EFFECTIVE MANAGEMENT OF DROUGHT TO BOOST AGRICULTURAL PRODUCTIVITY IN BENUE STATE: AN ASSESSMENT OF TSE-KUTCHA COMMUNITY OF GBOKO LGA FROM 2000-2024

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Abstract
The phenomenon of climate variability has increasingly led to prolonged periods of inadequate rainfall globally, even during rainy seasons. This paper investigates the direct and indirect causes of drought in the Tse-Kucha community of Gboko LGA, Benue State, Nigeria, from 2000 to 2024. The study is based on Lucien Fabvre's 1932 theory of environmental possibilism and utilizes frequency distribution, simple percentage, and Pearson correlation alongside time series analysis for statistical analysis of demographic data and hypothesis testing. Primary data were gathered by administering 200 questionnaires to farmers using multi-stage sampling, while secondary data were sourced from recent journal articles. The findings reveal that drought in Tse-Kucha is significantly linked to seasonal changes and exacerbated by industrial activities at the Dangote cement factory located in the community. Among other impacts, drought has caused substantial seasonal variability in annual rainfall patterns, with delayed onset and early cessation of the rainy season, leading to reduced rainfall frequency. Additionally, farmers have experienced lower crop yields, reduced incomes, and increased poverty. The study concludes that although drought events are natural, they have been intensified by human activities, contributing to increased poverty among farmers in the area. Recommendations

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include implementing irrigation schemes, enhancing air pollution control at the Dangote Cement plant, providing effective compensation to community farmers by the cement factory management, and resettling farmers living near the factory.

Keywords: Drought, agricultural productivity, anthropogenic interference, seasonal changes.

Introduction

The geographical phenomenon of climate variability involving ill-defined patterns of drops in rainfall amounts below observed normal averages has progressively assumed higher magnitudes across the globe even during rainy seasons when such irregularities are least expected of rainfall amount and its spatial distribution, (Cavalcante et al, 2024). According to Asaasuen et al (2024), such climatic occurrences are associated with seasonal changes on the earth's surface which, in turn are ascribedto the 'tilt effects' of the planet's axis relative to its orbital plane at 23.5 degrees. On the general note, it is imperative to state here that notwithstanding the positive correlation between climatic variability and seasonal changes, the severity of the former depends largely on anthropogenic interference, which over space and time, has heightened in their frequency and scope. The increasing magnitude of population growth especially in developing countries has correspondingly produced widespread effects of this phenomenon tagged 'drought' which manifests beyond mere dryness of soil and air to disruptions in ecological systems and global socioeconomic order, (Joger et al, 2019; Jedd, 2020; Luo et al, 2024).

Globally, drought scenarios are known to be initiated by population exponential growth, without corresponding advancements in scientific and technological applications in the production of food and other social services needed to sustain it. This phenomenal imbalance according to Oko et al, (2023) results in indiscriminate and primitive land use types involving uncontrolled proliferation of built-up architectures and grazing as well as cropping landscapes, all of which exert pressure on land and produce weather extremes as well as other environmental hazards. This is evidenced in the hinterlands of Jakarta, Indonesia and Bangladesh where rapid population growth has outstripped the carrying capacity of land resources, leading to multiple forms of environmental degradation that transcend to hazards such as drought and cold waves, (Faizal et al, 2024; Islam, 2024).

Across Africa, drought has produced spectacular landmarks which manifest both in natural and socioeconomic terms. In East Africa, Molla et al (2024) notes that shortfalls in rainfall during crops growth results in stunted growth and large-scale dwarfism which leads to poor yield and ultimately intensifying poverty levels among farming communities. In the same vein, Zambia in Southern Africa has increasingly suffered prolonged drought due to climate change events,which are ascribed to exponential growth in population.Similarly the Lake Chad Basin in Sub-Saharan Africa has progressively lost its size on annual basis in the past couple of years due to

drought and siltation which are respectively ascribed to successive occurrence of extreme weather events causing drought and the indiscriminate dumping of waste derived from anthropogenic routines which are ultimately washed and deposited in the lake's basin thereby reducing the space hitherto covered by water, that could be freely used for irrigation to boost crops in the wake of drought events, (Boubacar, 2012; Jingling et al, 2024).

In Nigeria, drought events have become an annual phenomenon that is progressively expanding in scope and magnitude. According to Oye and Well (2024), who studied drought vulnerability using a 12–monthtime scale computed from time-series analysis and meteorological records of Nigeria based upon 1060-2015 as wellas GIS maps found that there have been severe cases of droughts in Minna and Jos while Ilorin and Abuja has over the study period experienced moderate droughts. In either case, the study reported that there were poor performances on the part of crops leading to reduced food supply and household incomes. Further northwards in Nigeria, drought has led to widespread shortfalls in agricultural productivity in Yobe State, where stunted growth has resulted to low yields in cereal crops despite the application of irrigation technique to improve water supply to crops among the farming communities (Hassan et al, 2019).

From the forgoing, it is clear that the phenomenon of drought is universal with adverse impacts on livelihoods by the human society. It is also of great importance to note that the human society depends largely on food for survival. The effect of drought on agricultural operations is therefore an issue that needs decisive actions since agriculture does not only form the roots of human survival through sustainable food supply, but also constitutes a source of raw materials for industrial development and households' income in rural communities. It is against this background that the study carefully selects Tse-kutcha community of Gboko LGA to investigate drought especially as the community is located in a rural area where the population is typically farmers, producing crops under perceived effects of industrial pollutants derived from Dangote Cement Plant.It is also interesting to note that the trend of drought events greatly intensified involving prolonged periods of irregular rainfalls during the rainy season as well as delayed onset and early cessation of the rainy season. This climatic phenomenon which occurs on seasonal basis due to seasonal changes is also believed to be associated with the frequent emission of cement dust into the locality's atmosphere which constitutes greenhouse gases and their inherent adverse impacts on cycling of environmental nutrients. On the other, there has been no study in this community on this subject matter while farmers increasingly suffer low agricultural yield on yearly basis which is perceived to be associated within creasing magnitude of drought events.

Objectives

i To identify the remote and proximate causes of drought inTse-Kutcha community.

ii To assess the impact of drought events on agricultural productivity in the

study locality.
iii To examine the impact of drought on livelihood among the farmers as main population of the community.

Hypotheses

i There is no significant link between seasonal changes and drought events in Tse-kutcha community.
ii. There is no significant relationship between drought events and low agricultural productivity in Tse-kutcha community
iii. Drought events in Tse-kutcha have no significant impact on poverty levels among farmers of the community.

Geography of the study area

Tse–Kucha is a settlement named after the Kutcha family in Mbayion, Gboko Local Government Area of Benue State. The settlement area which has considerably grown in size along Makurdi to Gboko road has geographical coordinates of Latitude 7° 25` 26.4" N and Longitude 8° 58' 8.4" E with a linear spread of approximately three (3) Kilometers along the same road, which is however undergoing rapid outward expansion. The study area has an altitude of 150 m above sea level which is predominantly a lowland topography,without hills or rocky outcrops. The locality is drained by two main water bodies by name Ahungwa and Oratsor streaming in a north-south alignment across the Makurdi-Gboko road, (Ajon & Chagbe, 2018).

From climatic a perspective, the study area lies wholly within the tropical climate within the Aw (tropical rainy) group based on Koppen classification. Consequently, Tse-Kutcha has two distinctive seasonal affiliations of wet and dry seasons with varying temperature and rainfall regimes based substantially on cosmic configurations and anthropogenic impacts, (Brooccoli & Chaing, 2023; Jarayam, 2024). Generally, the rainy season commences from April to October on yearly basis with an average annual amount of 1412mm.The driest month is January with 3 mm. Most precipitations take place in September with an average of 264 mm This trend is however progressively changing due to the contemporary phenomenon of climate changeglobally which has also affected the study area, accordingly leading to delayed onset of rainy season and early cessation of rains, (Asaasuen et al, 2024). This development has led to unpredicted weather patterns in the study locality, which according to Hong and Hong (2021) results in prolong drought events that tend to punctuate rainy seasons. The dry season lasts from November to March and is characterized by the high prevalence of the harmattan windwith a drying tendency.The foregoing rainfall type has produced luxuriant growth of Guinea savannah which serve the local population in multiple ways. On the other hand,the average annual temperature in Tse–Kucha is approximately 26.8 °C. (Kankara & Galadanchi, 2020). The warmest month of the year is March with an average temperature of 29.4 °C.The average temperature of 25.4 °C, which is the lowest

average temperature for the whole year, is recorded in July (NIMET, 2024).

The soils in Tse–Kucha are mainly sandy soils with clay sub-soils with a characteristic reddish colour. The soils are mainly Ultisols (tropical ferruginous) which vary over space with respect to texture, drainage and gravel content. A typical soil profile in Tse–Kucha is highly weathered with a sandy surface layer overlying a clay mottled sub-soil (Ajon & Chagbe, 2018; Kankara & Galadanchi, 2020). Tse-Kucha is largely covered by cretaceous continental sediments of basement complex rocks (to the north) and marine sediments of clay and shale (to the south) causing the limestone reserves within the study area to be mostly of cretaceous sedimentary formation, (Kankara & Galadanchi, 2020). The average limestone within the area has a thickness of over 80m with a quarry-able reserve area of 1.5 Km with the mineral reserve standing at over 35.4 million metric tons. The calcium carbonate ($CaCO_3$) content of the limestone within the study area according to the author is over 80% indicating that the mineral is suitable for cement production. It is partially against the background of the limestone nature of the soil that drought events become rampant in the study area as limestone is a mineral that typically results in poor drainage on the land surface, ((Ajon & Chagbe, 2018).

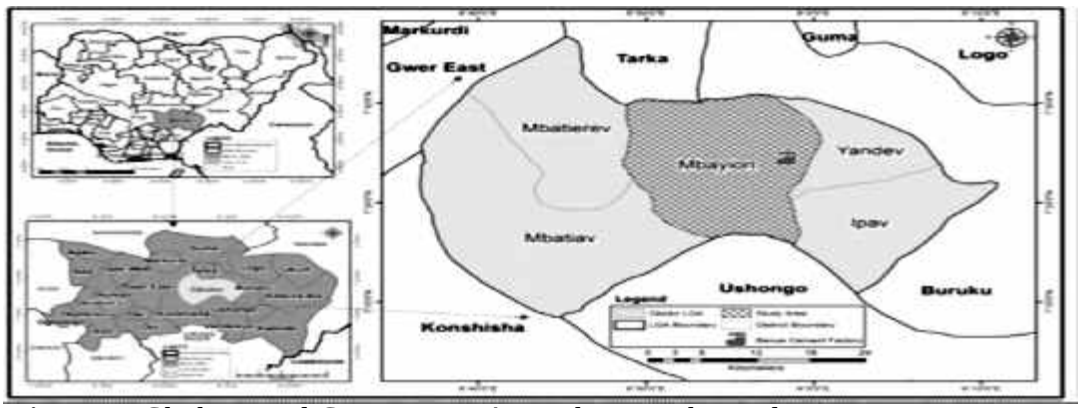

Figure 1: Gboko Local Government Area, showing the study area (Administrative Map of Gboko LGA, 2014).

Literature

This segment of the study is a review of related literature and it proceeds in the order of the objectives of the study

Remote and proximate causes of drought

The main cause of drought based on meteorological surveys has always been seasonal changes. In a study on the orbital eccentricity in the earth's seasonal climate, Broccoli and Chiang (2023), found and reported that the tilting of the axis of the earth at 23.45 degrees to the plane of its orbit around the sun is the primary cause of seasonal changes. On the other hand, this tilting of the earth's axis is due to the striking effect of "theia," an unusually huge object from space which struck the earth

shortly after formation throwing it off its perpendicular balance by 23.45 degrees. Thus, in its routine revolution around sun, when the North Pole tilts forward to the sun, the northern hemisphere faces summer and vice versa. Therefore, the tilt effect and revolution around the sun are basic factors in the occurrence of seasonal changes.

Beyond seasonal changes, climatic variability occurs mainly as a result of complications in other issues that also factor in the series of effects such as anthropogenic activities, which intensify the others. This position also harmonizes with that ofYila et al (2023) in their study on changes in rainfall and temperature and the impacts on crop production, in which they adopted regression analysis as basis for analyzing 400 questionnaires administered on farmers. The study found that variability in rainfall during periods of crops growth are due primarily to natural changes in the seasons, but such become intensified when human activities that are detrimental to natural cycles increase in their magnitudes of occurrence.

The foregoing is the exalt picture of the situation in the study area in which cement dust from the Dangote cement plant spills over into the air within the study locality and forms substantial ingredients in the built-up to global warning which retards the rain formation process and reduces frequency of rainfall. It is imperative to state here that the dust clouds of cement interrupts incoming solar radiation and the free flow of water vapour back to the atmosphere leading to significant shortfalls in rainfall amount and frequency, (Vanlin et al 2023 ; Alashanrani & Laiq, 2024).This explains why the Tse-kutcha stream demarcating the market square and the cement plant has long been a source of irrigation for assorted agricultural crops even during rainy seasons (Jayaram, 2024).

Impacts of drought on agricultural productivity

Drought effects on agricultural operations are global. In Berlin, Germany, Ring et al (2024) assessed the effect of drought on agro forestry using multi-proxy approach and reported that wilting of leaves is an early warning sign of water shortage in tree crops, which ultimately translates to low yield and total death of the tree stands, especially when such stands contain fruits. Similarly, Anjalic et al (2024) note that droughts exert direct impacts on agricultural ecosystems from a 20 years study using standardized precipitation Index (SPI), which focused on multiple agro-climate regions in the Ganga River Basin in India from 2001-2020.

In Nigeria, droughts have intensified their effects on agricultural productivity. In a study based in the north, Shiru et al (2022), reported that drought events in the country by virture of its geographical location coincide with the growing season for crops, which adversely affect their growth and maturity leading to poor yields. In the same vein, in an earlier study based in Yobe State, Hassan et al (2010) used focus group discussion as basis for interaction with officials of the Yobe State Ministry of Environment and reported that drought events translated to severe stunted growth in crops and accordingly led to poor yield.

Impact of drought events on livelihoods

Livelihood across the globe has been deadly hit by drought events. In Asia, Ahmad et al (2022) investigated four (4) villages in Panchagarh District of northern Bangladesh using focus group discussion and found that drought events over the years have aggravated poverty among the peasant farmers in the remote interior, where capital deficiency, low yields and inadequate agro-information had already been problems. As such, poverty levels heightened in the area. In the same vein, drought events have long been at the forefront of environmental disasters in the East African country of Kenya where over 80 percent of the landmass is located within arid and semi-arid regions. In a study by Mati et al (2023) on drought impacts on livelihoods in upper EwasoNgiro Basin, Kenya using structured questionnaire and key informant interview (KII), administered on 37 members of policy makers and 150 locals sourced from farmers and pastoralists in Meru, Laikipia and Isiolo Districts reported that drought events have been major agricultural and environmental problems, which have led to widespread water scarcity, shortage of pasture for livestock and large scale crop failure. In consequence, social ills like cattle theft, sand harvesting, charcoal burning and illegal logging emerged as alternative livelihood sources thereby triggering social conflicts among rural communities while exacerbating desertification. It is imperative to add here that, all above 3 districts are located within the leeward side of Mount Kenya where rainfall deficiency has always been a common phenomenon.

Across Nigeria and the study area, drought events have been widespread with increasing magnitudes and corresponding scales of socioeconomic effects, in which crop failures and livestock casualties have rendered farmers desperate due to unprecedented decline in income. This scenario is rampant in rural communities where agriculture is the bedrock of livelihoods among the masses. It is worthy to state here that the intensification of drought events over space and time in Nigeria and Benue State is rooted in rapid population growth, in which the country's current estimate hit a benchmark of over 210 million people as at June 2024 (United Nations, 2024) with rising demand for food supply and other social services. This development has led to indiscriminate proliferation of industrial activities, which have worsened the trend of natural catastrophes including drought events, (Olanunju, 2015).

Theory

This study adopts the philosophical doctrine of environmental possibilism founded by Lucien Febvre in 1932 with the caption “A geographical introduction to History” the basic tenent of the doctrine holds that, though the environment has placed restriction to cultural patterns, through the routine process of man-earth interaction under innovations in science and technology, possibilities have been opened up for breakthroughs. Thus,the natural environment provides options which multiply as knowledge of a cultural group expands. This theory is adopted for explanations in this study because of latter's focus on drought, which is one of the

many natural restrictions on human activities, but for which man's ingenuity is gradually overcoming it with continuous advancements in the scientific and technological realms.

Methods

This study generated primary data through the administration of 200 structured questionnaire administered on farmers in the locality using multi-stage sampling technique. Tse-Kutcha community is made up of three units comprising the factory site, market square and residential settlement. These constitute the basic clusters which were further subdivided into smaller units within which purposive random sampling was employed in the administration of the questionnaire. Also, key informant interviews and field survey were conducted. The study adopted the simple

Results

Data on demographic and socioeconomic profile of respondents

Table 1: Demographic profile and socioeconomic statues of respondents

Variables	Frequency	Percentages
Gender –male	135	67.5
Female	65	32.5
Age 20-30 years	33	16.5
31-40 years	53	26.5
41-50 years	57	28.5
51-60 years	34	17
Above 60	23	11
Marital status		
Married	138	69
Single	22	11
Separated	40	20
Education		
No formal education	88	44
Primary levels	67	33
Secondary level	26	13
Tertiary level	19	9.5
Type of crop produced		
Grains , tubers, nuts	98	58.33
Cereals & market gardening	60	29.16
Agroforestry	42	12.5
Income		
Income per annum before cement production	158	79
N250,000-N 355,000		

Table 1indicates that 67.5 percent of the sampled respondents were of the male gender while 32.5 were female. The table further indicates that 16.5 percent of them fall within the age bracket of 20-30 years while 26.5were within the 31 -40 years. The table againshows that 28.6 percent of sampled respondents were within 41-50 years. Similarly, the table further indicates that17 and 11 percentages were respectively within the age brackets of 51-60 and above 60 years. On marital status, the table indicates that69 percent of the respondents were married, 11 percent single and 20 percent separated. On educational attainment, the table indicates that 44 percent of the respondents had no formal education while 33 percent acquired primary school certificate and 13 percent schooled up to secondary school level with the remaining 9.5 attaining tertiary education. Table 1.1 finally indicates that 79 percent of the farmers in the study area had their annual farm income ranging from N250, 000-N300, 000 before the establishment and subsequent commencement of production by the cement factory while 70 percent indicated that their average income has significantly dropped to the range of N100,000- N200,000 per annum from their farm operations. The table therefore manifests a significant drop in the income of the farmers within the study area in the wake of cement production in their locality.

Test of hypotheses

This segment s is a test of hypotheses and if follows in line with the order of objectives

Hypothesis 1 *"There is no significant link between seasonal changes and drought events in Tse-kutcha community.*

Table 2: Test of relation ship between seasonal changes and drought events in the study area.

Variables	N.	Pearson correlating	Sig.(2tailed)
Seasonal changes Drought events	120	0.422	0.000

Table 2 indicates a positive correlation coefficient, which is significant at 0.422. This test implies that there is though a positive link between the variables of seasonal changes and droughts events, it however points to the homogeneity of other factors behind the occurrence of droughts in Tse-Kutcha community which are possible areas of another study. This is because, the positive coefficient does not manifest a strong degree of association despite the fact that seasonal changes and drought events move in the same direction within the community. Thus, the hypothesis which states that there is not significant link between seasonal changes and drought events is hereby rejected. This finding harmonizes with Table 2.3 which analyses the climatic variability involving increasing magnitudes of drought which is due mainly to climate change impacts from 2015 to date caused by large quantities of cement dust emissions from industrial operations at the Dangote Cement Plant.

Hypothesis 2 " *There is no significant relationship between drought events and low agricultural productivity in the study area".*

Table 3: Test of relationship between drought events and agricultural productivity

Variables	N.	Pearson correlating	Sig. (2 tailed)
Drought events	120	0.561	0.000
Agricultural productivity			

Table 3 indicates a significant correlation coefficient of 0.561 which is both positive and strong. This implies drought events and their impacts on agriculturalproductivity move together in the same direction at all times. Thus, the more the severity of drought events, the more devastating its impacts on agricultural productivity would be. Therefore null hypothesis which denies the existence of significant impacts of drought events on agricultural productivity is hereby rejected and in favour of an alternative one stating that drought events exerts significant impact on agricultural productivity in the study area.

To further strengthen this test result, a Time-Series Analysis (TSA) of drought events in the study area and their impact on agricultural covering over 30 years from 1990-2024 is presented in table 4.1, which also shows that over the years covered by this study, drought events have actually adversely impacted on agricultural productivity.

Drought events over time	Severity	Months(s)	Observed impacts on crops
1991-1995	2months	August	Stunted growth, poor yield
1996-2000	1 month	July, August	✓
2001-2005	3 weeks	July	Wilting of leaves
2006-2010	2 weeks	July	✓
2011-2015	1 month	July, August	Mass failure of grain crops
2016-2020	2 months	Jul, Aug, Oct.	Stunted growth, poor harvest
2021- date	2 months	May, Jul	Death of cereals, poor yield.

Impacts on crops.

Table 4 shows drought events in the study locality over time from 1990-2024 and its severity, months of occurrence and impacts on crops performance. The table indicates significant fluctuations in the trend of drought events between 1991-2015 with an initial severity of events summing up to 2 months between 1991-1995 in August which toward to 1 month from 1996 -2000 occurring within July and August. The table similarly indicates a further drop in drought events in 2001-2010 from 3-2 weeks occurring mainly in July.On the other hand,the table also indicates that between 2011 through 2015 till date the severity of drought events have intensified respectively from magnitudes of 1 month through 2 and 3 months according with series of adverse impacts on crops ranging from wilting of leaves, stunted growth and complete death especially within grain crops, all of which ultimately translate to poor yield that render farmers desperate.

Hypothesis 3 *"Drought events in Tse-kutcha community have nosignificant links with poverty levels*

Table 5: Test of links between drought events and poverty levels in Tse-kutcha community

Variables	N.	Pearson correlating	Sig. (2 tailed)
Drought events Poverty levels	120	0.621	0.000

Table 5 indicates a positive correlation coefficient of 0.621, which is significant implying that drought events in the study area move together with poverty levels in the same direction at all times. Thus, an increase in drought events in the area leads to corresponding increases in the magnitude of poverty amongfarmers especially as they depend largely on agricultural activities for their livelihoods. Therefore the null hypothesis which denies the existence of links between drought and poverty levels in Tse-kutcha is hereby rejected in favour of an alternative one that the two variables of drought and poverty levels have significant links.

Discussing of findings

This study dwells on drought events and their adverse effects on agriculture and livelihood in Tse-kutcha community of Gboko LGA of Benue State. The study was conducted objectively to trace drought from its origin to its adverse impact on agriculture and livelihood among the farmers in the study area. The study found that seasonal changes on the earth's surface are the primary causes of drought events in the study area. This finding aligns with earlier finding by Asaasuen et al, (2024), who studied seasonal changes in relation to their impacts on agrarian practices in Benue North Central Geographical District and found that the phenomenon of seasonal changes are the primary causes of drought events. Similarly, the finding harmonizes with the finding by Gaiser et al (2024), who studied agronomic and plant physiological characteristics of Cocksfoot (Dactylisglomerate), and reported that drought events are directly linked to climate change which in turn alters precipitation pattern inducing variability. In the same vein, Oko et al (2023), noted in their study on human activities relative to environmental degradation which intensify the magnitude of drought events as in the case of the Dangote Cement Plant which spills dust clouds in air within the study locality causing phenomenal variations in seasonal rainfall amount and distribution alongside the effects of orbital eccentricity in the earth's seasonal climate due to its routine revolution around the sun in a tilt position, (Broccoli & Chiang, 2023; Jayaram, 2024).

This study again found that drought events have adversely affected agricultural productivity in the study area through stunted growth of crops, wilting and ultimately poor yield. This finding again aligns with the finding of Anjali et al, (2024) in their study on meteorological drought in different agro-climate zones with the Ganga River Basin in India which in the world's most populous river basin. Their study reported that drought events impact directly on agricultural ecosystem resulting in large-scale crop failure.

Furthermore, this study also found that drought events in the study area have aggravated poverty levels in the already poverty-stricken rural locality. This finding is harmonious with earlier findings by Olufemi et al. (2022), in which they studied the impact of drought on cereal crops yield in northern Nigeria using drought indices in the Kaduna River Basin and reported that the positive correlation between droughts and crop yield has corresponding adverse impact on rural livelihood involving poor harvest and poor incomes as the locals depend substantially on agricultural productivity for a living. This finding also collaborates with earlier finding by Vivian et al (2012), in their study on climate change and poverty in Nigeria in which they found that global climate variability results in extreme events of weather such as drought of flooding all of which have destructive effects on crops and poverty implications on the masses.

Conclusion

This study investigated drought events against the background of their proximate and remote causes as well as impacts on agricultural productivity relative to livelihoods of Tse-kutcha community in Gboko LGA of Benue State. The paper found that droughts are natural and occur primarily as a result of climate variability and get intensified by land use types that cause alterations in rainfall amount and its distribution, such as typified by industrial operations at Dangote Cement factory and indiscriminate deforestation. The study accordingly found that drought has adversely affected agricultural productivity, which is the live-wire of livelihood in the study area and as such intensified poverty among the masses which are predominantly farmers. All agricultural stakeholders must therefore act decisively through collaborative efforts aimed at effective management of drought in the study area to revive the agricultural sector for a possible boost in productivity and a rise in food supply, domestic income and general improvement in the livelihood of the community members.

Recommendations

In order to effectively manage the drought events to minimize its negative impacts on agriculture in the study, area, the following measures are recommended.

i. Forestation programmes: for every tree cut down for whatever reason in the locality, at least four should be planted. This measure is to boost the rain-formation process through increased transpiration against drought events.
ii. Irrigation scheme should be aggressively put in place under agricultural mechanization. This will be an improvement upon existing traditional and localized irrigation practices limited along water courses.
iii. Establishment of agro-based industries in the study area to feed on crops produced by farmers. This effective integration of agriculture and industry will boost farmer's income and place them on vantage positions to expand on their agricultural scope-given that poverty levels have dropped.

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