

Research Article

The *Boko Haram* Insurgency and Its Effects on Crop Production in Northeast, Nigeria

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Abstract

The study examined the impacts of Boko Haram (BH) insurgency on output of crops in Borno, Adamawa and Yobe (BAY) states, Northeast, Nigeria. Time Series data from 1999-2023 was used which was sub divided into 1999-2008 (Period before Boko Haram), 2009-2017 (Period during the peak of Boko Haram) and 2020-2023 as current period. Percentage change, Instability Index and Hazell Decomposition models were used to determined changes, variability and its sources in area, production and productivity of major staple crops (Maize, Millet, Sorghum, Cowpea and Rice) in the study area. The results revealed that, millet recorded the highest decrease in area between period before BH and during the peak period of the insurgent's activities. Decrease in yield was noticed in all the states and was higher in sorghum, millet and cowpea, so does instability in area, production and productivity of the crops during the period of the insurgency. Similarly sources of change in average of production were majorly as a result of change in mean yield and change in mean area. The findings implied that, farmers has abandoned their farm lands for fear of attacks during the BH period and that poor management practices and inaccessibility to inputs resulted in low yield of crops, The study recommends employing all measures that would in the short and long run increase yield of crops and 'returnees' should be giving adequate attention to go back to active farming.

Keywords

Boko Haram, Insurgency, Instability, Crop Production, North East

1. Introduction

The North-eastern Nigeria particularly Borno, Adamawa and Yobe states (the BAY states) had suffered for over decades

from insecurity that led to loss of lives, properties and critical infrastructure. Insurgent violence and terrorism carried out by

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Boko Haram (BH) and Islamic State's West Africa Province (ISWAP) remains the major driver of insecurity across north-eastern Nigeria. Even though many other insecurity in recent years have emerged in form of Farmers- Headers conflict and the emergence of banditry and kidnappings especially in the Northern fringes of the country [1-4].

Boko Haram which means 'Western Education is forbidden' is officially named *Jama'atu Ahlis-Sunnah lid Da'awati wal Jihaad* (people committed to the propagation of the Prophet's teachings and jihad) emerged around 1995 as a non-violent Islamist group - *Salafist* movement that propagates an ultra-orthodox Islamic ideology seeking the moral reformation of Muslims and Nigeria's secular state with a strict Islamic system. However, BH's campaign has not been confined to Nigeria but also spilled over to neighbouring countries in the Lake Chad Basin region (LCB) [5]. The group started as a non-violent movement until 2002 when Muhammad Yusuf assumed its leadership [6, 7]. Its history of violence dates back to December 24, 2003, when it attacked police stations and public buildings in the towns of Geidam and Kanamma in Yobe State. In June 30th, 2009 Muhammad Yusuf was arrested and killed under police custody after a revolt following killings of thirteen (13) people on the 29th of June [8]. The group has evolved into an extremist violent group and its activities centered towards abductions and killings of both civilians and uniform men, traditional rulers and religious groups (both Muslims and Christians), destructions, arsons and full pledged terrorism against governments and institutional facilities like schools buildings, police stations and any infrastructure belonging to government [5, 6, 9-11]. Violence by the extremist group Boko Haram has severely affected the northeast for decades. This has resulted in widespread displacement between 2014 -2017 and a growing humanitarian emergency [12]. More than 80 per cent of the rural population in the BAY States depended on crops and or livestock farming for sustenance [13]. The activities of Boko Haram insurgents in BAY states had a significant negative effect on both the region's and country's economy [14].

Agriculture remains the major driver of the region's economy, contributing significantly to the region's Gross Domestic Product (GDP) and employs over 70% of the rural population. It is the main stay of Borno state's economy with over 70 percent of the population depending on it directly or indirectly for their livelihoods. It contributes up to 65% of the states GDP, thus provides the bulk of employment, income, food, and clothing for the growing population as well as supplying raw materials for industries [15]. Dominant agricultural activities centered largely on cultivation of both rain fed and irrigated crops, animal husbandry and fishing around Lake Chad basin. In Adamawa state before the incidence of BH, agriculture contributes to about 53.7 percent of the state's GDP comprising of crops, livestock, fisheries and forestry sub-sectors [15]. Eighty per cent (80%) of the people in Adamawa lived in rural areas and are engaged in primary agricultural production of crops like maize, millet, sorghum

cowpea, sesame, groundnut, vegetables and livestock. Adamawa state accounted for about 485,348 hectares out of a total of 16,137,644 hectares under cultivation of export crops in Nigeria and 74% of the total land of the state (2,873,000) is put under cultivation [16-18]. The state has irrigation potential of over 200,000 hectares and over 1,200 hectares are under irrigation during dry season [15]. Agricultural sector in Yobe State engages over 80 per cent of the entire population and contributes 40% of the GDP [19]. The state has a total land area of 47 153 square kilometer of which 70 percent of the land area (3, 262, 630 ha) is arable land for crop production. Millet, sorghum, cowpea, rice and maize are the major staple food crops while cash crops that are commonly grown in the state include groundnut, gum Arabic and sesame [19].

Access to farmland is a critical indicator for the level of agricultural activities and this was effectively reduced through displacement of farmers and destruction of their properties, particularly from 2014 to 2016 [20-22]. Contribution of aggregate output of crops to GDP in Nigeria had declined according to [22], from 37,050,164.84 tons in 2009 to 20,996,397.53 tons in 2013. Similarly [23] reported declined in yield of maize from 2,910.42 Kg/ha before BH to 1,309.69 Kg/ha after the peak of BH in Hawul LGA of Borno state. Yield of rice, cowpea and sorghum had accordingly decreased by -45.0%, -45.6% and -64.8% respectively. Production of staple foods such as rice, sorghum, corn, cowpeas and millet, has reportedly declined significantly according to [2, 14, 24]. Production output of crops is a product of area planted and yield per area, when area or yield changes (decrease or increase) output changes in that direction. The variability of these changes with respect to number of years of the insurgency in the northeast amounts to the level of instability in either yield, area or the overall production. The study therefore seeks to answer the questions as to what extent is the instability in area, yield or output of the selected crops. What are the sources of this instability? In view of the above, this study which is one of its kind from available literature, empirically assessed the percentage change and instability in area, production and productivity of the selected crops between period before the insurgency, during the insurgency and current period and also the sources of output variability of the major staple crops (maize, millet, sorghum, cowpea and rice) in Borno, Adamawa and Yobe states. This study has important implications during conflict and post crisis recovery.

2. Literature Review

2.1. Conceptual Framework

2.1.1. Insecurity

A general definition of insecurity is the state of being constantly threatened, harassed, molested, and intimidated. It is a condition of worry or anxiety brought on by lack of security. Similarly, [25] define insecurity as the state of being vulner-

able to harm or injury, and state of being open to risk or threat of danger. Being exposed to risk or experiencing worry, which is a vaguely uncomfortable emotion felt in expectation of some calamity. Insecurity was also defined by [26] as the state of fear or anxiety stemming from a concrete or alleged lack of protection. It refers to lack or inadequate freedom from danger. This definition reflects physical insecurity which is the most visible form of insecurity, and it feeds into many other forms of insecurity such as economic security and social security.

2.1.2. Insurgency

The dynamics of Insurgency according to scholars and theories is diverse, cutting across goals, organizational structure, tactics and strategy, size and international significance. According to [27] "Insurgency is a struggle to control a contested political space, between a state (or a group of states or occupying powers), and one or more popularly based, non-state challengers" It is characterized by open confrontation with state authorities in a form of political and military action designed to weaken a government or constituted authority through prolonged persistent war [5].

2.1.3. Terrorism and Counter Terrorism

The most challenging aspect of trying to differentiate between terrorism and other forms of violence is trying to distinguish between terrorism and insurgency. This difficulty is created by these terms being seemingly interchangeable [5]. Conversely, terrorists are noted as being underground groups that apply indirect violence without engaging government forces in the form of military units [28]. This indirect tactics aims to create fear and intimidation amongst civilians, as well as prompting political actions and reactions [29].

2.2. Empirical Review

Kah, PCNI, Foyou, V. E, Ngwafu, P., Santoyo, M. and Ortiz, A reported an unprecedented increased in the level of violence and mayhem perpetrated by Boko Haram that has engendered regional and international condemnation of its activities [30-32]. They asserted that a full-scale insurgency characterized by massacres, assassinations, kidnappings, enslavement and wanton destruction of property, population displacements, and other forms of aggression and crimes against humanity took place between 2009 and 2015. Number of casualties and death from insurgent violence in BAY states, Northeast had increased more in 2014 compared with 2011, nine hundred and thirty five (935) people were estimated to have been killed in 2011, while in the first six months of 2014 alone, 2,053 civilian casualties and over 95 attacks were recorded, and by August 2014, Boko Haram declared an "Islamic Caliphate" in the predominantly Christian town of Gwoza [32]. According to Global Terrorism Index, Nigeria accounted for 50% of the

total death (fatality) from terrorism in 2014, claiming a total of 6,644 death to top Islamic State of Iraq and Levant (ISIL) with 6,074 which makes Boko Haram the deadliest terror group globally ahead of ISIL from Iraq [33, 5].

Adelaja, A. and George. J [14] reported in their study, 'Effects of conflict on agriculture: evidence from Boko Haram' found out that, the increased intensity of Boko Haram attacks significantly reduces total output and productivity, but not land use, and reduces the outputs of specific staple crops such as sorghum, cassava, soya and yam. [34] had assessed the effect of Boko Haram insurgency on the agricultural sector of Nigeria using t-test for the analysis. The finding reveals that the agricultural sector contribution to the GDP before Boko Haram insurgency has reduced during the period of insurgency. [35] studied the impact of Boko Haram insurgency on agriculture in Adamawa state, the findings from Structural Equation Model revealed that agricultural sector was negatively impacted during the BH period. Plethora of research has reported decline in production and productivity of crops during the insurgency period, latest was the report from satellite image by Federal Ministry of Agriculture and Rural development in partnership with organisations like World Food Program (WFP), Famine Early Warning Systems Network (FEWSNET), Food and Agriculture Organization (FAO), National Agricultural Extension and Research Liaison Services (NAERLS) and Nigerian Meteorological Agency (NiMet) etc. Their report indicated that, "Adamawa state witnessed an average decreased of 68% in cropland performance in the hard-to-reach LGAs of Hong, Madagali, and Michika in 2023 compared to the reference year 2017. Borno state showed an estimated average of 74% deterioration, stability rate of 15% and improvement rate of 11% in the limited access and inaccessible areas in 2023 when compared to a reference year 2017. The deterioration rate reduced to an average of 50% when comparing the current year 2023 and the previous year 2022. In Yobe state however, there was a medium decrease of 67%, stability of 13%, and an improvement of 20% in the agricultural surface area in Bursari, Geidam, Gujba, Gulani, Tarmuwa, and Yunusari LGAs in 2023 compared to the reference year 2017 [36].

3. Materials and Methods

3.1. Study Area

The study area for the research was BAY states (Borno, Adamawa and Yobe) located in the North- Eastern region of Nigeria.

3.1.1. Borno State

Borno state is in the north-east geopolitical zone of Nigeria, it lies on coordinates 11°30' N and 13°00' E. The State shares common border with Niger Republic to the north, Chad to the

north-east and its eastern border forms part of national border with Cameroon. Similarly, within the country Borno state is bordered by Adamawa state to the south, Yobe state to the west and Gombe state to the south-west [15]. Average annual rainfall of the state ranges between 400mm to 577mm and rains between 4 and 5 months. Annual mean temperatures generally range between 29.4 °C and 35 °C. Maximum temperature occurs around April, May and June, occasionally exceeding 40 °C [37, 38].

3.1.2. Adamawa State

Adamawa state is bordered by Borno state to the northwest, Gombe state to the west and Taraba to the southwest, while its eastern border form National boundary with Cameroon Republic. Adamawa state is located on Latitude 9°19' N and Longitude 12°29' E (Latitude.co). It has an estimated population of 3,178,950 and account for 2.3% of Nigeria's population [39]. The projected population is estimated to be 4,902,100 as of 2021. The mean annual rainfall ranges from 700mm to 1 050mm [40]. Average annual temperature ranges from 15.2 °C in some region during harmattan to 43 °C during hot weather.

3.1.3. Yobe State

Yobe state is located in the North- East, Nigeria. The state lies from Latitudes 11°45'N - 13°30'N of the Equator and Longitudes 9°30'E - 12°30'E of the Greenwich meridian, It is situated in the Sudano-Sahelian vegetation zone which is characterized by a hot and dry climate for most of the year [15]. The state shares common boundaries with Borno State to the east and southeast, Jigawa State to the northwest, Bauchi and Gombe States to the southwest, while to the north is international border with Niger Republic. Annual average rainfall and temperature ranges between 423.3mm and 34 °C respectively, hottest months in the state are March-May with temperatures of between 39 °C - 44 °C [41, 42]. Agriculture is the main stay of the economy employing about 80% of the population [17]. Millet, sorghum, cowpea and maize are the major food crops. The cash crops that are commonly grown in the state include groundnut, gum Arabic and sesame seed.

3.2. Data Sources and Data Collection

The study used secondary data in form of Time Series that spanned a period from 1999 to 2023 obtained from different sources including National Agricultural Extension and Research Liaison Services (NAERLS) - Annual performance reports, Food and Agricultural Organization Database (FAOSTAT), National Bureau of Statistics (NBS) - various edition of annual abstract of statistics, Central Bank of Nigeria (CBN) annual reports, States Ministries of agriculture, Journal publications and other sources were also consulted. The agricultural variables sourced from the aforementioned databases include total output of crops (millet, sorghum, maize, cowpea, rice and groundnut) during the study periods, total land area cultivated and crops yield per ha in the BAY states.

3.3. Analytical Tools

Tools of analysis used in achieving research objectives were; Percentage change/Trend analysis, Coppock's Instability Index and Hazell's Decomposition Model. Specifications of the models are given below.

3.3.1. Percentage Change

Percentage change in area, production and productivity of crops between periods was calculated by finding the mean yearly difference between the quantities before the Boko Haram period (1999 – 2008) and during the active period of Boko Haram (2009 – 2017) and dividing the difference by the average quantities before the BH period, the result was then multiplied by 100 to capture the percentage change in trends. Specifically results were computed using 4 years average from 2005 to 2008 considered as period before the insurgency, 2013 to 2016 – as peak period of BH activities and 2020 to 2023 as current period. Comparison was made between period before and during the BH and also between during the peak activities of BH and current period to assess the quantum of changes.

$$\frac{M_{2013-2016}^{Ai, Pi, Yi} - M_{2005-2008}^{Ai, Pi, Yi}}{M_{2005-2008}^{Ai, Pi, Yi}} \times 100 - \text{period before and during the BH} \quad (1)$$

$$\frac{-M_{2020-2023}^{Ai, Pi, Yi} - M_{2013-2016}^{Ai, Pi, Yi}}{M_{2013-2016}^{Ai, Pi, Yi}} \times 100 - \text{peak period of BH and current period} \quad (2)$$

Where, $M_{2005-2008}^{Ai}$ = Average area in ('000'ha), $M_{2005-2008}^{Pi}$ = Production in ('000'tons) and $M_{2005-2008}^{Yi}$ = yield in (t/ha) from 2005 to 2008 as period before BH

$M_{2013-2016}^{Ai}$ = Average area in ('000'ha), $M_{2013-2016}^{Pi}$ = Production in ('000'tons) and $M_{2013-2016}^{Yi}$ = yield in (t/ha) from 2013 to 2016 as peak period of BH

$M_{2020-2023}^{Ai, Pi, Yi}$ = Average area in ('000'ha), $M_{2020-2023}^{Pi}$ = Production in ('000'tons) and $M_{2020-2023}^{Yi}$ = yield (t/ha) from 2020 to 2023 as current period

3.3.2. Coppock's Instability Index (CII)

This model estimates the average year to year percentage variation of observations after adjusting for trend. CII removes trend in time series data and does not over estimate results unlike other instability measures [43].

$$CII = (\text{Antilog} \sqrt{\log V} - 1) \times 100 \quad (3)$$

$$\text{Where } \log V = \sum (\log X_{t+1} - \log X_t - M)^2 / N - 1 \quad (4)$$

$$M = (\log X_{t+1} - \log X_t) / N - 1 \quad (5)$$

Where,

X_t = Area, production and productivity of crops in the year under consideration

N = Number of years, M = Arithmetic mean of the difference between the logs of series

$\log V$ = arithmetic variance of the series.

3.3.3. Hazell's Decomposition Model

This model determines changes in average of production between two periods – year in question 'n' and base year.

$$E(P) = \bar{A} \bar{Y} + COV(AY), \Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1 \Delta \bar{Y} + \bar{Y}_1 \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y} + \Delta COV(A, Y) \quad (6)$$

It has 4 components; Change in mean area - $\bar{A}_1 \Delta \bar{Y}$, change in mean yield - $\bar{Y}_1 \Delta \bar{A}$, Interaction between changes in mean area and mean yield - $\Delta \bar{A} \Delta \bar{Y}$, Changes in area – yield co-

These changes may be due to output price fluctuations and other climatic and institutional factors like conflicts, insurgency and other shocks which cause varying returns to farmers. The Boko Haram insurgency in the North-East (BAY states) from 2008 – 2017 was believed to be the major driver that caused changes in area and yield of crops. The insurgent's periodic attacks on farmers resulted in mass displacement [12] and abandonment of land, and where land is cropped, growing apprehension and fear of being killed or abducted, had evidently affected farming operations. Similarly, supply of inputs, extension contact and markets for produce were all distorted. Using [44] statistical methodology, variability in production of basic staple food crops as a result of BH insurgency and other natural factors were determined. Hazell decomposed the sources of change in mean production and change in production variance into four and ten components respectively. The study used 1999 - 2008 as base year (period before BH), and 2009 – 2018 as second period (period of BH).

i. Change in average production of the crops is affected by changes in the covariance between area and yield and also by changes in mean area and mean yield, it is expressed as;

variance - $\Delta COV(A, Y)$

ii. Change in variance of production has ten sources as follows;

$$\Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1 \Delta \bar{Y} + \bar{Y}_1 \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y} + \Delta COV(A, Y);$$

$$\begin{aligned} (\Delta V(P) = V(P_2) - V(P_1) = & \Delta \bar{A}^2 V(Y_1) + 2 \bar{A}_1 \Delta \bar{A} V(Y_1) + \bar{A}_1^2 \Delta V(Y) + \Delta \bar{A}^2 \Delta V(Y) + 2 \bar{A}_1 \Delta \bar{A} \Delta V(Y) + \Delta \bar{Y}^2 V(A_1) + \\ & 2 \bar{Y}_1 \Delta \bar{Y} V(A_1) + \bar{Y}_1^2 \Delta V(A) + \Delta \bar{Y}^2 V(A) + 2 \bar{Y}_1 \Delta \bar{Y} V(A) + 2 \bar{A}_1 \Delta \bar{Y} Cov(A_1, Y_1) + 2 \bar{Y}_1 \Delta \bar{A} Cov(A_1, Y_1) + 2 \Delta \bar{A} \Delta \bar{Y} Cov(A_1, Y_1) + \\ & 2 \bar{A}_1 \bar{Y}_1 \Delta Cov(A, Y) + 2 \bar{A}_1 \Delta \bar{Y} \Delta Cov(A, Y) + 2 \bar{Y}_1 \Delta \bar{A} \Delta Cov(A, Y) + 2 \Delta \bar{A} \Delta \bar{Y} Cov(A, Y) - \{\Delta Cov(A, Y)\}^2 - \\ & 2 Cov(A_1, Y_1) \Delta Cov(A, Y) + \Delta R \end{aligned} \quad (7)$$

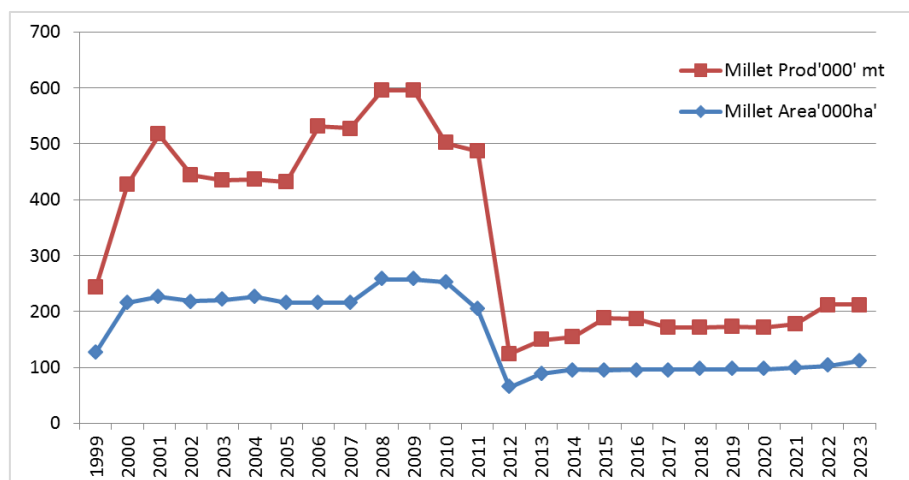
From above the 10 sources are; change in mean area, change in mean yield, change in area variance, change in yield variance, Interaction between changes in mean area and mean yield, change in area-yield covariance, Interaction between changes in mean area and yield variance, Interaction between changes in yield and area variance, Interaction between changes in mean area and mean yield and changes in area- yield covariance and changes in residuals.

4. Results and Discussion

4.1. Trend in Area, Production and Productivity

The study considered time series data of the above variables from 1999 to 2023 for Borno state as the worst hit by the insurgency and is depicted in Figures 1-4. It's visible from the graphs that, trends follows same pattern except in few cases. Area and production of crops were at peak between 2007 and 2011 and declined there after coinciding the period of BH. This decline continues till 2015 and begins to rise sharply. Major reason for this decrease was the BH insurgency as

evidenced by various studies [14, 36, 45, 46], however other reasons may be ascribed to climate, demand for crops and policies affecting agriculture.



Source: author's computation using data from NAERLS, NBS, Min of Agriculture Borno State

Figure 1. Depicting trends in Area and production of Millet in Borno State.

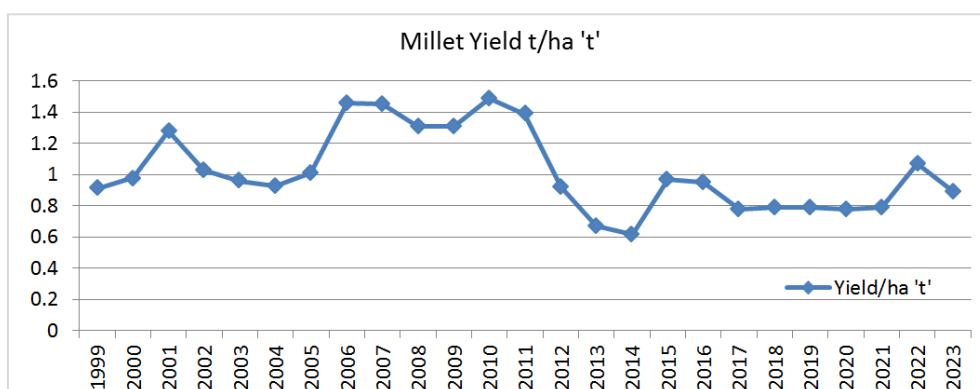
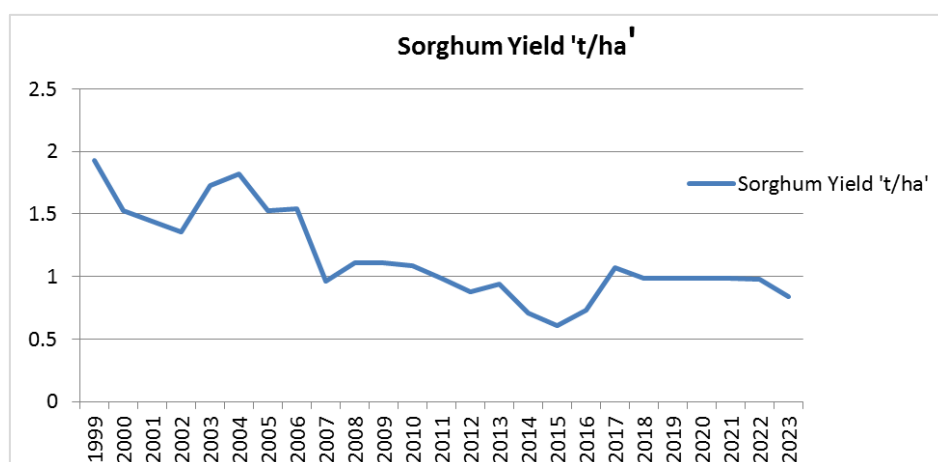


Figure 2. Millet yield in t/ha in Borno State.



Source: Author's computation using data from NAERLS, NBS, and MOA Borno State

Figure 3. Yield in tons/ha of sorghum in Borno State.

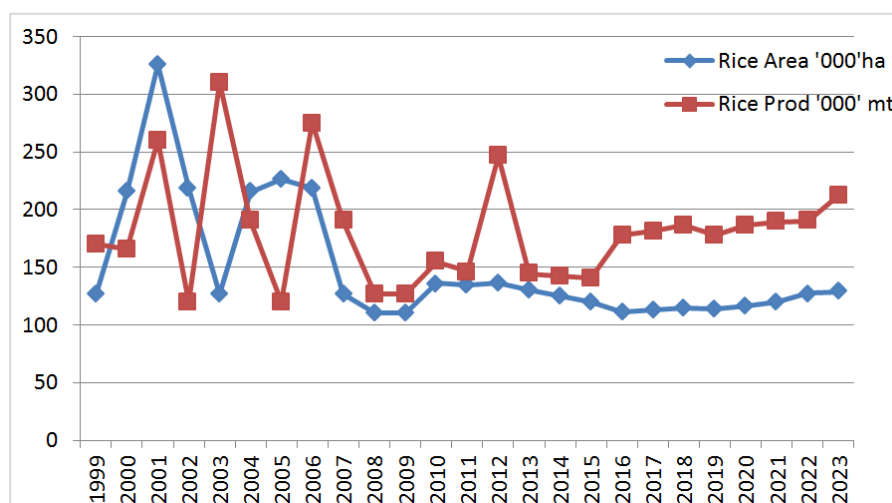


Figure 4. Area and Production of rice in Borno State.

4.2. Dynamic Analysis: Percentage Change in Area, Production and Productivity Between Periods

Tables 1-3 presented the results of percentage changes in area, production and productivity of the selected major staple crops in the BAY states. The results were computed using 4 years average from 2000 to 2003 considered as period before the insurgency, 2013 to 2016 – as peak period of BH activities and 2020 to 2023 as current period. Comparison was made between period before and during the BH and also between during the peak activities of BH and current period to assess the quantum of changes.

4.2.1. Dynamic Analysis in Borno State

Table 1 showed that almost all the crops recorded decrease in area, production and productivity during the insurgency period. Among the selected crops millet has recorded the highest decrease in area (-58.51%) between period before BH and during the peak period of the insurgents activities. Rice and sorghum followed closely with 37.65% and 30.95% respectively, millet is the most grown cereal crop in Borno state having low production cost and can adapt to varying climate. In terms of output the result indicated that, sorghum, cowpea and groundnut suffered the highest decline (40.96%, 35.86% and 35.4%), this was attributed more to decline in yields of the crops during the insurgency period. Rice is the only crop that recorded increase in yield (13.02%) between the periods this might perhaps be attributed to the Anchor Borrowers Programme by the Central Bank. Comparing the current period and the peak period of BH, all the crops recorded increase in area, production and productivity except millet that witnessed decrease in production by -60% from average of 232,290 tons in 2013 -2016 to 90,780 tons in 2020-2023. Findings revealed that, area and yield of millet increased marginally compared

to other crops probably due to tradeoff considering more economic gains associated with the crops. Cowpea had the highest increase in production (95.02%) followed by maize and sorghum (61.67% and 58.02%).

4.2.2. Dynamic Analysis in Adamawa State

Table 2 revealed the results from Adamawa state, varying increase in area and output has occurred despite the insurgent's activities. As stated earlier the results were computed for the whole state and only seven Local Government Areas (LGA's) out of twenty one were directly affected. Highest increase in area was noticed in sorghum (42.75%) followed by rice and maize (32.23% and 25.19) respectively. However insurgency and other factors like rainfall and cost of inputs caused shock leading to decline in the yields of some crops notably, millet, -18.46%, sorghum -11.38% and rice -1.78. By comparing current period and BH period, area and production output of all crops under study has increased, cowpea and millet has the major increase in area (162.96% and 161.87%), while millet, rice and maize has the highest increase in output.

4.2.3. Dynamic Analysis in Yobe State

The percentage changes in area, production and productivity between the chosen periods in Yobe state were similar to Borno state except in few cases. Area under millet, cowpea and maize decreased during the peak of BH by -29.73%, - 11.22% and -6.36% respectively, while rice and sorghum witnessed increase of about 55.1% and 0.81% respectively (Table 3). This increase was ascribed to Anchor Borrowers programme of the Central Bank. Production output of all the crops were negative except in cowpea and maize, millet recorded the highest decrease in output (-48.85%) closely followed by sorghum (-23.46). Similarly, yield of all the crops in Yobe state decline during the peak period of BH, cowpea has the highest decrease followed by sorghum and millet.

Table 1. Changes in average area, production and productivity of crops between periods in Borno State, Nigeria.

Crops	Borno state	Before BH period (2005-2008)	During the peak of BH (2013-2016)	Difference	% change	During the peak of BH (2013-2016)	Current Period (2020-2023)	Difference	% change
Millet	Area	225.99	93.78	-132.21	-58.51	93.78	102.29	8.51	9.08
	Production	295.52	232.29	-63	-21.39	232.29	90.78	-141.51	-60.92
	Productivity	1.307	0.805	-0.502	-38.41	0.805	0.882	0.077	9.59
Sorghum	Area	279.63	193.09	-86.54	-30.95	279.63	355.57	75.94	45.69
	Production	361.78	213.56	-148.22	-40.96	213.56	337.48	123.94	58.02
	Productivity	1.28	0.75	-0.53	-41.72	0.75	0.95	0.2	27.09
Cowpea	Area	177.72	175.82	-1.9	-1.07	175.82	187.05	11.23	6.38
	Production	119.47	76.62	-42.85	-35.86	76.62	149.43	72.81	95.02
	Productivity	0.67	0.45	-0.22	-33.46	0.45	0.81	0.36	81.01
Maize	Area	323.16	310.92	-12.24	-3.78	310.92	395.89	84.97	27.33
	Production	428.00	338.31	-89.69	-20.96	338.31	546.96	208.65	61.67
	Productivity	1.47	1.38	-0.09	-5.46	1.38	1.39	0.01	0.54
Rice	Area	195.38	121.86	-73.52	-37.63	121.86	128.79	6.93	1.18
	Production	178.15	151.58	-26.57	-14.91	151.58	194.63	43.05	28.41
	Productivity	1.11	1.25	0.14	13.03	1.25	1.64	0.39	30.42
Groundnut	Area	153.66	147.6	-6.06	-3.94	147.6	159.96	12.36	8.38
	Production	252.74	163.24	-89.5	-35.4	163.24	193.56	30.32	18.57
	Productivity	1.92	1.11	-0.81	-42.31	1.11	1.21	0.11	9.48

Area ('000'ha), Production ('000't) and Productivity (t/ha)

Source: Author's computation using data from NAERLS, NBS, MOA.

Table 2. Changes in average area, production and productivity of crops between periods in Adamawa State, Nigeria.

Crops	Adamawa State	Before BH period (2005-2008)	During the peak of BH (2013-2016)	Difference	% change	During the peak of BH (2013-2016)	Current Period (2020-2023)	Difference	% change
Millet	Area	48.75	52.72	3.9	8.15	52.72	138.66	83.9	161.87
	Production	39.287	52.307	13.0	33.14	52.307	172.75	120.4	230.27
	Productivity	0.812	0.662	-0.15	-18.46	0.662	1.127	0.47	70.188
Sorghum	Area	123.59	154.185	30.6	42.75	154.185	269.84	115.6	75.01
	Production	165.24	173.55	8.31	5.03	173.55	293.2	119.7	68.94
	Productivity	1.34	1.18	-0.16	-11.38	1.18	1.06	-0.12	-10.32
Cowpea	Area	63.475	76.755	13.3	20.92	76.755	201.84	125.1	162.96
	Production	51.733	103.42	51.7	99.92	103.42	204.82	101.4	98.04
	Productivity	0.815	1.74	0.93	113.34	1.74	1.09	-0.6	-37.36
Maize	Area	159.30	205.81	46.5	25.19	205.81	209.78	3.97	1.93
	Production	179.35	206.78	27.4	15.95	206.78	429.18	222.4	106.65

Crops	Adamawa State	Before BH period (2005-2008)	During the peak of BH (2013-2016)	Difference	% change	During the peak of BH (2013-2016)	Current Period (2020-2023)	Difference	% change
Rice	Productivity	1.13	1.16	0.03	2.58	1.16	1.22	0.06	5.38
	Area	68.157	90.125	21.9	32.23	90.125	178.12	87.9	97.63
	Production	119.65	130.156	10.5	8.77	130.156	281.08	150.9	115.96
	Productivity	1.756	1.725	-0.03	-1.78	1.725	1.6175	-0.11	-6.209

Area ('000'ha), Production ('000't) and Productivity (t/ha)

Source: Author's computation using data from NAERLS, NBS, MOA.

Table 3. Changes in average area, production and productivity of crops between periods in Yobe State, Nigeria.

Crops	Yobe State	Before BH period (2005-2008)	During the peak of BH (2013-2016)	Difference	% change	During the peak of BH (2013-2016)	Current Period (2020-2023)	Difference	% change
Millet	Area	298.65	209.87	-88.8	-29.73	209.87	215.10	5.3	2.49
	Production	301.08	154.0	-147.1	-48.85	154.0	235.36	81.4	52.83
	Productivity	0.985	0.733	-0.25	-25.63	0.733	1.095	0.362	49.48
Sorghum	Area	168.89	170.26	1.9	0.811	170.26	206.36	36.1	21.21
	Production	185.63	142.08	-43.6	-23.46	142.08	205.19	63.11	44.42
	Productivity	1.11	0.82	-0.29	-26.14	0.82	0.99	0.17	21.34
Cowpea	Area	120.95	107.38	-13.57	-11.22	107.38	122.72	15.34	4.97
	Production	67.93	68.22	0.29	0.434	68.22	204.32	136.1	199.49
	Productivity	0.56	0.42	-0.14	-26.24	0.42	1.83	1.41	341.56
Maize	Area	8.48	7.94	-0.54	-6.36	7.94	9.15	1.21	15.24
	Production	13.66	12.8	-0.86	-6.31	12.8	13.88	1.08	8.46
	Productivity	1.63	1.17	-0.46	-17.0	1.17	1.52	0.35	30.04
Rice	Area	23.56	36.54	12.98	55.10	36.54	97.19	60.65	165.95
	Production	30.46	36.85	6.39	21.01	36.85	174.64	137.8	373.88
	Productivity	1.28	1.02	-0.26	-20.97	1.02	1.79	0.77	77.09

Area ('000'ha), Production ('000't) and Productivity (t/ha)

Source: Author's computation using data from NAERLS, NBS, MOA

4.3. Instability in Area, Production and Productivity

Instability in area, production and productivity of the selected crops is presented in Table 4. CII give close approximation of the average year to year percentage variation adjusted for trend especially when time series data is used. Trends are always predictable and are deviation from instability. The measurement of instability requires that an implicit

or explicit judgment be made as to what constitutes the acceptable or unacceptable variability. Variability portrays the instability and deviation from the trend constitutes the variability. The model used 1999-2008 as the base year, which is period before the Boko Haram insurgency and 2009-2018- the period of BH insurgency. The results generally showed that, variability in area, production and productivity of the crops are high during the BH period. This entails numerous reasons inflicted by the activities of the insurgents ranging from nature and frequency of attacks, types of destruction, number of

people abducted and the kind of fear and growing apprehension subjected to farmers.

4.3.1. Instability in Area, Production and Productivity in Borno State

Instability in area of millet before BH was 18.3% which was the highest among the crops, whereas it was 29.12% during the period of BH (Table 4). This implied that, changes or variability in area under millet has often occurred during the ten (10) years period. Similarly, highest instability was noticed in rice area during the BH period (50.47%). A number of factors including activities and massive killings of farmers by BH in the rice grown areas, impact of the Anchor Borrowers Policy, high demand for the home grown (Local) rice as a result of importation ban policy and the rising price of the commodity were ostensibly responsible for high instability. Output production instability among the crops was high in period of BH in millet maize and cowpea. Instability in yield was also higher during the BH period except in rice and

groundnut (73.25% and 61.34%) where policy interventions from 2009-2018 presumably reduces yield variability and stabilized output.

4.3.2. Instability in Area, Production and Productivity in Adamawa State

Table 4 revealed the results in Adamawa state, instability in area, production and productivity were higher in all the crops during the BH period. Millet has the highest variability in area, production and productivity (83.97%, 48.86% and 40.88%) followed by cowpea (29.83%, 48.07% and 40.26%). Instability in yield of maize and rice were also high compared to period before BH, maize CII was only 4.21% before BH and 27.46% during the period of BH. Similarly, there was almost 14% increase in CII of rice between period before and during the BH insurgency. Instability in Adamawa state was more of a product of weather variability, policies affecting demand and supply, ethnic and religious violence as percentage of areas affected by BH in the state was small.

4.3.3. Instability in Area Production and Productivity in Yobe State

Table 4. Instability Index for major staple crops in BAY States.

Period	Crops	Borno State			Adamawa State			Yobe State		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
		CII in%			CII in%			CII in%		
1999 -2008 Before BH	Millet	18.83	28.11	18.81	19.95	27.78	14.41	14.47	26.58	14.47
	Maize	13.28	19.94	21.56	10.69	14.54	4.21	24.82	24.18	12.93
	Sorghum	8.16	33.61	22.13	11.83	9.20	8.25	3.60	9.29	11.42
	Cowpea	15.86	27.58	12.72	7.46	10.09	9.10	5.42	16.93	16.23
	Rice	8.07	80.44	73.26	20.7	25.47	7.63	27.87	40.93	19.93
	G/nut	12.82	42.30	61.34	-	-	-	-	-	-
2009 -2018	Millet	29.12	56.65	24.52	83.97	48.86	40.88	10.48	27.88	16.18
	Maize	15.53	21.57	27.51	14.05	32.37	27.46	6.33	10.29	21.68
	Sorghum	23.05	20.65	22.94	18.50	22.92	9.83	6.22	17.26	12.37
BH period	Cowpea	11.06	28.97	24.87	29.83	48.07	40.26	7.86	44.41	37.84
	Rice	50.47	24.10	23.03	27.44	33.98	21.23	31.93	53.22	25.58
	G/nut	11.13	10.70	13.21	-	-	-	-	-	-

Source: Author's computation using secondary data from NAERLS, NBS, MOA.

Instability in production was higher than in area and productivity in Yobe state (Table 4). Rice, cowpea and millet has the highest production instability (53.22%, 44.41% and

27.88%) during the period of BH. Area instability was generally low compared with yield this implied that, farmer's production technology, access to farm and productive re-

sources were more affected by the menace of BH. Instability in yield during BH period was higher than in before the period in all the crops and was more in cowpea (37.8%) followed by rice, maize and millet. Variability in yield of rice may also be ascribed partly to the increasing demand and high benefit-cost ratio derived from the crop amidst fixed area. Rice area increased steadily from 1999 while millet sorghum and cowpea areas seemed to fluctuate throughout the periods (Table 4).

4.4. Decomposing Sources of Changes in Average of Production

The results of the sources of change in average of production of the selected crops are presented in table 5 and as earlier noted changes in average and variance of production were decomposed into four (4) and ten (10) sources. Period before the Boko Haram (1999 -2008) was the base year and 2009 – 2018 was the current period (period of BH), the changes in mean production between the two periods can be due to change in mean area, change in mean yield, interaction between mean area and mean yield or change in area-yield covariance.

4.4.1. Sources of Change in Average of Production in Borno State

Table 5 captured the results of sources of change in average of production of the selected crops, change in mean yield of millet was the dominant factor (160.74%) responsible for change in average of millet production between the 2 periods while, interaction effect was the least factor that contributed to changes in millet output. Similarly change in mean yield was also the major reason in maize, sorghum and groundnut average output changes, whereas change in mean area was responsible for change in average of production of cowpea and rice, contributing 536.45% and 159.06% respectively. The result implied that, changes in yield per ha due to insurgents activities had more effect than changes in area in four (millet, maize, sorghum and groundnut) out of the six crops selected and policy direction should focus more on the increase in productivity of the crops.

4.4.2. Sources of Change in Average of Production in Adamawa State

Change in mean area was the major source of change that affected crops output in Adamawa state during the period of the study. Change in average of production of maize, millet, sorghum and rice were all as a result of change in mean area, whereas change in mean yield was only responsible for output change in cowpea (55.54%). Millet has the highest area effect (168.72%) followed by rice and sorghum (120.08% and 116.04%) respectively. The results indicated that, variability in area put under cultivation of crops was the major source of change in production in Adamawa state (Table 5).

4.4.3. Sources of Change in Average of Production in Yobe State

In Yobe state (Table 5), change in mean area and change in mean yield accounted for 76.48% and 31.49% of the change in average of production of millet. Similarly, rice and maize outputs were solely affected by changes in mean area (122.23% and 359.71%) as changes in area-yield covariance had negligible contributions. Change in mean yield was responsible for change in average of production of sorghum, cowpea and groundnut contributing 251.46%, 211.49% and 144.14% respectively. The results of decomposition in Yobe depicted that both area and yield changes as a results of the insurgent's activities significantly disrupted average production output of the studied crops.

4.5. Changes in Variance of Production

Variance of production between the two periods (Before and during the BH insurgency) was the difference, deviation or variation in production of particular crop that occurred and is a function of ten (10) sources [44] (Hazell, 1984); Change in mean area, change in mean yield, change in area variance, change in yield variance, interaction between changes in mean area and mean yield, change in area-yield covariance, interaction between changes in mean area and yield variance, interaction between mean yield and area variance, interaction between changes in mean area and yield and changes in area-yield covariance and change in residual. Table 6 presented the results from BAY states.

4.5.1. Sources of Change in Variance of Production in Borno State

Change in yield variance was majorly responsible for change in variance of millet and maize production accounting for 70.51% and 363.1% respectively. Similarly, change in mean yield was the major source of change in variance of sorghum production (23620%) followed by change in area variance (12372.2%) and change in yield variance (11081.68%). Other sources contributed negatively to reduce and adjust the model to full percentage level. Change in variance of cowpea production was influenced largely by change in residuals (307.62%) and change in area variance (252.36%), while change in area variance (1524.7%) and interaction between changes in mean yield and area variance (659.79%) accounted for the change in variance of rice production between the two periods. Changes in groundnut production output in Borno state was seemed to be affected by differences in mean yield and changes in area- yield covariance, it was observed that, variability in output of crops between period before the BH and period of insurgency were the results of mixed sources/component of change that centered on changes in yield, area variance, interaction between changes in mean yield and area variance and changes in the residuals. Policy direction to stabilize production in the short and long run

should consider the gap in cropped area established by internally displaced persons (IDPs), yield gap occasioned by inadequate inputs technology and good management practices and the defects suffered by returnees in their various camps.

4.5.2. Sources of Change in Variance of Production in Adamawa State

Among the sources of change in variance of production (Table 6), change in yield variance, changes in area – yield covariance and interaction between changes in mean area and yield variance were the major ones that influenced variance of maize output contributing 34.22%, 25.29% and 18.34% respectively. In millet, sorghum and rice however, it was uniquely change in area variance accounting for 109.8%, 264.97% and 170.12% respectively. While other sources of instability in those crops contributed slightly, others acted to reduce the instability. Cowpea's change in variance of production between the periods was determined largely by the interaction between changes in mean yield and area variance (92.97%) and change in area variance (36.13%). It could be inferred from above that, change in variance of production in Adamawa state was majorly anchored around variability in area keeping yield a little bit stable.

4.5.3. Sources of Change in Variance of Production in Yobe State

Change in variance of sorghum production in Yobe state was as a result of changes in area – yield covariance (120.85%) and changes in the residuals that is sum of other components (100.97%). Similarly, changes in the residuals was the major component of change in variance of millet production accounting for 100.6% followed by changes in area-yield covariance (28.03%) and changes in area variance (22.23%). Change in yield variance was the next source of change in cowpea variance of production (32.42%) closely behind changes in area-yield covariance (47.97%). Yield of cowpea fluctuated between 0.34 tonnes to 1.08 tonnes within the study periods. Major sources or components of change in variance of rice production were change in area variance between the two periods (75.23%), changes in area-yield covariance (18.55%) and Interaction between changes in mean area and mean yield and area- yield covariance (15.83%). Area and yield of rice in Yobe has witnessed changes from 1999 to 2018 due to various policy interventions, area kept increasing and was at its peak around 2016 - 2017 while yield oscillates around 1 to 2 tonnes per ha. Similarly, change in yield variance was the major source of change in variance of groundnut production in Yobe state contributing 145.15%. (Table 6).

Table 5. Sources of change in average of production of major crops in BAY States during Insurgency (values in percentage).

State	Crop	Change in mean Area $\Delta \bar{A}$	Change in mean Yield $\Delta \bar{Y}$	Interaction between mean Yield and mean Area $\Delta \bar{A} \Delta \bar{Y}$	Changes in Area - Yield covariance $\Delta COV(A, Y)$
Borno	Millet	-7.60	160.74	-59.59	6.51
	Maize	-419.91	472.47	26.65	21.07
	Sorghum	1.69	101.83	-0.66	-1.83
	Cowpea	536.45	-373.69	-63.26	-5.93
	Rice	159.06	-88.48	31.33	-1.08
	Groundnut	-110.87	158.31	51.23	1.29
Adamawa	Maize	45.08	42.74	10.23	2.01
	Millet	168.72	-52.89	-19.03	4.11
	Sorghum	116.04	-8.76	-1.33	-6.67
	Cowpea	24.49	55.54	21.81	-1.83
	Rice	120.08	-13.11	-2.96	-3.60
	Groundnut	-	-	-	-
Yobe	Millet	76.48	31.49	1.85	-4.50
	Maize	359.71	-207.19	-54.90	2.32
	Sorghum	-197.6	251.46	50.05	-3.18
	Cowpea	-85.36	211.49	-21.55	-4.49
	Rice	122.23	-13.16	-14.19	4.98

State	Crop	Change in mean Area $\Delta \bar{A}$	Change in mean Yield $\Delta \bar{Y}$	Interaction between mean Yield and mean Area $\Delta \bar{A} \Delta \bar{Y}$	Changes in Area - Yield covariance $\Delta COV(A, Y)$
	Groundnut	-18.06	144.14	-26.66	1.39

Source: Author's computation using data from NAERLS, NBS, MOA

Table 6. Sources of change in variance of production in BAY states (values in percentage).

States and Crops	Change in mean Yield $\Delta \bar{Y}$	Change in mean Area $\Delta \bar{A}$	Change in area variance $\Delta V(A)$	Change in yield variance $\Delta V(Y)$	Interaction b/w changes in mean area and mean yield $\Delta \bar{A} \Delta \bar{Y}$	Changes in area-yield covariance $\Delta Cov(A, Y)$	Interaction b/w changes in mean yield and area variance $\Delta \bar{Y} \Delta V(A)$	Interaction b/w changes in mean area and yield variance $\Delta \bar{A} \Delta V(Y)$	Interaction between changes in mean area and mean yield and area- yield covariance	Changes in residuals ΔR
Borno State										
Maize	-15.99	-0.35	-5.89	363.1	0.03	-280.8	0.72	42.12	2.98	-5.9
Millet	6.90	-0.14	0.19	70.51	-0.41	6.85	14.83	-42.59	37.41	6.45
Sorghum	23620	52.16	12372.2	11081.68	39.12	-1407.8	-7783.77	-144.14	5536.16	-30598.7
Cowpea	-230.93	11.96	252.36	-70.09	3.75	-90.09	-56.03	-25.74	-2.28	307.62
Rice	480.71	-82.89	1524.7	-413.2	-80.78	-784.47	659.79	240.8	177.53	-1622.2
Groundnut	64.69	-1.08	5.63	-10.45	0.48	60.95	-4.00	-7'86	-17.53	9.17
Adamawa State										
Maize	3.03	0.57	2.79	34.22	0.08	25.29	1.41	18.34	13.25	0.99
Millet	3.63	7.23	109.8	-5.65	-0.17	15.66	-23.80	-4.91	3.31	-5.1
Sorghum	-37.72	-1.34	264.97	24.63	0.06	-173.79	-6.03	8.03	-23.88	45.08
Cowpea	2.45	0.21	36.13	0.96	0.11	-12.17	92.97	0.91	-19.59	-1.98
Rice	8.39	7.48	170.12	-9.49	-0.05	-39.27	-8.29	-4.77	-7.67	-16.46
Groundnut	-	-	-	-	-	-	-	-	-	-
Yobe state										
Maize	38.23	0.14	107.48	-1.21	-0.02	-11.09	-30.30	-0.73	-0.79	-1.71
Millet	-69.94	-6.65	22.23	19.81	-0.09	28.03	1.08	2.38	2.37	100.6
Sorghum	-101.19	-3.43	-78.87	25.62	2.61	120.85	34.89	11.21	-12.65	100.97
Cowpea	-1.88	25.50	-6.09	32.42	0.05	47.97	-3.46	-6.27	5.97	5.78
Rice	-1.26	1.32	75.23	0.45	0.13	18.55	-16.45	1.51	15.83	4.68
Groundnut	4.43	-11.11	-0.17	145.15	-0.89	2.81	-0.86	-51.74	2.93	0.45

Source: Author's computation using data from NAERLS, NBS, MOA.

5. Conclusion and Recommendations

Findings from this study indicated that all the crops in

Borno state recorded decrease in area, production and productivity during the insurgency period. Among the selected crops millet has recorded the highest decrease in area (-58.51%) between period before BH and during the peak of

the insurgents activities. Rice and sorghum followed closely with 37.65% and 30.95% respectively. Area under millet, cowpea and maize in Yobe state decreased during the peak of BH by -29.73%, - 11.22% and -6.36% respectively. Production outputs of all the crops were negative except in cowpea, and millet recorded the highest decrease in output (-48.85%) closely followed by sorghum (-23.46). Similarly, yield of all the crops in Yobe state decline during the peak period of BH, in Adamawa state however decrease in yield was recorded in majority of the crops while, area and production slightly increases as BH activities were more confined to northern part of the state. Instability in production was higher than in area and productivity in Yobe state, rice, cowpea and millet has the highest production instability (53.22%, 44.41% and 27.88%) during the period of BH. Area instability was generally low compared with yield this implied that, farmer's production technology, access to farm and productive resources were more affected by the menace of BH.

The result of sources of change in average of production in Borno state implied that, changes in yield per ha due to insurgents activities had more effect than changes in area in four (millet, maize, sorghum and groundnut) out of the six crops selected. In Yobe state change in mean area and change in mean yield accounted for 76.48% and 31.49% of the sources of change in average of production of millet. Similarly, rice and maize outputs were solely affected by changes in mean area (122.23% and 359.71%). Change in mean area was the major source of change that affected crops output in Adamawa state during the period of the study. Change in average of production of maize, millet, sorghum and rice were all as a result of change in mean area, implying that, variability in area across years was the major source of change in production whereas change in mean yield was only responsible for output change in cowpea (55.54%). Sources of change in variance of production in most crops in the study areas were majorly due to change in yield variance, changes in area-yield covariance and change in area variance. From above therefore, the findings implied that, farmers has abandoned their farm lands for fear of attacks during the period of BH and that poor farm management and inaccessibility of inputs had resulted in low yield of crops. Social implication of this is low income to farmers, rising prices of the commodities and general food insecurity. In view of the above, the study recommended policy to focus on increasing farmer's yield per ha through provision of improved high yielding varieties, timely credit or subsidy interventions as land is still inaccessible in some areas. The inability of the returnees to access farm due to poor economic condition should be looked at by Government and Non-Governmental Organizations (NGOs), specifically in the area of wealth creation involving farm and off farm activities.

Abbreviations

BAY	Borno, Adamawa and Yobe States
BH	Boko Haram

CBN	Central Bank of Nigeria
CII	Coppock's Instability Index
FAO	Food and Agriculture Organization
FEWS NET	Famine Early Warning Systems Network
GDP	Gross Domestic Product
HA	Hectre
ISIL	Islamic State of Iraq and Levant
ISWAP	Islamic State's West Africa Province
KG	Kilogram
LCB	Lake Chad Basin
MOA	Ministry of Agriculture
NAERLS	National Agricultural Extension and Research Liaison Services
NBS	National Bureau of Statistics
NiMet	Nigerian Meteorological Agency
WFP	World Food Program

Conflicts of Interest

The authors declare no conflicts of interest.

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