IMPACT OF CLIMATE CHANGE ON FOOD PRODUCTION IN NIGERIA

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ABSTRACT: Food remains the most critical need for human survival. This is because of its importance in supporting livelihoods and healthy conditions of individuals in the society. This study therefore examined the impact of climate change on food production in Nigeria for the period, 1990-2020.Time series data on agricultural output was used as a proxy for food production which was the dependent variable, while the independent variables were annual temperature and annual rainfall. The data used for the study was collected from Central Bank of Nigeria Statistical Bulletin. OLS technique was employed for data analysis. The result of the analysis showed that annual temperature and rainfall had significant impact on food production in Nigeria. The studyalso discovered that increase in the amount of annual temperature led to fall in food productionwhile increase in the amount of annual rainfall led to increase in food production in Nigeria.

Based on the findings, the study recommended that government should set some agencies that should be responsible for the measuring of the degree of hotness and coldness for food production and also to determine the amount of annual temperature which could be used to improve food production in Nigeria. Government should also encourage sensitization of farmerson the importance of weather forecast in order to predict the amount of annual rainfall that could yield bumper harvest that could increase food production in Nigeria.

Key words: climate change, food production, temperature and rainfall.

INTRODUCTION

Climate change refers to long-run shifts in temperature and weather patterns.. This shifts according to Nwafor (2007) may be natural such as through variations in the solar cycle. Thus,in all economic sectors, agriculture is the most climates responsive. This is because; decline in production of agricultural products is attributed to some intertwining factors including climate change. Indisputably, Climate change is a global phenomenon, the impact however, is spatially heterogeneous and the risk is generally believed to belee in developed countries and more in developing countries like Nigeria.(Obeta 2014).

Climate change can also weaken the progress made in poverty reduction and unfavorably affectfood security and economic growth in vulnerable rural areas (Jonathan &Emmanuel 2017).

Increase exposure to high temperatures, drought, and shifting seasonal patterns, increases incidence of diseases and pests and soil erosion which are most risky in agricultural productionsince it can damage agricultural productivity at any time (Onuoha 2009). At the same time, climate vulnerability has exacerbated by sub-optimal policies, the deficient management of natural resources and associated infrastructure, and poor adaptive capacities. Soil erosion is a huge problem: 60 percent of the territory is affected; while 30 percent of agricultural land has annual soil loss rates of around 20 to 70 tons hackler (Intergovernmental Panel on Climate Change 2017)

Since agricultural sector uses water for it production, water resources is very important to maintain its growing strength. However, intensive rain fall that causes flood and droughts are regarded as abnormal situation in terms of agricultural production. All these are caused as a result of Climate change. Climate change according to Chikeie et.al (2015) therefore influences a range of biophysical factors, including plants and animals, water, biodiversity and nutrient cycles, as well as the ways in which these are managed for agricultural practices and land use forfood production.. However, Ministry of Agriculture, Food and Consumer Protection and its agencies at regional and local levels are expected to provide information and assistance to farmers as how to coop with climate change effects and risks and opportunities any time suchevents occur (Intergovernmental Panel on Climate Change, 2017).

It is indispensable to mainstream and integrate climate change issues into policy and investmentdecisions, since changes in agricultural patterns and performance will affect food supply at localand global levels. For instance, low-income countries may depend on their own production to meet demand since they have limited financial capacity to engage in trading to source for agricultural products they cannot produce. In this case, it may not be possible to offset reductions in local supply without increasing reliance on food aid (Intergovernmental Panel on Climate Change, 2017).

Climate change is the biggest environmental problem of our time that is threatening the existenceof man and the environment. It is a major threat to agricultural system and food production in many countries in sub-Saharan Africa (Nigeria inclusive). Climate change according to Josephine&Amaeci (2014) is a threat to food production because of its impacts on the agricultural system. This is because Food productions in most Sub-Saharan African Countries like Nigeria are dependent on weather. Climate change has a direct impact on the productivity ofphysical production factors such as soils moisture and soil fertility and this affects farming outputs which in turn impacts negatively on food production (Intergovernmental Panel on Climate Change (IPCC) 2017). Climate change is marked with increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance and these have implications forfuture food availability (Food and Agricultural Organization, 2007). Climate variability is rapidly becoming the most important environmental challenge facing mankind and food production used by man. Relevant literature shows that there is variability in Nigerian rainfall and temperature (Deressa 2006), however; unsteady temperature and rainfall pattern could be due to effects of climatic change which often influence food production in Nigeria.

Over the past 100 years, the earths average surface temperature has risen by 0.75ºCelsius (Anyadike, 2009). This rise in the temperature of the earth has brought some changes in the global weather pattern by affecting natural resources and balance of nature, upsetting seasonal cycles, disrupting the ecosystem and water supply or rainfall, causing sea levels to rise, affectingfood production.

Food production in Nigeria over the years are determined by the rate of stability and sustainability of sufficient rainfall, but to no avail climate change due to high degree of temperature and low amount of rainfall results to decline in the level of food production in the agricultural sector in Nigeria. Hence, this serves as the driving force of this paper which is theimpact of climate change on food production in Nigeria.

RESEARCH QUESTIONS

1. What is the impact of the amount of annual temperature on food production in Nigeria?
2. What is the impact of the amount of annual rainfall on food production in Nigeria?

RESEARCH OBJECTIVES

The main objective of the study is to examine the impact of climate change on food productionin Nigeria. The specific objectives of the study are:

3. To ascertain the impact of the amount of annual temperature on food production inNigeria.
4. To determine the impact of the amount of annual rainfall on food production in Nigeria.

RESEARCH HYPOTHESES

5. **H_{o1}:** The amount of annual temperature has no significant impact on food production inNigeria.
6. **H_{o2}:** The amount of annual rainfall has no significant impact on food production inNigeria.

LITERATURE REVIEW

Chikezie et.al (2015) studied the effect of climate change on selected food crop production in Southeast, Nigeria. The data were sourced from National Root Crops Research Institute, Umudike, National Bureau of Statistics and the Central Bank of Nigeria (CBN) Bulletin. Data oncrop yield and climate variables from 1984 to 2014 were collected. Descriptive Statistics, Co- integration analysis and Error Correction Model were adopted. The finding reveals unsteady climatic pattern with peak points across the period under review. The Augmented Dickey-Fuller test for unit root reveals that yam; maize and cassava outputs were non stationary but became stationary after the differencing. All climate variables showed stationary at first level. Result shows the existence of one co-integrating vector in the three models. The results shows that the coefficients of ECM(-1) which indicates speed of adjustment of the crop outputs to the equilibrium when a disturbance has occurred are -0.365 ($p<0.01$), -0.211 ($p<0.05$) and -0.599 ($p<0.001$) for yam, maize and cassava output models respectively. The coefficients of multiple determination (R2) for yam, maize and cassava were 0.611, 0.440 and 0.2669 respectively. In yam model, the coefficients show that all variables except lagged yam output and temperature have positive relationship with the yam output; the coefficients of lagged maize output, rain days and temperature are negative while rainfall volume, humidity and sunshine are positive in maizemodel and in cassava model, coefficients of rainfall volume, rain days, sunshine and lagged cassava output are positive while temperature and humidity are negative. Results show that climate change impacted yam and maize output.

Josephine & Amaechi (2014) observed that Climate Change is caused by the release of billions of tons of carbon dioxide (CO2) and other heat trapping gases known as Green House Gases intothe atmosphere. This results in depletion of ozone layer leading to increase in the earths surface temperature due to direct heating of earths surface by the sun. This paper discusses the impact of climate change on food security. Climate change impacts on food security in a number of ways. Climate change is impacting on oceans, seas, lakes and rivers and on the animals and plants that are found and/or cultured in them. In Nigeria, thousands of people and their families whose livelihood depend on fishing and aquaculture are affected by climate change as fish become less abundant because many migrate to other areas due to extreme weather events, droughts and the warming of waters. Furthermore, climate change results in low agricultural productivity increasein agricultural pests and diseases, hunger and starvation and in extreme cases death. Various adaptation strategies for coping with the effects of climate change on food security are discussed among which are: use of more efficient crop varieties, more efficient irrigation and watershed management, efficient use of climate data and forecasts, through early warning systems, changing planting dates, and introducing irrigation into current rain fed systems.

Clemens, et.al. (2011) provides a model-based assessment of local and global climate change impacts for the case of Yemen, focusing on agricultural production, household incomes and foodsecurity. Global climate change is mainly transmitted through rising world food prices. Our simulation results suggest that climate change induced price increases for food will raise agricultural GDP while decreasing real household incomes and food security. Rural nonfarm households are hit hardest as they tend to be net food consumers with high food budget shares, but farm households also experience real income losses given that many of them are net buyers of food. The impacts of local climate change are less clear given the ambiguous predictions of global climate models (GCMs) with respect to future rainfall patterns in Yemen. Local climate change impacts manifest itself in long term yield changes, which differ between two alternative climate scenarios considered. Under the MIR scenario, agricultural GDP is somewhat higher than with perfect mitigation and rural incomes rise due to higher yields and lower prices for sorghum and millet. Under the CSI scenario, positive and negative yield changes cancel each other out. As a result, agricultural GDP and household incomes hardly change compared to perfect mitigation. Mano & Nhemachena (2006) finds that when farm revenue in Zimbabwe is regressed against various climates, soil, hydrological and socio-economic variables in a Ricardian framework, thenet effect of climate change on agriculture in Zimbabwe is quite significant. Sensitivity analysisof alternative climatic scenarios that is, 2.50C and 50C increases in temperature resulted to decrease in net farm revenues of approximately US$0.3 and US$0.3 billions respectively. In Kenya the results were not much different.

Mariara & Karanja (2006) find that climate change also affects agricultural productivity using a seasonal Ricardian analysis. The results showed that increased winter temperatures are associated with higher crop revenue, but increased summer temperatures have a negative impact.Increased precipitation is positively correlated with net crop yield. The result further suggests that there is a non-linear relationship between temperature and revenue on the one hand and between precipitation and revenue on the other. For Cameroon, Molua & Lambi, (2006) finds that a 3.5 per cent increase in temperature associated with a 4.5 per cent increase in precipitation in the absence of irrigation facilities would be detrimental to Cameroons agriculture, leading to a loss of almost 46.7 per cent in output value. This would negatively affect the economy as a whole, since close to 30 per cent ofCameroons national GDP comes from agriculture. In Egypt, empirical results from four variantsof the standard Ricardian model showed that a rise in temperature would have negative effects on farm net revenue in Egypt. In the second, third, and fourth models, adding the linear term of hydrology, the linear and quadratic terms of hydrology, and the hydrology term and heavy machinery to the analysis improved the adaptability of farm net revenue to high temperature.

Marginal analysis indicated that the harmful effect of temperature was reduced by adding the hydrology term and heavy machinery to the analysis. Also, estimates from two climate changescenarios showed that high temperatures will constrain agricultural production in Egypt (Sene.et al., 2006).

Other studies in this study include (Sene et al. 2006), who assessed the impacts of CC on the revenues and adaptation of farmers in Senegal and finds that farmers have several ways of adapting to climatic constraints in Senegal. These include amongst others diversifying crops, choosing crops with a short growing cycle, weeding early in the north and late in the south, andpraying etc.

For Seo & Mendelsohn, (2006), using two variants of the standard Ricardian model, results suggest that the livestock net revenues of large farms in Africa fall as temperatures rise but thatsmall farms are not temperature sensitive (Model 1), while in the second model the authors findthat higher temperatures reduce both the size of the stock and the net revenue per value of stockfor large farms. In Kurukulasuriya & Mendelsohn, (2006), assessing the impact of climate change on African cropland from 11 countries involving over 9000 farmers, the authors find that net farm revenuesfall as precipitation falls or as temperatures warm across all the surveyed farms.

In Burkina Faso, Ouedraogo et al. (2006) find that if temperature increases by 1°C, farm revenuewill fall by 19.9 US$/ha, while if precipitation increases by 1 mm/month, net revenue increases by 2.7 US$/h using a standard Ricardian model. The elasticity shows that agriculture is very sensitive to precipitation in Burkina Faso.

In Ethiopia, the results were not much different, Deressa (2006), also finds that net farm revenuewould fall in summer and winter if temperature increases whereas increase in precipitation during spring will increase net farm revenue. Simulation of uniform scenarios that is increasing temperature by 2.50C and 50C; and decreasing precipitation by 7 per cent and 14 per cent suggest that increasing temperature and decreasing precipitation are both damaging to Ethiopian agriculture. However, the author concludes that decreasing precipitation appeared to be more damaging than increasing temperature.

Also in Zambia, Jain (2006), finds that an increase in the November—December mean temperature and a decrease in the January—February mean rainfall have negative impacts on netfarm revenue in Zambia, whereas an increase in the January—February mean temperature and mean annual runoff has a positive impact.

Jonathan &Emmanuel (2017) examined the impact of climate change the overall growth of the Nigerian economy for the period of 1981-2014 using ordinary least square (OLS) estimation for data analysis. Changes in annual rainfall, carbon emission and forest depletion were used to capture climate change , while changes in government expenditure, domestic private investment and exchange rate were used as control variables. The results of the analysis revealed that both inlong-run and in short-run, carbon emission affect growth adversely. In addition, forest depletion impact negatively on growth in the short-run.

Davis & Sadiq, (2010) carried out a research on the effect of climate change on cocoa yield. Thestudy revealed that there is a weak inverse correlation in rainfall (0.0073), meaning that increasein rainfall result in decrease in yield. While positive weak correlation (0.2196) was established for temperature on yield. The study also revealed a strong positive correlation between yields/pods and temperature. They concluded that a combination of optimal temperature (29°c) and minimal rainfall (900 to 1000mm) will give a better yield and improve production and the economy of both Cocoa farmers and Nigeria at large. Lawal & Emaku, (2007) during their own study on the effect of climate change on cocoa production in Nigeria found out that there is a weak negative correlation for both rainfall and relative humidity on cocoa yield over the years while they established positive correlation for temperature on yield. On the same study, they found out that the incidence of black pod diseasehas a positive correlation with temperature and relative humidity but a negative correlation withrainfall. Just like Davis and Sadiq, they concluded that a better yield and reduced incidence of black pod disease on cocoa in Nigeria require an optimal temperature of 29°c and minimal rainfall of 1,125mm and relative humidity of about 74%. In line with the above findings, Ajayi et al, (2010) revealed that rainfall has a constraining abilityon cocoa yield in the core cocoa production areas of Ondo state, Nigeria. They found that Cocoayield was also shown to be the inverse of annual rainfall level as cocoa yield increased in the early and latter months of the year when the rains are yet to fully come, and suffered in the mid year at the heart of rain season. Contrary to the negative correlation between rainfall and cocoa yield, Ouedraogo et al, (2006) found that high rainfall and favorable temperature promote flowering intensity of cacao in Nigeria. This study differ from the above researches because it used times series data which spans from 1990-2020 for the analysis and employed long run staticmodel to examine the impact of climate change proxy by annual temperature and annual rainfall on food production proxy by agricultural output in Nigeria.

METHODOLOGY

This study made use of descriptive and analytical tools. The descriptive tool was used to analyzethe data on agricultural output, temperature and rainfall. The analytical tool used consists of long run static model.

MODEL SPECIFICATION

The functional form of the long run static model is represented in Equation [1]

[1] AGOUT=f (TEMP, RAINF)

The model in its mathematical form is specified as showed in Equation [2]

[2] AGOUT= $\beta_o + \beta_1$TEMP + β_2RAINF

The stochastic or econometric form of the model is represented in Equation [3]

[3] AGOUT= $\beta_0 + \beta_1$TEMP + β_2RAINF +µWhere;

AGOUT represents agricultural output as proxy for food production

TEMP represents amount of annual temperature as proxy for climate changeRAINF represents amount of annual rainfall as proxy for climate change

B_o is intercept of the long run static model

β_1 is the long run static model coefficient of the amount of annual temperatureβ_2 is the long run static model coefficient of the amount annual rainfall

µ is error or stochastic variable.

DATA FOR THE STUDY

The data used for this study was predominantly secondary data. The study used times series datawhich spans from 1990-2020 for the analysis. The major source of data was from the Central Bank of Nigeria (CBN) Statistical Bulletin.

PRESENTATION AND DISCUSSION OF RESULTS

From the long run static model results in table 1, agricultural output (AGOUT) was the dependent variable while annual temperature (TEMP) and annual rainfall (RAINF) were theindependent variables. The following results below were obtained.

Table 1 ***Long Run Static Model Result***

Variables	Coefficients	Standard error	t-statistics	Probability
C	133.6656	12.67854	10.54267	0.0009
TEMP	-9.366420	2.175085	4.306231	0.0127
RAINF	11.356789	3.456648	3.285491	0.0214
R^2 =0.946963		F-Statistics)=9.325814		
Adjusted R^2=0.830801		Prob(F-Statistic)= 0.000067		

D.W Statistic=1.516962

Source: Authors Computation using E-Views 9.5 Version, 2017ANALYSIS OF LONG STATIC MODEL RESULTS

The intercept of the long run static model on the table 1 above is 133.6656. Other things beingequal, it represents the value of agricultural output (AGOUT) which is the proxy for food production if annual temperature is zero holding annual rainfall constant. The regression coefficient of annual temperature (TEMP) is -9.366420.It shows that a unit increase in annual temperature will bring about 9.366420 unit decreases in agricultural output (AGOUT) in Nigeria. It is negative showing an inverse relationship between annual temperature(TEMP) and agricultural output (AGOUT) in Nigeria. Hence, an increased in annual temperature would lead to fall in food production in Nigeria.

The regression coefficient of annual rainfall (RAINF) is 11.356789. It shows that a unit increasein annual rainfall (RAINF) will bring about 11.356789 unit increases in agricultural output (AGOUT) in Nigeria. It is positive showing a direct relationship between annual rainfall (RAINF) and annual rainfall in Nigeria. Hence, an increased in annual rainfall would lead to increase in food production in Nigeria.

Table 2 ***Economic a priori Criteria***

Variables	Parameter	Expected sign	Decision
TEMP	B_1	-	Conformed
RAINF	B2	+	Conformed

Source: Authors computation, 2017

The above table shows the expected sign of the independent variables used in this research model, and based on economic experience, we expected the independent variables (annual temperature and annual rainfall) to have negative and positive relationship respectively with thedependent variable; i.e. agricultural output and they all conformed. Hence, the parameters

(B_1, and B_2) of the independent variables are statistically significant.

STANDARD ERROR TEST

This can be analyzed using the table below

Table 3 ***Summary of the Standard Error Test***

Variables	Parameters	andarderror	½(coefficient)	Decision	Conclusion
TEMP	B_1	2.175085	4.68321	Reject H_0	Significant
RAINF	B_2	3.456648	5.67839	Reject H_0	Significant

Source: Authors computation using E-views 9.5 version, 2017.

The standard error test on table 3 shows that the coefficients of the independent variables, annualtemperature and annual rainfall are statistically significant because the standard errors of their parameter estimates are less than half of their coefficients.

PROBABILITY TEST

Table 4 ***Summary of the Probability Test***

Variables	Parameters	P-values	Level of significance	Decision	Conclusion
TEMP	B_1	0.0127	0.05	Reject H_0	Significant
RAINF	B_2	0.0214	0.05	Reject H_0	Significant

Source: Authors Computation using E-Views 9.5 version, 2017.Decision Rule

If p-value>0.05, accept the Ho and reject the H_1 and conclude that the estimated parameter is notstatistically significant. On the contrary, if the p-value<0.05, reject the H_0 and accept the H_1 and conclude that the estimated parameter is statistically significant. Table 4 shows that the probability values of temperature and rainfall are less than 0.05. Hence, temperature and rainfallhad significant impact on food production in Nigeria within the study period.

COEFFICIENT OF DETERMINATION

This shows the proportion of the total variation in the dependent variable which is caused by the independent variable, in the estimated long run static model, the R^2 of 0.946963 shows that about94% of the total variation in agricultural output is caused by the independent variables i.e. annualtemperature and annual rainfall. While the remaining 6% unexplained by these variables (amountof temperature and rainfall) but caused by other factors which are not included in the model are captured within the stochastic or error term. Since the R^2 is close to one, we can conclude that the model is a good fit.

F-STATISTIC (ANALYSIS OF VARIANCE TEST)

H_o: $B_1=B_2=0$ (the overall model is not statistically significant)H_1: $B_1 \neq B_2 \neq 0$ (the overall model is statistically significant) Level of significance=5%

Degrees of freedom = (V_1,V_2) Where

V_1=K-1 and V_2=N-K V_1= 3-1=2, V_2=28

F0.05 (2, 28) = 2.76

Decision Rule: since the F-value or F-calculated (9.325814)> the F-tabulated (2.76), we acceptthe alternative hypothesis H_1: $B_1 \neq B_2 \neq 0$ and reject the null hypothesis H_o: $B_1=B_2=0$

Conclusion: since the alternative hypothesis is accepted, we can deduce from our findings thatthe parameter estimates of the model or the overall model is statistically significant at 5% levelof significance.

DURBIN WATSON TEST FOR AUTOCORRELATION

Decision Rule:

If D.W statistic is less than 2, we conclude that there is positive autocorrelation, if D.W Statisticis greater than 2, we conclude that there is a negative autocorrelation and lastly, if D.W is approximately equal to 2, we conclude that there is no autocorrelation.

Conclusion:

Since the D.W statistic = 1.516962 which is approximately equal to 2 **,** we therefore concludethat there is no autocorrelation in the model

Table 5

Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.465305	Prob. F(2, 11)	0.6398
Obs*R-squared	2.418057	Prob. Chi-Square(2)	0.2985

Source: Authors Computation using Eviews version 9.5, 2018.

From the above Breusch-Godfrey serial correlation LM test, the result revealed that there is no evidence of serial correlations in the model since the probability value of the F-statistic is greaterthan 0.05. Hence, the null hypothesis of no serial correlation in the model is accepted while the alternative hypothesis of serial correlation is rejected.

Table 6

Heteroskedasticity Test: Breusch-Pagan-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.947554	Prob. F(17 ,13)	0.5498
Obs*R-squared	17.15521	Prob. Chi-Square(17)	0.4439
Scaled explained SS	9.238107	Prob. Chi-Square(17)	0.9325

Source: Authors Computation using Eviews version 9.

From the above Breusch-Godfrey heteroskedasticity test, the result revealed that there is no evidence of heteroskedasticity in the model since the probability value of the F-statistic is greater than 0.05. Hence, the null hypothesis of no heteroskedasticity in the model is accepted while the alternative hypothesis of heteroskedasticity is rejected.

Table 7 ***Multicollinearity Test: using Variance Inflation Factor (VIF)***

Variance Inflation Factors

Date: 02/02/17 Time: 15:24

Sample: 1986 2017

Included observations: 31

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	16658184	17.44471	6.455363
TEMP	3430.032	14.71571	1.111864
RAINF	280.5909	12.67902	1.111864

Source: Authors Computation using Eviews version 9.5

On the table above, all of the centered Variance Inflation Factor (VIF) is less than 10, suggesting that a low degree of multicollinearity is present. On the other hand, the uncentered Variance Inflation Factor (VIF) showed that the variables have values greater than 10, indicating severe multicollinearity.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study examined the impact of climate change on food production in Nigeria. The study examined the impact of climate change on food production in Nigeria. The study employed the long run static model to examine the impact of climate change proxy by annual temperature andannual rainfall on food production proxy by agricultural output in Nigeria. Agricultural output was used as a proxy for food production which is the dependent variable while annual temperature and annual rainfall were the independent variables.

The long run static model result showed that annual temperature and rainfall had significant impact on agricultural output in Nigeria. Hence, climate change had significant impact on foodproduction in Nigeria.

Recommendations

Based on the findings, this study therefore recommends the following:

7. Government should set some agencies that will be responsible for the measuring of thedegree of hotness and coldness and their effects on food production, such that they willdetermine the amount of annual temperature that could improve food production in Nigeria. These agencies can help and educate the farmers on how to manage climate change in the production of agricultural products in Nigeria.
8. Government should encourage and sensitize farmers on the importance of weather forecast in order to predict the amount of annual rainfall to yield bumper harvest towardsincreasing food production in Nigeria.
9. Finally, the agencies of the government should also educate the farmers on other factorsof climate change that affect food production other than annual temperature and rainfallso as to increase food production in Nigeria.

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