Impact of Climate Change Shock on Rice Productivity of Smallholder Farmers in Nigeria's North Central Region

e-ISSN 2687-4563
2021, Vol. 3(2) pp. 119-133
https://dergipark.org.tr/tr/pub/aujfe

Research Article

Received: 28.04.2021

Revised: 25.08.2021

Accepted: 25.08.2021

To cite this document:
……………………..
Sadiq, S.M., Singh, P.I., & Ahmad, M.M. (2021). Impact of Climate Change Shock on Rice Productivity of Smallholder Farmers in Nigeria's North Central Region. *Anadolu University Journal of Faculty of Economics*, 3 (2), 119-133

Sanusi Mohammed SADIQ
sadiqsanusi30@gmail.com
Federal University Dutse
Department of Agricultural Economics and Extension
Dutse, Nigeria
0000-0003-4336-5723

Paul Invinder SINGH
drsinghip.eco@gmail.com
SKRAU Department of Agricultural Economics
Bikaner, India
0000-0002-1886-5956

Muhammad Makarfi AHMAD
amakarfi@gmail.com
Bayero University Kano
Department of Agricultural Economics and Extension
Kano, Nigeria
0000-0003-4565-0683

Abstract

The consequence of climate change shock on arable crop productivity especially rice, the largest consumed food in the world is threatening the global food security and a light out of this dark is very pertinent for continuous human existence. In lieu of the foregoing, this research attempt to determine the impact and quantified the contribution of climate change shock vis-à-vis climate change shock versus endowment effect on rice productivity using crucial econometric tools- inferential statistics. A total of 360 farmers were drawn from the sampling frame through a multi-stage sampling technique and data elicitations were done through the use of structured questionnaire coupled with interview schedule. An easy cost-route approach was used to collect the field survey data during the 2020 cropping season. Succinctly, from the empirical evidences it was established that most (60.83%) of the farmers have their average rice productivity been affected by climate change shock. Furthermore, climate change shock had both short and long runs effect on the average rice productivity, thus making the production structural change of the vulnerable farmers poor in comparison to the non-vulnerable farmers. Besides, structural effect termed climate change shock accounts for approximately 89.37% of the yield gap/differential between the two groups while 10.63% owes to their endowment related factors. Therefore, the study enjoins affected farmers to adopt smart agricultural practices viz. emulation of peers not affected by climate change shock, thus enhancing the sustainability of the enterprise and rice food security in the studied area.

Keywords: *Climate change, Shock, Rice, Yield, Nigeria*

JEL Codes: *O13, Q01, Q54*

Introduction

The consequences of anthropogenic climate change have gotten a lot of attention in the first two decades of the twenty-first century. Climate change's impact on agricultural production and food security in terms of access, consumption, and stable prices are of particular concern (Dinar and Mendelsohn, 2011; IPCC, 2014; FAO, 2016; FAO, 2018). The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) confirms the detrimental impact of climate change on agricultural development (IPCC 2014). Despite the fact that climate change knows no limits, vulnerability remains unequally distributed across nations, communities, and crops (Mahdu, 2019). Climate change poses a danger with far-reaching socio-economic consequences for developing countries like Nigeria, which rely heavily on agriculture for food, employment, and export earnings. Climate change typically results in lower incomes at both the household and national levels (FAO, 2016).

Climate change would have an irreversible impact on food production and security, according to Shah *et al*. (2009) and Adedeji *et al*. (2017), particularly in developing countries with limited capacity to cope with and adapt to these challenges. The influence of climate change on farm production, which is the subject of this study, can be used to determine the economic impact of climate change at the micro enterprise point. According to Morton (2007), who was cited by Adedeji *et al*.(2017), while climate change issues have recently received a lot of empirical and documentary attention, especially as they affect rural areas of developing countries, there have been relatively few discussions about the impact of climate change shock on agriculture, particularly in the area of smallholder and subsistence systems.

Without directly addressing the impacts of climate change, achieving the Sustainable Development Goals of eradicating poverty (SDG 1), hunger (SDG 2), and clean water and sanitation (SDG 6) would be impossible (SDG 13). Agriculture and food systems are at the cutting edge of this problem. Temperatures and extreme weather events are expected to rise as a result of climate change, while precipitation and weather predictability are expected to decrease. Although there will be differences based on local specificity, this will result in a general decrease in crop and livestock production and productivity across all farming systems (FAO, 2018). Given that 60 to 70 percent of Nigeria's north-central poor live in rural areas and depend on agriculture, this would have significant consequences for hunger and poverty reduction.

Furthermore, since small-scale farmers account for roughly 80% of the region's agricultural output their ability to produce is directly linked to the region's food security. In this context, climate change's impact serves as a risk multiplier in a vulnerable area that is already struggling to sustain food security due to a slew of challenges, including natural resource scarcity, low agricultural productivity, and conflict. The livelihoods of small-scale farmers are in jeopardy due to their reliance on natural resources. These farmers are currently among the region poorest and most marginalized. They are cut off from resources, markets, extension programs, and social security systems, which makes them much more vulnerable to climate change's effects. The small-scale farmers who are already struggling to make ends meet could be driven over the edge. As a result, the effect of climate change on small-scale farmers is profoundly rooted in the region's socio-economic fabric. This will be particularly true as agricultural productivity declines, reducing options for sustainable rural livelihoods and encouraging distressed migration. Supporting these farmers in managing their production and productivity in a changing environment, as well as improving income diversification options, will be critical to ensuring their long-term viability.

Since small-scale farmers are the primary domestic agricultural producers, the effect of climate change on them spreads beyond the farm to the region's food security. This makes it much more important for policymakers to find out the best ways to assist small-scale farmers in order to ensure that agricultural production and productivity can be maintained in the face of changing climate conditions and growing uncertainty.

Climate change is one of the most important long-term challenges to achieving sustainable rice production growth (Wassmann *et al*., 2007; Ayinde *et al*., 2013). Biological and abiotic stresses endanger rice production and sustainability, and the impact of these stresses can be exacerbated by drastic changes in global climate. Drought and flood already cause widespread rice yield losses around the world, and climate change's predicted rise in drought and flood incidence will exacerbate rice production losses in the future. As a result, the major challenge is the possible negative impact of changing climate on rice production, which is a factor limiting annual yield growth. Thus, livelihoods for already poor farmers are jeopardized.

In Nigeria, increasing income and food provision will be severely hampered unless the impact of climate change is seriously addressed. This is undeniable because agriculture provides food and income to more than 70% of Nigeria's population (Iheoma, 2015). Hence, increasing agricultural output is a prerequisite for increasing income and eradicating hunger. Furthermore, people can only contribute meaningfully to national growth if they are well fed and nourished. Therefore, it is critical to conduct research to assess the reality of yields in order to effectively respond to any food security threats to farmers through interventions.

Thus, in lieu of the above narrative, this research attempts to determine the short and long runs effect of climate change shock on rice productivity of smallholder farmers in Nigeria's North-Central region. The specific objectives were to determine the climate change shock status of the farmers; determine the short and long runs effect of climate change shock on rice productivity; and, to determine the productivity gap due to climate change shock in the studied area.

Table 1. Production trend of rice in Nigeria

Year	Area (ha)	Yield (hg)	Production (kg)	Yield growth (%)
2000	2199000	14998	3298000	0
2001	2117000	13000	2752000	-15.3692
2002	2185000	13400	2928000	2.985075
2003	2210000	14100	3116000	4.964539
2004	2348000	14199	3334000	0.697232
2005	2494000	14302	3567000	0.720179
2006	2725000	14833	4042000	3.579856
2007	2451000	12999	3186000	-14.1088
2008	2382000	17544	4179000	25.90629
2009	1836880	19306	3546250	9.126696
2010	2432630	18386	4472520	-5.00381
2011	2269410	20325	4612614	9.539975
2012	2863815	18971	5432930	-7.13721

2013	2931400	16454	4823330	-15.2972
2014	3081923	19478	6002831	15.52521
2015	3121562	20042	6256228	2.81409
2016	3745134	20197	7564050	0.767441
2017	3308876	19970	6607703	-1.13671
2018	3345969	20351	6809327	1.872144

Source: www.fao.org

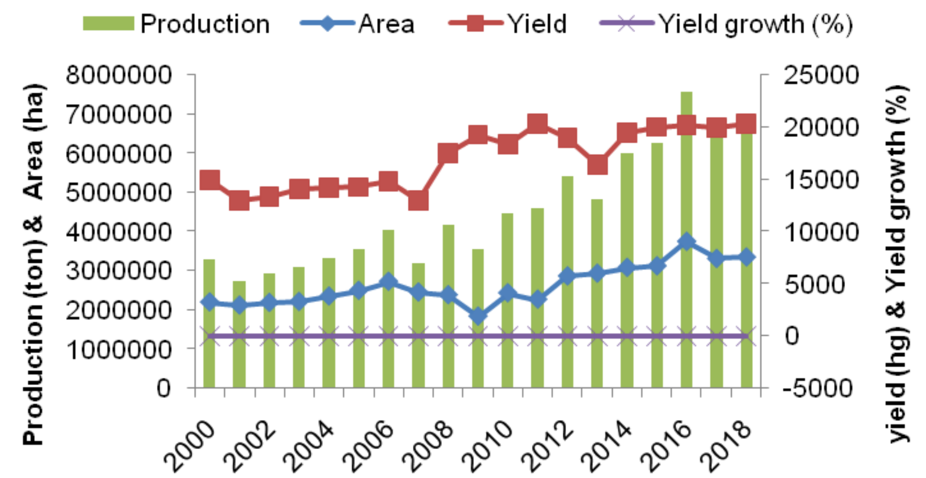

Figure 1. Production trend of rice in Nigeria (2000-2018)

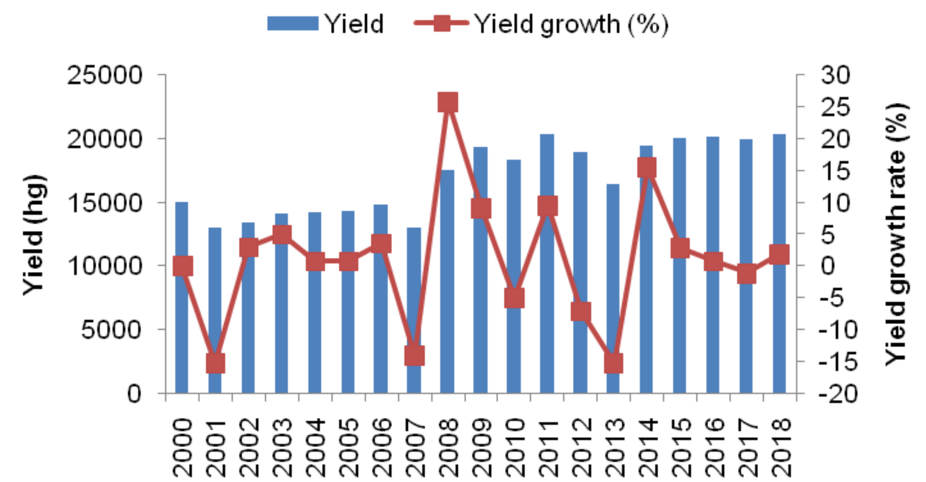

Figure 2. Yield and Yield growth rate

Data and Methods

The North-Central region of Nigeria is geographically located in the country's middle belt and is made up of six states: Benue, Nasarawa, Niger, Plateau, Kogi, and Kwara, as well as a Federal Unity Territory named Abuja (Figure 3). The area stretched from the west to the tranquility of the confluence of two major rivers, the

Niger and Benue. The region's geographical coordinates are latitude 10˚ 20' and longitude 7˚ 45', and its vegetation is mostly guinea savannah, with some mountainous and tropical vegetation thrown in for good measure. The region's mean annual cumulative and monthly rainfall are 1247.52 ± 166.68mm and 103.96mm, respectively, with annual mean temperature hovering around22.55 ± 0.42˚C and 33.54 ± 0.23˚C. The relative humidity averaged slightly above 50% and ranged between 50.08 and 52.75 percent. Monthly rainfall is distributed from May to October, with a unimodal peak in August (274.23mm) (Olayemiet al., 2014). The months of January and February are fully dry (no rain), while April and November have little spring, and are thus referred to as the pre and post-rainy season transition periods, respectively. Arable crop production, as well as tree cropping, fishing, hunting, artisanal, civil service, and Ayurvedic medicine, have been the mainstays of the region's people.

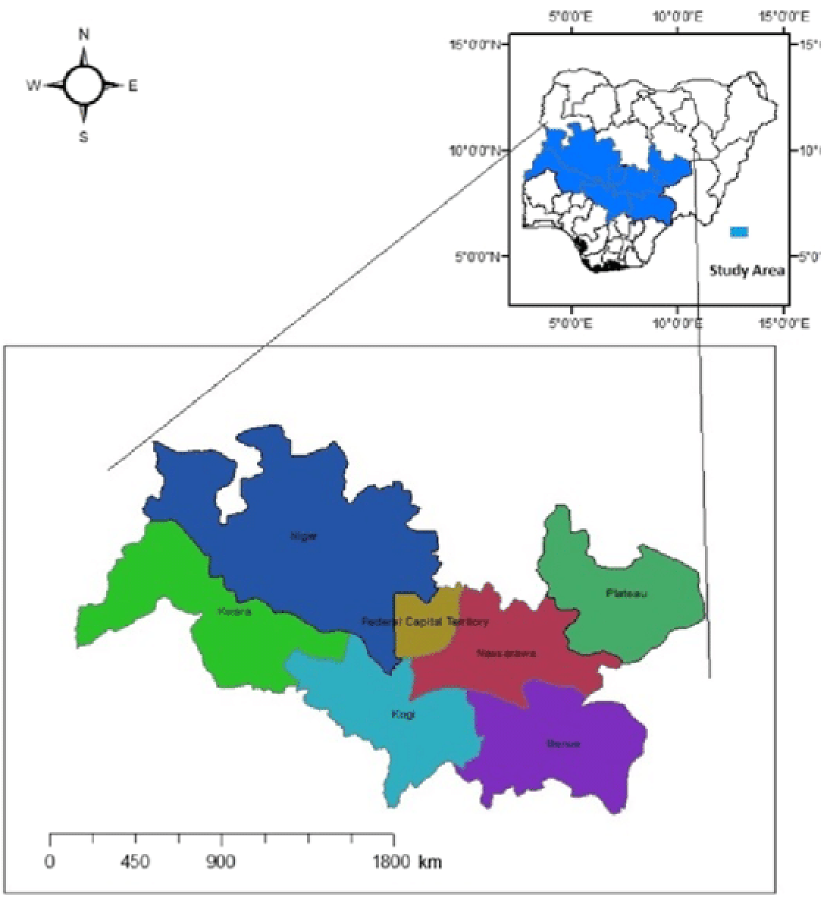

Figure 3. Map of Nigeria’s North-Central region
Source: Culled from researchgate.net

A multi-stage sampling technique was used to achieve a representative sampling size. All the State units and the Federal unity territory, with the exception of Benue state, are suitable for rice cultivation. As a result, three of the seven units, namely the states of Niger and Kogi, as well as the Federal Capital Territory of Abuja, were conveniently chosen. Given the high prevalence of rice cultivation in the chosen units, two Local Government Areas (LGAs)/Municipal Area Councils (MACs) were randomly selected from each of the units using Microsoft's inbuilt sampling analytical tool. Furthermore, two villages were randomly selected from each of the chosen LGAs/MACs using the same Microsoft sampling analytical method. A scale ratio of 18 percent was used to determine the representative sample size based on the sampling frame sourced from the states' agricultural agencies and reconnaissance survey (Table 2). As a result, a total of 376 active rice farmers were selected using a simple random sampling technique. However, outliers were found in 16 of the 376 questionnaires, so they were removed. As a result, the study included a total of 360 accurate questionnaires. A structured questionnaire complemented with an interview schedule was used to obtain cross-sectional data from farmers for the 2020 rice cropping seasons using an easy cost route approach. Objective I, II and III were achieved using Stalling's weather index; chow test and Average treatment effect; and, Oaxaca-Blinder decomposition models respectively.

Table 2. Sampling frame of rice farmers

States	LGAs/MACs	Villages	Sample frame	Sample size
FCT Abuja	Kwali	Dabi	85	15
		Gada-biu	109	20
	Abaji	Yaba	100	18
		Pandagi	90	16
Kogi State	Yagba West	Omi	198	36
		Ejiba	220	40
	Kogi	Giryan	250	45
		Panda	180	32
Niger State	Borgu	Swashi	208	37
		Saminaka	170	31
	Katcha	Katcha	238	43
		Badeggi	242	43
Total	**6**	**12**	**2090**	**376**

Source: States' Agricultural Agencies & Reconnaissance survey, 2020
Note: District unit is called Municipal Area Council (MAC) and Local Government area (LGA) in FCT Abuja and State respectively.

Model specification

1. Weather index

The effect of weather on yield variability was calculated using a Stalling's weather index (Stalling, 1960). To calculate the estimated yield, the yield was regressed. The weather variable is described as the actual to expected yield ratio. This index can capture weather effects such as rainfall, temperature, and so on (Ayalew, 2015; Sadiq *et al.*, 2020a).The formula is given below:

$$WI = \frac{Actual\ yield}{Predicted\ yield} \quad (1)$$

Where WI = weather index

$$Y_t = \alpha + X\beta + \varepsilon_t \quad (2)$$

$$Y_t^* = \alpha + X_1\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + X_5\beta_5 + \cdots + X_n\beta_n + \varepsilon_t \quad (3)$$

Where, Y= actual yield (kg); Y_i^*= predicted yield (kg); X_1-X_8 are human labour, inorganic fertilizer, seeds, herbicides, pesticides, depreciation on capital items and farm size respectively.

2. Chow F-statistic test

Following Onyenweaku (1997); Amaefula et al. (2012), the F-statistics tests for test for effect of climate change shock, test for homogeneity of slopes and test for differences in intercepts are given below:

To isolate the effect of climate change shock, the error sum of squares for yield function of: (i) vulnerable farmers (ii) non-vulnerable farmers (iii) pooled data without a dummy variable (iv) pooled data with a dummy variable (vulnerable=1, non-vulnerable =0)

Test for effect of the shock: $F^* = \frac{[\sum e_3^2 - (\sum e_1^2 + \sum e_2^2)]/[K_3 - K_1 - K_2]}{(\sum e_1^2 + \sum e_2^2)/K_1 + K_2}$ ……………………(4)

Where $\sum e_3^2$ and K_3 are the error sum of square and degree of freedom respectively for the pool(vulnerable and non-vulnerable), $\sum e_1^2$ and K_1 are the error sum of square and degree of freedom respectively for the vulnerable group, and, $\sum e_2^2$ and K_2 are the error sum of square and degree of freedom respectively for the non-vulnerable group.

If the F-cal is greater than the F-tab, it implies that climate change shock has effect on the yield of the vulnerable group.

Test for homogeneity of slope: $F^* = \frac{[\sum e_4^2 - (\sum e_1^2 + \sum e_2^2)]/[K_4 - K_1 - K_2]}{(\sum e_1^2 + \sum e_2^2)/K_1 + K_2}$ ……………………………(5)

Where $\sum e_4^2$ and K_4 are the error sum of square and degree of freedom respectively for the pool (both vulnerable and non-vulnerable groups) with a dummy variable.

If the F-cal is greater than the F-tab, it implies that climate change shockbrings about a structural change or shift in the yieldparameter.

Test for differences in intercepts: $F^* = \frac{[\sum e_3^2 - \sum e_4^2]/[K_3 - K_4]}{\sum e_4^2/K_4}$ ………………………………(6)

If the F-cal is greater than the F-tab, it implies that the productivityof the vulnerable group differs from that of the non-vulnerable group.

3. Average treatment effect (ATE)

It shows the average difference in outcome between units assigned to the treatment and units assigned to the placebo (control). Following Lokshin and Sajaia (2011); Wang *et al*. (2017); Sadiq *et al*.(2020b&c); Sadiq *et al*.(2021) the equation is given below:

Shock index of the vulnerable farmers is given by: $E(y_{1i} | I = 1; X)$ …………(7)

Shock index of the non-vulnerable farmers is given by: $E(y_{2i}|I = 0; X) \ldots.(8)$

Shock index of the vulnerable farmers if there is no climate change shock difference is denoted by: $E(y_{2i}|I = 1; X) \ldots\ldots(9)$

Shock index of the non-vulnerable farmers if there is no climate change shock difference is denoted by: $E(y_{1i}|I = 0; X) \ldots\ldots\ldots\ldots\ldots(10)$

Where:

$E(.)$ = Expectation operator

y_{1i} = yield of the vulnerable farmers (dependent variable)

y_{2i} = yield of the non-vulnerable farmers (dependent variable)

I = Dummy variable (1 = vulnerable, 0 = non-vulnerable)

X = Explanatory variables that is common to both vulnerable and non-vulnerable farmers.

$$ATT = E(y_{1i}|I = 1; X) - E(y_{2i}|I = 1; X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(11)$$

$$ATU = E(y_{1i}|I = 1; X) - E(y_{2i}|I = 1; X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(12)$$

$\text{Average Treatment effect on Treated} = ATET$

$\text{Average Treatment effect on Untreated} = ATEU$

Equations (9) and (10) were further simplified as:

$$ATT = \frac{1}{N_1}\sum_{i=1}^{N_2}[p(y_{1i}|I = 1; X) - p(y_{2i}|I = 1; X)] \ldots\ldots\ldots\ldots\ldots\ldots(13)$$

$$ATU = \frac{1}{N_2}\sum_{i=1}^{N^2}[p(y_{2i}|I = 0; X) - p(y_{1i}|I = 0; X)] \ldots\ldots\ldots\ldots\ldots\ldots(14)$$

Where, $N_1$and N_2 are number of vulnerable and non-vulnerable farmers respectively, and p= probability.

4. **Oaxaca-Blinder decomposition model**

Using the standard Oaxaca-Blinder procedure (Oaxaca 1973; Blinder 1973)the extent to which the productivity gap between the vulnerable and non-vulnerable farmers can be explained by differences in observed human capital characteristics (Marwa, 2014; Revathy *et al*., 2020; Sadiq *et al*., 2020b&c; Sadiq *et al*. 2021). The productivity functions are given below:

$$ln\bar{Y}_V = \beta_0 + \beta_i\sum_{i=1}^{i}X_i + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(15)$$

$$ln\bar{Y}_{NV} = \beta_0 + \beta_i\sum_{i=1}^{i}X_i + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(16)$$

Where, $\bar{Y}_V$= average productivity of vulnerable farmers; $\bar{Y}_{NV}$= average productivity of non-vulnerable farmers;X_{i-n} $-$ $explanatory\ variables; \beta_0 - intercept$; $\beta_{i-n} = parameter\ estimates$; and, $\varepsilon_i = stochastic\ term$.

The total difference can be explain by,

$$\Delta lnY = ln\bar{Y}_V - ln\bar{Y}_{NV} \quad (17)$$

The Oaxaca-Blinder decomposition equation is,

$$\ln Y_V - \ln Y_{NV} = (X_V \beta_V - X_{NV} \beta_{NV}) + (X_V \beta_{NV} - X_V \beta_{NV}) \quad (18)$$
$$\therefore \ln Y_V - \ln Y_{NV} = (X_V - X_{NV})\beta_V + (\beta_{NV} - \beta_V) X_{NV} \quad (19)$$

Where the first $(X_V - X_{NV})\beta_V$ and the second $(\beta_{NV} - \beta_V)X_{NV}$ terms respectively, captured the endowment effect (characteristics differences between the vulnerable and non-vulnerable) and the discrimination effect.

Research Findings and Discussion

The result of the weather generated index showed that majority (60.83%) of the farmers were vulnerable to climate change, that is, they have their average yield level been affected by climate change shock (Table 3). However, close to 40 percent of the farmers had their average yield level not affected by climate change shock and this may be attributed to the use of smart agricultural practices among these farmers as climate change is a general phenomenon in the studied area. Furthermore, it was established that disproportion exists in the yield distribution between the vulnerable and non-vulnerable groups as evidenced by the plausibility of the t-statistic at 10% degree of freedom (Table 3) (Figure 4).

Table 3. Climate change shock index status of the farmers

Status	Frequency	t-statistic
Vulnerable (< 1.00)	219 (60.83)	8.421[3.702e-017]***
Non-vulnerable (≥ 1.00)	131(39.17)	

Source: Field survey, 2020
Note: Values in ( ) and [ ] are percentage and probability level respectively.

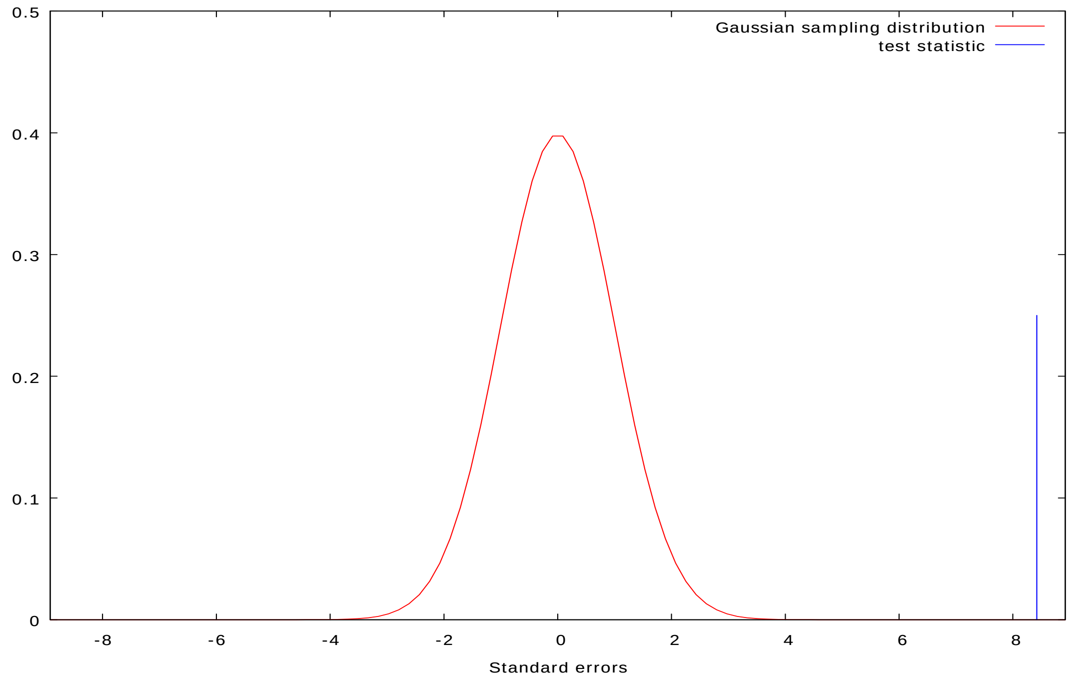

Figure 4. Distribution of the climate change shock index vis-à-vis proportion between vulnerable and non-vulnerable

Effect of Climate Change Shocks on Productivity

In the short-run the empirical evidence showed that climate change shock has effect on the average yield level of the vulnerable farmers as evidenced by the plausibility of the F-statistics at 10% probability level (Table 4). This implies that there is significant difference between the average yields of the climate shock prone farmers versus their counterparts that are not prone to climate change shock. Furthermore, for the slope homogeneity test, the f-statistic been different from zero at 10% degree of freedom implies that the climate change shock induced structural change in the productivity of the farmers. This confirms heterogeneity between the yields of farmers that were prone to climate change shocks versus the non-vulnerable farmers. Besides, it shows that the slopes of the productivity function are heterogeneous. Heterogeneity of slopes means that productivity functions are factor-biased. The f-statistic for the test of differences in the intercept been within the acceptable margin of 10% significance level indicates differences in the productivity between the climate shocked farmers versus the non-shocked farmers. In addition, it implies differences exist in the productivity attitudes of the climate shock prone farmers versus the non-vulnerable farmers.

Table 4. Effect of climate change shock on rice productivity

Items	ESS	DF	Test	F-stat
Vulnerable	27.53036	218		
Non-vulnerable	27.84518	140	I	3.00E+02***
Pooled	101.7343	359	II	5.82E+00***
Pooled with dummy	57.47574	359	III	2.76E+02***

Source: Field survey, 2020

Note: $^{***\ **\ *\ \&NS}$ means significant at 1%, 5%, 10% & Non-significant, respectively.

Impact of Climate Change Shocks on Rice Yield

A cursory review of the Average treatment estimation (ATE) results viz. regression adjustment, inverse-probability weight, nearest neighbor matching, propensity score matching, augmented inverse-probability weight (AIPW) and inverse-probability weight (IPW) regression adjustment showed that climate change shock has impact on the average yield level of the farmers as indicated by their respective ATE estimated coefficients which were within the plausibility of 10% significance level (Table 5). Thus, it implies that climate change shock makes the average yield level of the climate shock affected farmers to plummet. In other words, farmers that are vulnerable to climate change shock have their average yield level less than their counterparts that were non-vulnerable to climate change shock. Therefore, it can be inferred that climate change shock impacted on the average rice productivity of the vulnerable group by plummeting their yield in comparison to that of their counterparts that are non-vulnerable to climate change shock. The ATE coefficients of -1224.06, -1191.59, -1245.54, -1221.58, -1229.58 and -1229.86 respectively for regression adjustment, inverse-probability weight, nearest neighbor matching, propensity score matching, augmented inverse-probability weight (IPW) and inverse-probability weight (IPW) regression adjustment mean that climate shock vulnerable farmers had their average yield level less than that of the non-vulnerable climate shock farmers by 1224.06kg, 1191.59kg, 1245.54kg, 1221.58kg, 1229.58kg and 1229.86kg vis-à-vis the estimations.

Furthermore, except the augmented IPW which does not generate ATET estimate for within the stratum, within each stratum viz. vulnerable and non-vulnerable, all the remaining estimations showed that climate change shock has impact on the average yield level as indicated by their respective average treatment effect on treated (ATET)(vulnerable) and average treatment effect on untreated (ATEU) (non-vulnerable) which were different from zero at 10% probability level. The ATET and ATEU coefficients of -1244.62 and 1192.13 respectively for the regression adjustment mean that on the average, the vulnerable group lost 1244.62 kg in their rice yield due to climate change shock while the non-vulnerable group gains1192.13 kg in their average yield level. In the same vein, the ATET and ATEU coefficients of-1218.34 and 1287.80 respectively for the nearest neighbor matching imply that the vulnerable group lost 1218.34kg of their rice yield due to climate change shock while the non-vulnerable group gains1287.80kg in their rice yield level. Besides, for the propensity score matching, the ATET and ATEU estimated coefficients of -1215.35 and 1231.26 respectively imply that the vulnerable group lost approximately 1215.35 kg while the non-vulnerable group gained 1231.26 kg. In the same vein, for the inverse-probability weight, the ATET and ATEU coefficients been -1200.52 and 1178.21 respectively mean that the vulnerable group if not for the climate change shock, they would have gained a significant rice yield of approximately 1200.52 kg while the non-vulnerable group, if they were affected by the climate change shock, they would have loss significant rice yield of approximately 1178.21kg.

Table 5. Impact of climate change shock on rice productivity

Items	Coefficient	t-stat	Coefficient	t-stat
	Regression adjustment		**Inverse-probability weight**	
ATE	-1224.06(158.17)	7.74***	-1191.59(150.83)	7.90***
ATET (V)	-1244.62(172.78)	7.20***	-1200.51(165.53)	7.25***
ATEU (NV)	1192.12(153.22)	7.78***	1178.20(156.12)	7.55***
Mean (V)	1489.12(61.96)	24.03***	1494.54(62.68)	23.84***
Mean (NV)	2713.18(147.39)	18.41***	2686.13(139.78)	19.22***
	Nearest-neighbor matching		**Propensity-score matching**	
ATE	-1245.54(156.41)	7.96***	-1221.58(148.10)	8.25***
ATET (V)	-1218.33(186.17)	6.54***	-1215.35(177.85)	6.83***
ATEU (NV)	1287.79(167.71)	7.68***	1231.25(185.75)	6.63***
	Augmented inverse-probability weight		**IPW regression adjustment**	
ATE	-1229.58(159.12)	7.73***	-1229.85(158.68)	7.75***
ATET (V)	-	-	-1266.84(175.61)	7.21***
ATEU (NV)	-	-	1176.71(154.36)	7.62***
Mean (V)	-	-	1495.07(62.11)	24.07***
Mean (NV)	-	-	2724.92(147.63)	18.46***

Source: Field survey, 2020

Note: ATE, ATET and ATEU respectively mean Average treatment effect, Average treatment effect on treated and Average treatment effect on untreated. *** ** * &NS means significant at 1%, 5%, 10% & Non-significant, respectively. Figure in ( ) is standard error; V = vulnerable; NV = non-vulnerable

Productivity Gap due to Climate Change Shock

A cursory review of the absolute contribution of each of the explanatory variables towards the overall yield gap between the vulnerable and non-vulnerable farmers show personal endowment related factors- age, gender, educational level, farming experience, mode of land ownership and co-operative membership to favour the vulnerable group (Table 6). However, it was observed that personal endowment related factors viz. marital status, household size, distance from home to farm and distance from home to market contributed favourably to the non-vulnerable group.

Furthermore, the empirical evidence showed that the differences in the coefficients of the predictor variables of the two-yield equations are responsible for the contribution of the different factors towards the yield differential between the two groups.

The results showed that structural differences- discrimination effect called climate change shock was responsible for 89.37% of the yield differential between the vulnerable and non-vulnerable groups while endowment effect called human capital was responsible for 10.63% variation in the yield gap. The average yields of the vulnerable and non-vulnerable groups are 1418.80kg and 2790.46k respectively, thus given a yield gap of 1371.65kg. Of the yield gap of 1371.65kg, the difference due to superior endowment of the non-vulnerable group was responsible for 145.86kg while shock discrimination was responsible for 1225.80kg. Thus, the consequence of climate change shock made the vulnerable group lost 1225.80kg of rice output per hectare.

The discrimination value represents 86.40% of the actual average yield level of the vulnerable group. Given the technology at the disposal of the climate shock vulnerable farmers, without climate change shock discrimination, their actual average yield should be 2644.60kg. The part of the yield gap that can be explained by differences in covariates is negative among those that are vulnerable. This implies that relative to non-vulnerable group, the vulnerable farmers, on the average, have more characteristics that are associated with higher productivity.

Table 6. Productivity gap due to climate change shock

Items	**V**	**NV**	$\bar{X}_V$	$\bar{X}_{NV}$	$\beta_V(\bar{X}_V - \bar{X}_{NV})$	$\bar{X}_{NV}(\beta_V - \beta_{NV})$
Intercept	7.637409	6.474255				1.163154
Age	0.009126	-0.00822	41.85388	40.93617	0.008375	0.710034
Gender	-0.20584	0.075692	0.803653	0.822695	0.00392	-0.23161
Marital status	0.041706	0.288696	0.840183	0.851064	-0.00045	-0.2102
Education	-0.00804	0.008111	7.954338	8.283688	0.002647	-0.13375
Household size	-0.08903	-0.0058	4.56621	3.943262	-0.05546	-0.32819
Experience	0.00901	0.00865	9.689498	9.659574	0.00027	0.00348
Mode of land acquisition	0.051298	-0.01821	0.753425	0.70922	0.002268	0.049298
Dist. from home to farm	0.015973	-0.0095	4.237443	4.507092	-0.00431	0.11481
Dist. from home to market	0.025554	0.067595	5.182648	6.453901	-0.03249	-0.27133
Co-operative organization	-0.02024	0.304012	0.716895	0.723404	0.000132	-0.23457
Average productivity	**1418.802**	**2790.455**				
Productivity gap		**1371.653**				
Endowment effect					**-0.0751**	
Discrimination effect						**0.631121**
Overall effect					**0.70622**	
% from overall effect					**10.63364**	**89.3664**
Contribution to Gap					**145.857**	**1225.797**
Without Discrimination					**2644.598**	**2644.598**
% of Disc. in yield						**86.39664**

Source: Field survey, 2020

Conclusions

From the empirical findings it was established that majority of the farmers had their average rice productivity been affected by climate change shock. Besides, both in the short and long runs, it was discovered that climate change shock had effect on the average rice productivity in the studied area. Thus, the yield of the climate prone farmers plummets against the average normal yield obtained by the farmers that were not affected by the climate change shock. Furthermore, it was observed that the productivity variation between the groups viz. yield gap was majorly caused by structural effect called climate change shock, as the endowment effect contribution was marginal. Sequel to this findings, the study advise the farmers to emulate their peers- non-vulnerable farmers by adopting climate change smart agricultural practices- recommended agronomic practices, thus containing the impact of climate change on rice productivity. Doing so will aid in enhancing the food security of rice in the study area in particular and the nation in general as aside of the region's higher comparative advantage in rice production, it is the largest producer of rice among all the regions of the country if put together.

References

Adedeji, I.A., Tiku, N.E., Waziri-Ugwu, P.R. and Sanusi, S.O.(2017).The effect of climate change on rice production in Adamawa State, Nigeria. *Agroeconomia Croatica*, 7(1):1-13

Amaefula, C., Okezie, C.A. and Mejeha, R.(2012).Risk attitude and insurance: A causal analysis. *American Journal of Economics*, 2(3): 26-32

Ayalew, B.(2015).Supply response of maize in Ethiopia: cointegeration and vector error correction approach. *Trends in Agricultural Economics*, 8 (1):13-20

Ayinde, O.E., Ojehomon, V.E.T., Daramola, F.S. and Falaki, A.A.(2013).Evaluation of the effects of climate change on rice production in Niger State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 6(Supplement):763-773

Blinder, A.S.(1973).Wage discrimination: reduced form and structural estimates. *Journal of Human Resources*, 8(4):436-455.

Dinar, A. and Mendelsohn, R.(2011).*Handbook on Climate Change and Agriculture*. Cheltenham, UK: Edward Elgar Publishing Limited.

FAO(2016).The *State of Food and Agriculture: Climate Change, Agriculture, and Food Security*. Rome, Italy.

FAO(2018).*The State of Agricultural Commodity Markets: Agricultural Trade, Climate Change, and Food Security*. Rome, Italy.

Iheoma, C.G.(2015).Impact of climate change on agricultural production and sustainability in Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology,* 4(1):29-41

IPCC(2014).*Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.Geneva, Switzerland. https://doi.org/10.1017/CBO9781107415324.

Lokshin, M. and Sajaia, Z.(2011).Impact of interventions on discrete outcomes: Maximum likelihood estimation of the binary choice models with binary endogenous regressors. *The Stata Journal*, 11(3): 11-21.

Marwa, B.(2014).Estimation of gender wage differentials in Egypt using Oaxaca Decomposition technique. *Paper presented at the 34th annual MEEA meeting* *in conjunction with the Allied Social Science Association (ASSA)*, Philadelphia, January 3-6, 2014, Pp. 1-26

Mahdu, O.(2019).The impacts of climate change on rice production and small farmers' adaptation: A case of Guyana. A *Ph.D Dissertation* submitted to the Faculty of the Virginia Polytechnic Institute and State University (Virginia Tech) in Blacksburg, Virginia.

Morton, J. F.(2007).The impact of climate change on smallholder and subsistence Agriculture. *PNAS*, 104(50). Available from: www.pnas.org_cgi_doi_10.1073_pnas.0701855104.

Oaxaca, R.(1973).Male-female wage differentials in urban labor markets. *International Economic Review*, 9:693-709.

Olayemi, I.K., Idris, B., Ejima, I.A.A., Adeniyi, K., Ukubuiwe, A.C. and Isah, B.(2014).The climate of north-central Nigeria and potential influence on mosquito (*Diptera culicidae*) vectorial capacity for disease transmission. *Global Journal of Multidisciplinary and Applied Sciences*, 2(2):26-31

Onyenweaku,C.E.(1997).Impact of technological change on output, income, employment and factor shares in rice production in Southeastern Nigeria. Issues in African Rural Development *Monograph Series, Monograph #5*, African Rural Social Sciences Research Networks, Winrock International, 1997.

Revathy, N., Thilagavathi, M. and Surendran, A.(2020).A comparative analysis of rural-urban migrants and non-migrants in the selected region of Tamil Nadu, India. *Economic Affairs*, 65(1): 23-30.

Sadiq, M.S., Singh, I.P. and Ahmad, M.M.(2020a).Rescuing Nigeria's Tobacco Industry-A Battle between Life and Death. *Indian Journal of Economics and Development*, 16(SS):46-57

Sadiq, M.S., Singh, I.P. and Ahmad, M.M.(2020b).Rice yield differentials between IFAD participating and non-participating farmers in Nigeria's Niger State. *Economic Affairs*, 65(4): 01-15

Sadiq, M.S., Singh, I.P., Ahmad, M.M. and Kumari, V.(2020c).Effect of gender on income gap among fish farmers in Nigeria's Kogi State. *Atatürk Üniversitesi Kadın Araştırmaları Dergisi (Atatürk University Journal of Woman's Studies)*, 2(2): 27-45

Sadiq, M.S., Singh, I.P., Ahmad, M.M. and Orifa, M.O.(2021).Impacts of farmers-herders conflict on livelihoods of farming households in Nigeria's middle-belt region. *Moroccan Journal of Agricultural Science*, 2(1): 14-24

Shah, M., Fischer, G. and Van Velthuizen, H.T.(2009).Food security and sustainable agriculture: The challenges of climate change in sub-Saharan Africa. In: *Climate Change and Economic Development in Sub-Saharan Africa-AERC Senior Policy Seminar X*, Addis Ababa, Ethiopia, 7-9 April 2008: Seminar Papers, African Economic Research Consortium, Nairobi, Kenya.

Stalling, J.L.(1960).Weather indexes. *Journal of Farm Economics*, 42: 180-186.

Wang, A., Nianogo, R.A. and Arah, O.A. (2017).G-computation of average treatment effects on the treated and the untreated. *BMC Medical Research Methodology*, 17(3): 1-5.

Wassmann, R., Butterbach-Bahl, K. and Dobermann, A.(2007).Irrigated rice production systems and greenhouse gas emissions: crop and residue management trends, climate change impacts and mitigation strategies. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources*, 2:4-14.