without these parameters being established. The results showed that the COVID-19 era recorded a tremendous drop and/or fall in these agricultural inputs and materials in the area as compared to the period before the pandemic which recorded higher values. The higher values showed that the agricultural inputs and materials were relatively stable before the pandemic as compared to the COVID-19 era. The COVID-19 era brought about serious instability of these agricultural inputs and materials which negatively influenced agricultural production and food security. This is further confirmed in the mean estimated values of 115 and 17.5 respectively.

Table 7: Distribution of the respondents according to the stability of agricultural inputs and materials

Inputs and materials	Before the pandemics	During COVID-19
Labour	86	8
Planting materials	145	10
Fertilizer	90	20
Pesticides	150	28
Day old chicks	94	18
Poultry feed	125	21
Mean	115	17.5

From Tables 7 and 8, we observed that the mean affirmative response for "before and during the pandemic" is 115 and 17.50 respectively. Moreover, the F statistic of 64.70 is greater than the F critical of 4.96. We, therefore, conclude that the mean difference between the affirmative response and negative response is significant. Furthermore, the computed P-value is less than a 0.05 confidence interval and we thus reject the null hypothesis and conclude that the difference in mean stability of the inputs is significant. We infer that the agricultural inputs had more stability rate before the COVID-19 pandemic.

Table 8: ANOVA table for stability

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	28518.75	1	28518.75	64.70505	1.12E-05	4.964603
Within Groups	4407.5	10	440.75			

The distribution of the affirmative responses according to the food supply chain of agricultural inputs and materials is shown in Table 9. Table 9 showed that the agricultural inputs and materials are categorized into availability, affordability, accessibility, stability, and utility respectively. It is obvious from the Table 9 results that the food supply chain in the area was much better off prior to the pandemic than during the COVID-19 era. This is shown consequently upon the high values reported before the pandemic era on food availability, 117, affordability, 126, accessibility, 119, stability, 121 and utility, 116as against the decreasing values reported during the COVID-19pandemic. It could also be seen that the food supply chain before the pandemic era recorded over 100 percent in food availability, affordability, accessibility, stability, and utility in the area relative to the COVID-19 era which is less than 55 percent. Also, the mean estimated food supply chain prior to the pandemic was as high as 119.80 as against 42.20 recorded during the COVID-19, which further confirmed the consistency and growth of the food supply chain before the pandemic. However, the distribution of the food supply chain is further shown in Fig. 1 and Table 10 shows ANOVA for the food supply chain.

Table 9: Distribution of the respondents according to food supply chain

Inputs and materials	Before the pandemics	During COVID-19
Availability	117	43
Affordability	126	34
Accessibility	119	41
Stability	121	39
Utility	116	54
Mean	119.80	42.20

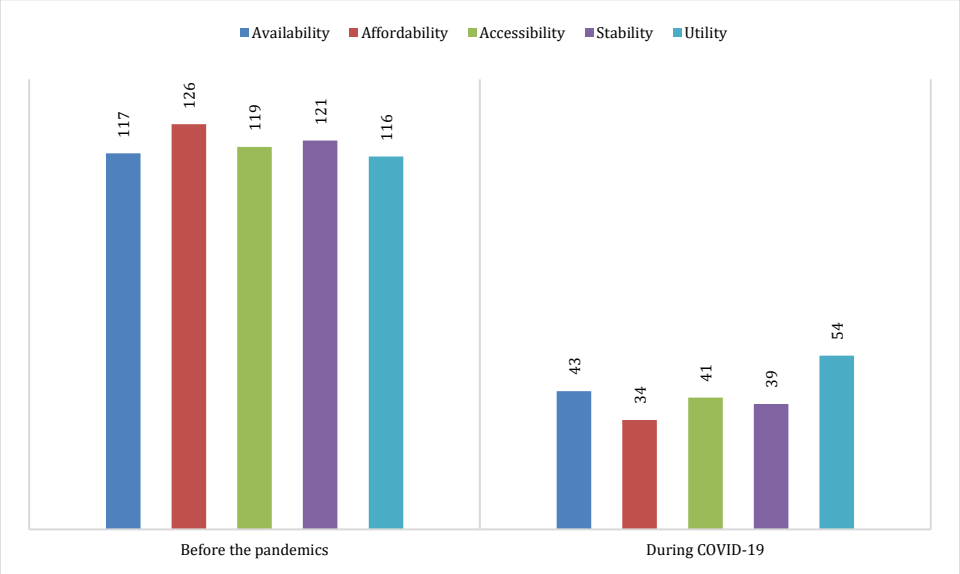

Fig. 1: Food supply chain

Table 10: ANOVA for food supply chain

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	15054.4	1	15054.4	427.6818	3.13E-08	5.317655
Within Groups	281.6	8	35.2			

From Tables 9 and 10, we observe that the mean affirmative response for "before and during the pandemic" equals 119.80 and 42.20 respectively. Moreover, the F statistic of 427.68 is greater than the F critical of 5.32. We, therefore, conclude that the difference in the mean food supply chain before and during the COVID-19 pandemic is significant. That is, these inputs were available, affordable, accessible, stable, and overtly utilized in the area before the pandemic era.

Table 11 showed the respondents' climate change awareness level as it affects food security in the area. The results showed that about 81 percent of the respondents attested to being aware of climate change in the area, while 19 percent reported otherwise, this implies that the majority of the respondents in the area were fully aware of climate change and exacerbating impacts on food security in the area. Furthermore, their good knowledge of climate change pushes them to employ or adapt proven adaptation and mitigation strategies in sustaining food availability and security (FAO 2021).

Table 11: Responses on climate change awareness level as it affects food security

Climate Change Awareness	% of Awareness	% of Non-Awareness
Respondents	81	19

Table 12 shows the respondents' perceptions of climate change as it affects food security in the area. Table 12 employed 4-way Likert scale methods in estimating the overall perceptions of the respondents to climate change and food security. This gave an estimated mean value of 2.5 which became a threshold in categorizing the respondent's perceptions of climate change as it affects food security in the area. Values higher than 2.5 were adjudged as major climate change perceptions and fewer of them were adjudged otherwise.

Table 12: Responses on climate change perceptions as it affects food security

Climate Change Perception	Mean	SD	Remarks
Temperature varies	2.79	1.09	Major
Increase in number of sunny days	2.55	2.99	Major
Increase in amount of rainfall	2.60	1.99	Major
Variation in rainfall pattern	2.28	2.30	Minor
Decrease in total rainfall	2.67	1.02	Major
Increase in frequency of heavy rains	2.89	1.09	Major
Increase in flooding and duration of flood	2.11	1.04	Minor
Decrease in ground water table	2.16	2.12	Minor
Increase in the intensity of heat	2.91	2.01	Major
Decrease in number of sunshine days during rainy season	2.70	1.06	Major
Increased duration of dryness during rainy season	2.22	1.90	Minor

It can be seen from Table 12 that a good number of the climate change variables were perceived as major climatic threats affecting food security in the area, these include temperature variations, increase in the number of sunny days, increase in the amount of rainfall, decrease in total rainfall, increase in the frequency of heavy rains, increase in the intensity of heat, and decrease in the number of sunshine days during rainy season while variation in rainfall pattern, increase in flooding and duration of the flood, decrease in the ground water table and increased duration of dryness during the rainy season. This implies that the respondents experienced heavy and excruciating impacts of climate change which negatively influenced their farm productivity leading to food shortage and unavailability. Thus, climate change is typically known to impair food production at all times resulting in food insecurity (FAO, 2021).

4. Conclusion

The findings from the study revealed that the COVID-19pandemic caused a drastic reduction in the food supply chain with respect to the agricultural inputs and materials in the area. There is a forceful drop in availability, affordability, accessibility, and stability of agricultural inputs and materials as well as in the food supply chain during the COVID-19 era, while tremendous increases were noticed prior to the pandemic, significantly indicating the availability, affordability, accessibility, and stability of these agricultural inputs and materials in the area. The above results were also confirmed by the ANOVA results which showed significant values in each of the categories of the food supply chain in the area. Again, the results showed that about 81 percent of the respondents attested to being aware of climate change in the area, while 19 percent reported otherwise. The perception of respondents to climate change was recorded as a major threat affecting food security in the area. Government subsidization of agricultural inputs and materials, as well as adoption of proven climate change adaptation and mitigation strategies, were overtly recommended.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Reference

Amare M, Abay KA, Tiberti L, and Chamberlin J (2020). Impacts of COVID-19 on food security: Panel data evidence from Nigeria. Volume 1956, International Food Policy Research Institute, Washington, USA. https://doi.org/10.2499/p15738coll2.133866

Andam K, Edeh H, Oboh V, Pauw K, and Thurlow J (2020). Impacts of COVID-19 on food systems and poverty in Nigeria. Advances in Food Security and Sustainability, 5: 145-173. https://doi.org/10.1016/bs.af2s.2020.09.002 **PMCid:PMC7550085**

Arora NK (2019). Impact of climate change on agriculture production and its sustainable solutions. Environmental Sustainability, 2(2): 95-96. https://doi.org/10.1007/s42398-019-00078-w

Babatunde JA, Ayobami TS, and Mark T (2011). Developing climate change scenarios, biophysical impacts and adaptation strategies in Nigeria. A Final Report Submitted to Nigerian Environmental Study/Action Team (NEST) as Part of the Building Nigeria Response to Climate Change (BNRCC) Project, Ibadan, Nigeria.

Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, and White LL (2014). Climate change 2014 impacts, adaptation, and vulnerability. Part B: Regional aspects. Working Group II Contribution to the 5th Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK: 1-1820. https://doi.org/10.1017/CBO9781107415386

BNRCC (2011). National adaptation strategy and plan of action on climate change for Nigeria. Federal Ministry of Environment Special Climate Change Unit, Building Nigeria's Response to Climate Change, Ibadan, Nigeria.

Brida AB, Owiyo T, and Sokona Y (2013). Loss and damage from the double blow of flood and drought in Mozambique. International Journal of Global Warming, 5(4): 514-531. https://doi.org/10.1504/IJGW.2013.057291

FAO (2020). Climate change incidences on agricultural production in Africa. Food and Agricultural Organization, Rome, Italy.

FAO (2021). FAO statistical reports. Food and Agricultural Organization, Rome, Italy.

IPCC (2015). Meeting report of the intergovernmental panel on climate change expert meeting on climate change, food, and agriculture. Intergovernmental Panel on Climate Change, Geneva, Switzerland. https://doi.org/10.1017/CBO9781107415416

Laborde D, Martin W, Swinnen J, and Vos R (2020). COVID-19 risks to global food security. Science, 369(6503): 500-502. https://doi.org/10.1126/science.abc4765 **PMid:32732407**

Ladapo HL, Aminu FO, Selesi OS, and Adelokun IA (2020). Determinants of the effects of pesticide use on the health of rice farmers in Kwara State, Nigeria. Journal of Research in Forestry, Wildlife and Environment, 12(3): 198-205.

Mondal S and Reddy IJ (2018). Impact of climate change on livestock production. In: Singh RL and Mondal S (Eds.), Biotechnology for sustainable agriculture: 235-256. Woodhead Publishing, Sawston, UK. https://doi.org/10.1016/B978-0-12-812160-3.00008-8

NBS (2006). Official Gazette (FGP 71/52007/2,500(OL24): Legal notice on publication of the details of the breakdown of the national and state provisional totals, 2006 Census. National Bureau of Statistics Abuja, Nigeria.

Nelson R, Kokic P, Crimp S, Martin P, Meinke H, Howden SM, and Nidumolu U (2010). The vulnerability of Australian rural communities to climate variability and change: Part II-Integrating impacts with adaptive capacity. Environmental Science and Policy, 13(1): 18-27. https://doi.org/10.1016/j.envsci.2009.09.007

NEST (2011). Climate change adaptation strategy technical reports. Nigerian Environmental Study/Action Team, Ibadan, Nigeria.

Nwajiuba CU, Onyeneke RU, and Yakubu AA (2011). Climate change adaptation strategy technical report for Nigeria: Agriculture sector. A Compendium of Studies Commissioned and Published by Building Nigeria's Response to Climate Change (BNRCC) Project Coordinated by the Nigerian Environmental Study/Action Team (NEST), Ibadan, Nigeria.

Obayelu AE, Obayelu OA, Bolarinwa KK, and Oyeyinka RA (2021). Assessment of the immediate and potential long-term effects of COVID-19 outbreak on socioeconomics, agriculture, security of food and dietary intake in Nigeria. Food Ethics, 6(1): 1-22. https://doi.org/10.1007/s41055-021-00085-w **PMid:33758778 PMCid:PMC7972817**

OECD (2014). Green growth indicators for agriculture: A preliminary assessment. OECD Green Growth Studies, The Organization for Economic Co-operation and Development, Paris, French. https://doi.org/10.1787/9789264225503-en

OECD (2015). Agriculture and climate change: Trade and agriculture directorate. The Organization for Economic Co-Operation and Development, Paris, French.

Okonkwo UU, Ukaogo VO, Ejikeme JNU, Okagu G, and Onu A (2021). COVID-19 and the food deficit economy in southeastern Nigeria. Cogent Arts and Humanities, 8(1): 1909893. https://doi.org/10.1080/23311983.2021.1909893

Olufemi OS, Joshua MI, and Abraham Salamatu E (2020). Assessment of temperature variability effect on rice production in Nasarawa State Nigeria. International Journal of Environment and Climate Change, Nigeria, Assessment, 10(8): 91-100. https://doi.org/10.9734/ijecc/2020/v10i830221

Onyeneke RU (2016a). Effects and coping measures of the 2012 flood among farming households in Oguta local government area of Imo State, Nigeria. Nigerian Journal of Agriculture, Food and Environment, 12(3): 225-229.

Onyeneke RU (2016b). Effects of livelihood strategies on sustainable land management practices among food crop farmers in Imo State, Nigeria. Nigerian Journal of Agriculture, Food and Environment, 12: 230-235.

Onyeneke RU, Igberi CO, Uwadoka CO, and Aligbe JO (2018). Status of climate-smart agriculture in southeast Nigeria. GeoJournal, 83(2): 333-346. https://doi.org/10.1007/s10708-017-9773-z

Ortiz-Bobea A, Ault TR, Carrillo CM, Chambers RG, and Lobell DB (2021). Anthropogenic climate change has slowed global agricultural productivity growth. Nature Climate Change, 11(4): 306-312. https://doi.org/10.1038/s41558-021-01000-1

Oti OG, Okoye CU, and Obasi IO (2021). Awareness and perception of climate change among farmers in Nigeria: Implications for food security. Nigeria Agricultural Journal, 52(2): 164-173.

Pakravan-Charvadeh MR, Mohammadi-Nasrabadi F, Gholamrezai S, Vatanparast H, Flora C, and Nabavi-Pelesaraei A (2021). The short-term effects of COVID-19 outbreak on dietary diversity and food security status of Iranian households (A case study in Tehran province). Journal of Cleaner Production, 281, 124537. https://doi.org/10.1016/j.jclepro.2020.124537 **PMid:33052173 PMCid:PMC7537655**

Pokhrel P, Dhakal D, Gauchan D, Panta H, and Mainali RP (2021). Impact of climate change on rice production: An empirical study in Kaski and Nawalparasi, Nepal. Journal of Agriculture and Natural Resources, 4(1): 79-86. https://doi.org/10.3126/janr.v4i1.33229

Prasanna V (2014). Impact of monsoon rainfall on the total foodgrain yield over India. Journal of Earth System Science, 123(5): 1129-1145. https://doi.org/10.1007/s12040-014-0444-x

Schmidhuber J, Pound J, and Qiao B (2020). COVID-19: Channels of transmission to food and agriculture. Food and Agriculture Organization, Rome, Italy.

Shankar S (2018). Impacts of climate change on agriculture and food security. In: Singh RL and Mondal S (Eds.), Biotechnology for sustainable agriculture: 207-234. Woodhead Publishing, Sawston, UK. https://doi.org/10.1016/B978-0-12-812160-3.00007-6

Shrestha J, Subedi S, Kushwaha UKS, and Maharjan B (2021). Evaluation of growth and yield traits in rice genotypes using multivariate analysis. Heliyon, 7(9): e07940. https://doi.org/10.1016/j.heliyon.2021.e07940 **PMid:34527828 PMCid:PMC8429088**

Singh G, Mishra D, Singh K, and Parmar R (2013). Effects of rainwater harvesting on plant growth, soil water dynamics and herbaceous biomass during rehabilitation of degraded hills in Rajasthan, India. Forest Ecology and Management, 310: 612-622. https://doi.org/10.1016/j.foreco.2013.09.002

UNPB (2020). The impact of COVID-19 on food security and nutrition. United Nations Policy Brief, New York, USA.

WHO (2020). Coronavirus disease (COVID-2019) situation reports. World Health Organization, Geneva, Switzerland.

Zhang X (2020). Chinese livestock farms struggle under COVID-19 restrictions. In: Swinnen J and McDermott J (Eds.), COVID-19 and global food security: 84-85. International Food Policy Research Institute, Washington, USA. https://doi.org/10.2499/p15738coll2.133762_19