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## Climatic variation and food security implications in sub-Saharan Africa

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**Abstract:** The changing temperature has been identified as a major factor militating against food and nutrition security in sub-Saharan Africa (SSA). The food production index and undernourished population growth index are used as a proxy for food and nutritional security. The study controlled climatic change responses on some agricultural characteristics and factors like the share of arable land, irrigation, population, and labor. The dynamic panel of the generalized method of moments (GMM) was applied to the global water balance empirical framework. The scope of the study is sub-

Sahara Africa, drawn from 29 countries from 2000 to 2016. Findings from the study reveal that the short-run effect of temperature degrees increase poses at least -3.1% negative and significant impact on the food production while the long-run elasticity hits -7.5%. The controlled effect on arable land shows a positive impact on food production to the tune of 3.9%. Contrarily, arable land expansion reduces the undernourished population by -8.55%. Population increase, on the other hand, increases the undernourished population in the region to the tune of 11.95%. The study recommends the reservation of more arable land for agricultural practice. At the same time, the population control policy is encouraged to jointly negate the undesired effects of temperature on food and nutritional security timely now that food and nutritional security is the panacea for a standard of living.

**Keywords** – Agricultural, Climate, Food security, Sub-Saharan Africa, Temperature change

### 1. INTRODUCTION

Agricultural performance in the world has been tied to climatic factors and patterns that vary across zones and regions. However, the roles of climatic determinants and the variance in ecological zones pose a fundamental challenge to food-nutrition security in sub-Saharan Africa (SSA) (Al, Orking & Clima, 2008). Despite the efforts in the past to promote agriculture, almost 800 million people are chronically undernourished, from which 161 million are children under five years with stunted growth; furthermore, the most vulnerable set from the group cannot still access the basic major macronutrients (carbohydrate, fat, and protein), (Gitz, Meybeck, Lipper, Young & Braatz, 2016). Hence, the varying climatic indicators in the region, as shown in Figure 1 below, further question the thrust for a steady and stable food production leading to food security. Food security is a multidimensional yet complex phenomenon, Bellouni (2014) expanded the scope for measuring food security to include food production index,

mortality rate, and life expectancy at birth total while rainfall and annual temperature were the indicators for climate change.

Climate change has constantly threatened food and nutrition security in sub-Saharan Africa despite several reforms of the national agricultural policy accompanying some external interventions. For instance, Baietti, Shlyakhtenko, La Rocca and Patel (2012) respectively states that the regular rainfall in 2011 caused a sharp decline in the year's cereal and pasture production in Africa. Likewise, in Central Africa, Cameroon's mixed weather conditions and the Central Africa Republic in early 2012 posed negative impacts on the early crop. Also, North Africa witnessed a sharp fall in cereal production in Morocco due to erratic and insufficient rains during late 2011 and 2012. These climatic factors amount to pressure on the food price index and subsequently heighten food insecurity in the region. Africa is therefore confirmed to be ranked as one of the regions to be the worst hit by continued climate change with greater impacts on the agricultural sectors based on the 2050 projection. The projected food outcomes on cereal production in the year 2050 are expected to decline by 3.2%, and wheat production is expected to share more from the negative effects of climate change. Conversely, the projected food price is expected to be 4%, 7%, and 15% higher than the historical price of food attributed to climate change and climatic dynamics whilst outcomes threaten food availability, affordability, and food self-sufficiency in sub-Saharan Africa states (Ringler, Zhu, Cai, Koo & Wang, 2010).

Furthermore, efforts to mainstream Smart Climate agriculture (SCA) which comprise of all agricultural practices with reduced environmental consequences in the region, reiterates the emphasis on agriculture as the mainstay of the African economy despite the negative impacts of climate change on food security and the associated loss in interest by the youth population (Baietti et al., 2012). Although the agricultural sector could have been stationed to benefit from the dense population growth in sub-Saharan Africa, reverse is the outcome now. For instance, Africa's population is predicted to grow with a geometric progression and could lead to the projected population growth of between 1.93 and 2.27 billion people in the year 2050 compared to 1.02 billion in 2010 alongside the dehumanizing scourge of food insecurity in the region, Juxtaposing the population growth rate in Africa and food production and it could be seen that if the population growth trend sustains, the current outcome of food and nutrition insecurity would be worse. Furthermore, the estimated number of people facing chronic food deprivation has risen to 821 million in the year 2017 from 804 million in 2016. This suggests that the prevalence of food insecurity is worsening in Africa, just as the region has the highest prevalence of undernourishment that affects close to 21% of the population (256 million people) compared to other regions such as South America with a 5% prevalence of undernourishment in 2017 and Asia prevalence of undernourishment decreased to 11.4%, (Nakai, 2018).

On the other hand, several programs and policies have been put in place to thrust for a sustainable food secured region. The most recent of these policies are tied with the Millennium and Sustainable development goals. Sadly, these efforts by organized institutions and regional governments to ensure sustainability and adaptability in climatic dynamics towards realizing food security have not fully delivered on their promise (Nakai, 2018; Al, Orking & Clima, 2008). Food security, as reported indicators by the United Nations for Food and Agriculture Organization within a period of 2014-2016, still shows a decline valued at \$161 per person from \$163 per person for a period of 2013-2015 on the average in food production. Considering other food production components, the percentage of arable lands in sub-Saharan Africa used for agriculture also declined to 42.14% in 2011-2014 from 43.16% in 2010. Also, hectare per person declined to 0.21% in 2000 from 0.27% in 2015, yet the average carbon content in the topsoil as a percentage in weight in 2008 and 1991 were 1.12% and 2.1% respectively for Africa. Another major devastating blow that hit the region's economy is that the share of agriculture employment also declined by 4.1% within 2017-2018, yet, food insecurity persists in the region, (Nakai, 2018; Al et al., 2018).

Therefore, it is on this premise that this study examines the effects of changing temperature on food and its associated nutritional security in Sub-Saharan Africa. To achieve this, the effects of the fluctuating temperature on

food production in the region are measured over time and in line with the nutritional value. The correlations between the share of arable land for agricultural purposes and the crop outcomes are further investigated while controlling for the increasing population on food security. The remaining part of this research would be organized in headings starting from introduction, patterns of climate dynamics in sub-Sahara Africa, empirical pieces of literature, empirical framework, result and discussion, and summary and conclusion. Besides, this study's findings would, to a great extent, inform the regional and multinational organizations responsible for food security issues in SSA on the real policy framework towards obtaining sustainable food security in Sub-Sahara Africa.

## 2. LITERATURE SURVEY

The consequences of climate change are not limited to its impacts on the agricultural sector, and it is ordinarily not caused by the forces of natural cycles. Evidence has shown that the anthropogenic factor adds up to influence climate change and further incurs a cost for government used for adaptation and mitigation. The outcomes of these human factors come in several forms against human and sustainable coexistence. For example, the anti-social attitude like dumping of solid into drainage, the undue cutting of trees, and the incessant burning and release of GHG into space have shown to be significant in influencing climate change, and effects extend to food insecurity (Abdullahi & Oyinlola, 2020; Adu-Boahen 2020; Baltagi, 2001). A review of Sivakumar and Valentin (1997) opines that agroecology applies the concepts of ecology and the basics to the agricultural system's styles and management. Just as it is in the world, sub-Sahara Africa shares unique economic zoning and zones. Majorly, the food crops grown in the region include but are not limited to sorghum, millet, cowpea, pigeon pea, groundnut, sweet potato, rice, maize, cotton, cassava, yam, bananas, plantain, tea, coffee, and others.

Furthermore, Sivakumar and Valentin (1997) considered rainfall as the major proxy for ecology measurement and stressed the essence for the knowledge of the ecology of a region, which mainly helps in the (i) numerical evaluation of the biophysical resources and endowment upon which agriculture and forestry depend and (ii) identification of location-based variance required to increase food production through of the farming system. Upon these, the hope for an increased potential for crop productivity in many agro-ecological zones in the world, the burgeoning population of the world in time, exerts much pressure on the cultivation expansion and other land resources. Conversely, Patel (2003) revealed that agroecology's primary aim is the assessment of land suitability and its potentials for productivity. Also, the identified elements of the agroecological zoning are land resources, inventory and land utilization types, and land suitability evaluation. Before the modern methods and tools for agro-ecological zoning (remote sensing and geographic information system), several attempts were to stratify the land area into climatic regions. For example, the manual overlay of isolines representing either potential evapotranspiration or temperature or their combination. In a case of ecological zoning in a Mountain ecosystem in Kumaon Himalayas in India with spatial variability (latitudes 28°45' to 30°00'N, longitude 78°45' to 80°15') using Global Digital elevation model observed a close similitude between the spot height observation and Global Digital Elevation Model based elevation data to the tune of R-square equals 0.98. The long-term series regressing monthly and annual averages of mean temperatures based on six stations using specialized microstate software show that the yearly weather's derivation equals  $24.443 - 0.0045$  multiply by elevation.

Similarly, the rainfall recorded at various rain gauges regressed against elevation for the advancement of rainfall produces outcome as annual rainfall equals  $515.1 + 0.3843$  multiplied by elevation with the R-square as 0.75. The conclusion drawn from the study suggested that a strong negative correlation between climate status and elevation would be a basis for estimating spatial variation in temperature with bias in the mountain ecosystem. Likewise, Kabasa and Sage (2009) further buttressed that the rising case of climate change and temperature put the African region at the risk of increased hunger with the increase in climate change potentials to reduce food security in the region. The lesson drawn from the study reveals that the threat to food security skews hits more on the small and medium farmers. Furthermore, another measure shows that the impact of climate change on food security affects

crop yield, but the nutrient composition of the crop yield is still not defined (Sova, Flowers & Man, 2019). A plethora of literature now accepts the fate that the impact of climate change is now a global phenomenon but the weight of effects now varies from region.

The role of agroecology which implies the application of ecological principles to agricultural practices in the planning and development of agricultural systems, simultaneously targets the thrust for increasing crop productivity vis a vis food and nutritional security in the face of the growing population in the world. Van Wart, van Bussel, Wolf, Licker, Grassini, Nelson and Cassman (2013), a study on the “use of agro-climatic zones to promote “crop yield potential” in the United States and the result shows that there exists a difference in the crop yield capacities from water-limited yield potential as some crops are of climatic zone specific. The study was drawn from a sample frame of six global climate zoning schemes and examined over homogeneous groups within a limited weather zoning and also comprise of the crop area. The outcome of the study reveals that the Global yield Gap atlas Extrapolation model dominates in approach from the four schemes. The matrix of three categorical variables limits climatic zoning covers and 80% of global crop area was of a climate homogeneity in zones. Similarly, a zoning scheme from two climate-related indicators demands a comparable number of zones to the tune of 80 percent of the crop area. In contrast, the heterogeneity was greater than the Domain of Global yield Gap Atlas Extrapolation for most atmospheric variables that affects crop production elements (Van Wart et al., 2013). In a similar study by Edreira, Mourtzinis, Conley, Roth, Ciampitti, Licht and Naeve (2017), the yield gap is the difference in the crop (soybean) potential yield from water or rain-fed production, crop yield is found to vary from the regional climate as in North America. The United States, known as the major producer of soya beans, showed by the observation that across the 10 technology extrapolation domain, soybeans average yield potential ranged from 33 to 5.3Mg for rain-fed space and from 5.3 to 5.6 Mg per hectare for moistened land. These also support the possibility of climatic zoning affecting the yield of a crop. Several academics and practitioners reports from empirical studies identified the understanding of agroecological zoning as the basis for better agricultural planning.

African region being characterized with varied ecological zoning suggested that agricultural planning starts with the agro-ecology zoning of the region (Ogungbile, Tabo, Van Duivenbooden & Debrah, 1998; Kenga, Njoya & Mbiandoum, 2005; Amujoyegbe & Alabi, 2012). In the same way, the Indonesia study's findings support that agro-ecology influences the variation in productivity with the yardstick for agroecology to include: rainfall, air temperature, soil texture, slope, drainage, and slope as the biophysical land variables. The Fuzzy logic model was adopted in contrast to another literature model (Prasetyo, Hasiholan & Hartomo, 2012). Apart from the influence of agroecology on the yield gap of crop and agricultural system, the technical efficiency of the crops is seemed affected by agroecology. A major crop case- on wheat production also showed that even the technical efficiency of crop yield is also influenced by the agro-ecology. For example, the mean technical efficiency estimates for lowland, midland, and highland agro-ecologies were 57%, 82%, and 78% respectively. Also, the technical efficiency ranges from 24.4 to 88.6% in the lowland, 51.6% to 94.4% in the midland, and 34.5% to 94.3% in the highland agro-ecologies all in Ethiopia. The result from the study points to the fact that agroecology design is key for the assessment of the agro productivity since the study adopted an appropriate function (Cobb Douglas) and adequate model (Stochastic Frontier) for analysis (Alemu, Emanu & Legesse, 2014). Similarly, rainfall and other agroecology components were identified as the determinants of the marginal technical efficiency that exists in the family of maize farmers in Nigeria; evidence based on Oyo and Kebbi farmers case study. The author applied imaginative statistics and stochastic frontier models. The result indicated that the sample farmers were not technically efficient, with mean technical efficiency of only 0.5588 and 0.5758 in Oyo and Kebbi state, respectively (Olarinde, 2011).

For example, in Kogi state, other socio-economic characteristics that still affect the technical efficiency of maize include sex, education, household size, and age (Opaluwa, Otitoliaye & Ibitoye, 2014). Climate variability as an agro-ecological factor also affects the production of maize. Sowunmi (2010) revealed substantive differences in the mean of annual rainfall, temperature, maize hectare, and outcomes in the seven known ecological zone at a 5% level. While

all these still suggest the role of agroecology on the production of a crop. Considering rice production's methodological efficiency in Northcentral Nigeria, the average technical efficiency was revealed to be 81.6 percent for highland rice and 76.9 percent for low-lying (Okoruwa, Ogundele & Oyewusi, 2006). The upland and low land composition make up the agro-ecology factors as reviewed. This indirectly suggests the effects of the agroecological zoning on the technical efficacy of rice production in Nigeria. A departure from the conventional survey data analysis to panel data analysis study by Oni, Nkonya, Pender, Philip and Kato (2009), using panel data econometric model for 1995 and 2006 suggests that another agroecological factor like land expansion influence the crop productivity in Nigeria. The dry savannah showed an inverse relationship (-0.353) with crop production, while the moist savannah shows a direct relationship with crop production (0.008). Although not significant, the coefficients' signs suggest a varied relationship of various ecological zones with the crop productivity in the country.

### 3. PROBLEM STATEMENT

Increased variability in the climate change pattern continuously threatens the future and sustainability of agriculture in the world, but of all the hunger hotspots in the world, Sub-Saharan African countries are the worst hit. Projections have revealed that there would be an increased concentration of the poor who depend heavily on agriculture as a major means of livelihood in the developing countries of South Asia and sub-Sahara Africa. In this light, Lipper et al. (2014) suggested climate-smart-driven agriculture (CSA) for food security policy that integrates climate change challenges in both the adaptation and mitigation practices. Among other findings, CSA found building evidence, rising local institutional effectiveness, supporting coherence between climate and agricultural policies, and linking climate change and agricultural financing as the road map for inclusive climate and agricultural policy strengthening. Global water scarcity reemerged as an aspect of climate change that threatens the food policy in addition to the energy crisis and credit crisis. Therefore, it was revealed that the increasing population growth, water scarcity, and income had put pressure on food production, thereby leading to delayed food security attainment (Hanjra & Qureshi, 2010). Furthermore, a micro perspective on the influence of climate change on food security provision in Ethiopia used a two-stage regression approach, and findings from the first stage show that credit, extension, and information are the major drivers of adaption. Secondly, the effect of adaptation on food productivity showed that there exists a significant difference in food productivity between farmers that applied adaptation practices and the farmers that do not apply adaptation practices to cope with climate change using an econometric approach on the Ricardian model (Mendelsohn, Nordhaus & Shaw, 1994). Mexico has also shown to be one of the countries whose crop production is heavily limited by climate change. For example, maize production out increases higher than the production area of cultivation due to climate factors like low, seasonal, and fluctuating rainfall limits the crop area for the growing of maize (Appendini & Liverman, 1994).

On the other hand, the African region has been classified to be one of the poorest regions in the world with slow growth in the agricultural sector and low per capita income in 2010 to the value of \$688 (in constant 2000 USD) compared to \$1,717 in the rest of the developing world (Di-Falco, Veronesi & Yesuf, 2011). The African region's geographical location is a unifying factor that classifies the region as a unit with a homogenous climatic experience characterized by common vegetation and originated from the Atlantic coast on the west of the red sea. Africa as a large continent is usually referred to as a dry region with the biggest dry land in the World. For instance, about 1,274 million hectares out of the total area of more than 3, 052 million hectares are deserts in the region. The rainfall and temperature dynamics and their effect on food production remain unpredictable over time (Al, Orking & Clima, 2008).

Hence, the agricultural sector's performance may not have reflected in the climatic change with the region. For example, despite the common characteristics in climate component in Africa, temperature fluctuation still varies from countries in the region with the period of 2000-2016 as in Figure 1 below, but a cross response of food production to

temperature change reveals that during the period 2000 to 2016, food production performed well between 0.5°C and 1.2°C for the regional agricultural performance (WDI, 2018). Likewise, from table 1 below, climatic factors such as precipitation and evaporation vary greatly from regions. For example, Africa's level of precipitation seems the same with Asia at 696mm/year, but Africa has higher evaporation of 582 relatives to Asia with 420. The other regions like Europe also vary in level of precipitation and evaporation. In this way, the respective performance in agriculture in these regions tied to climatic factors would also grossly vary across the continents. For example, the food production response to temperature varies from country to country between regions and within countries in Africa, shown in Figure 1 below and Appendix Figure 2.

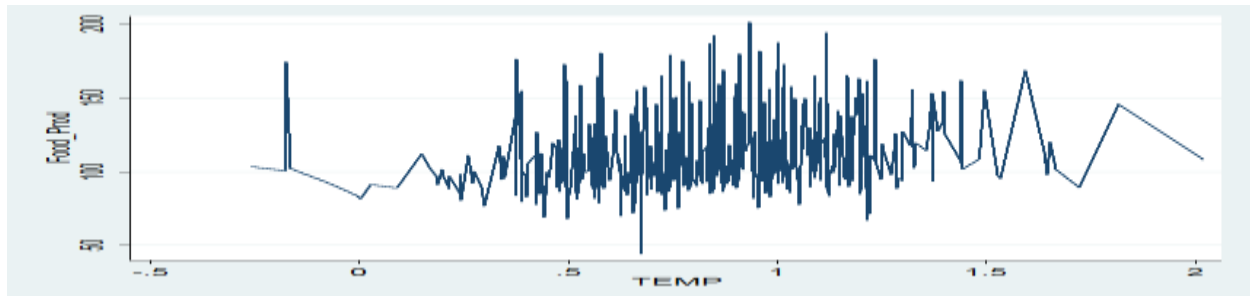


Figure 1: Response of Food Production to Temperature change and country perspective

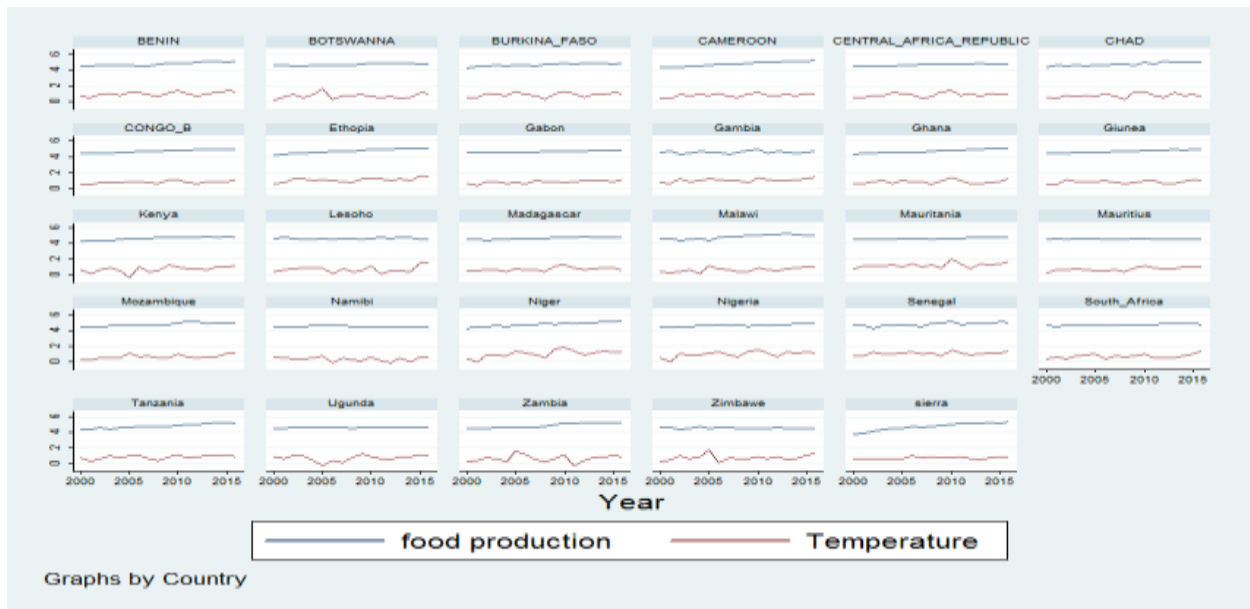


Figure 2: Food production and temperature

*Computed by the author using WDI data and across the countries.*

**Table 1:** Estimate of Regular yearly Precipitation (P), Evaporation€, Runoff Rate (P-E) and Runoff Ratio [(P-E)/P]

Region	Surface Area(10 Km <sup>2</sup> )	P(mm/year)	E(mm/year)	P-E(mm/year)	(P-E)/P
Europe	10.0	657	375	282	0.43
Asia	44.1	696	420	276	0.40
Africa	29.8	696	420	276	0.40
Australia	8.9	803	534	269	0.33
North America	24.1	645	403	242	0.38
South America	17.9	1564	946	618	0.40
Antarctica	14.1	169	28	141	0.83
All land areas	148.9	746	480	266	0.36
Arctic Ocean	8.5	97	53	44	0.45
Atlantic Ocean	98.0	761	1133	-372	-0.49
Indian Ocean	77.7	1043	1294	90	-0.24
Pacific Ocean	176.9	1292	1202	90	0.07
All Oceans	361.1	1066	1176	-110	-0.10
Globe	510.0	973	973	0	0

*Source: Pagano, T.C. and Sorooshian, S., Encyclopedia of Hydrological Sciences, John Wiley and Sons, New York 2005 and cited from Rai and Singh, (2012).*

In a similar report, Ogbuabor and Egwuchukwu (2017) used annual rainfall, forest depletion, and carbon emission as a proxy for climate change. Among the variables, carbon emission showed to be consistent with its impact on the Nigerian economy both in the short run and in the long run. Al et al. (2008) also revealed the dimensions of impact on food security by climate change, including food availability, food accessibility, and food price system. Another regional study by Bellouni (2014) expanded the scope for measuring food security to include food production index, mortality rate, and life expectancy at birth total while rainfall and annual temperature were used to study the indicators for climate change. Evidence from the study revealed that a decreased rainfall coupled with an increased temperature reduces food production and increases the total undernourished population as well as increases the mortality rate. Following the Bellouni (2014) approach, this study analyses the effects of climatic dynamics on the food security index in Africa, the study used food production index and undernourishment population rate as an alternative to measuring food safety while, the climate dynamics were measured using annual temperature, rainfall and carbon emission spread across its lag.

#### 4. RESEARCH METHODOLOGY OR METHODS

##### 4.1. Agronomic crop yield model

The plethora of literature has revealed several models for the study of climate change interaction with agriculture. The agronomic model, for example, is primarily built on the ground to stir the active reaction of crops to their atmosphere (Jeuffroy, Casadebaig, Debaeke, Loyce & Meynard, 2014). Most authors adopted environmental elements' representation by a climatic factor as an indicator capable of influencing the cropping systems. Therefore,

the agronomic model makes it possible for a speedy evaluation capable of reducing environmental problems. Furthermore, the agronomic models' application breaks down the phenotypic effect into genotype, earth crust, and genotype-environs interaction. The agronomic model's driving aims include; (i) a better characterization of the environment for a probable change in the alignment network. (ii) Enrichment of the genotype-environment interaction by reducing the components into factors to limit the factors for probe genotype, (iii) experiment and findings.

To measure the impacts of climatic variation in time on food production in the region, the study of Bellouni (2014) was adopted with the framework of agronomic crop yield model and food and nutritional security measured by food production index and undernourishment rate in sub-Sahara Africa. Therefore, building food security on the global water balance (Rai & Singh, 2012).

$$FS_{it} = F \left[ GWB = \frac{dS_{atm}}{d_t} = E - P \right], \dots, (1)$$

Where FS is the vector of food security indicators (food production and undernourishment population growth), GWB is the Global water balance,  $S_{atm}$  is the total amount of water banking in the entire atmosphere in the form of the combination of vapor, liquid and solid; P and E are the associated global fluxes of rainfall and evapotranspiration respectively. Using the applied stochastic model to a Cobb Douglas production function as expresses in equation 2 to satisfy the nonlinear characteristic of the climatic factor concerning Food security indicators, we state as mentioned by Gujarati (2004) in the general expression:

$$Y_i = \beta_1 X_{2i}^{\beta_2} X_{3i}^{\beta_3} \varepsilon^{ui} \dots (2)$$

Y is the output, X2 is the climatic inputs, X3 is the non-climatic inputs (labor and capital), u is the stochastic disturbance term, and e is the natural base logarithm. We represent equation 1 in the panel data regression model as:

$$y_{it} = \delta y_{i,t-1} + x_{it}^1 \beta + \mu_i + u_{it}, \dots (3)$$

For  $I = 1, 2, \dots, N$  and  $t = 1, 2, \dots, T$ .  $\delta$  is a scalar  $x_{it}$  is  $k \times 1$ ,  $\mu_i$  denotes the i-th individual's effect, and  $u_{it}$  is the disturbance (Blundell, Bond & Windmeijer, 2001). We are therefore allowed to specified in specific terms of this study where the output is measured food security indicators and inputs are combined with the control variables like climatic dynamics indicators in as in equation (3)

$$\text{LogFP}_{it} = \tau_0 + \tau_1 / \text{LogFP}_{it-1} + \tau_2 / \text{Loglabour}_{it} + \tau_3 / \log \text{Arable\_land}_{it} + \tau_4 / \text{Logtemp\_change}_{it} + \tau_5 \text{rainfall}_{it} + \tau_6 \text{Logagro\_value\_output} + \tau_7 \log \text{land\_use\_irrigation} + \alpha_i + \mu_{it}, \dots (4)$$

LogFP<sub>it</sub> is denoted the log of food production index across countries in Africa.

FPI includes edible crops and rich in nutrients. Coffee and tea are excluded from the index calculation for not having nutritive value, and the calculated index is given as (2004-2006 = 100). LogLabour denotes the labor of the countries in Africa measured share of agricultural employment. Employment in the is context refers to a labor force of working age and involved in any activity with utility outcomes in the form of goods and services for exchange of payment or profit. Furthermore, it extends to working in a time or not due to momentary lack from a job or a working-time procedure and is measured in total employment ratio.

Logland denotes the ratio of land used for agriculture across African countries. Arable land on the other hand comprises land under non-permanent crops, non-permanent meadows for green grassland, land under market or

kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded and is measured as Arable land (% of land area). Temperature change denotes the log of ecology temperature obtained in the countries and is measured in A<sup>0</sup>C for the respective countries. Logland use denotes the Land area equipped for irrigation. This study's data were collected from the United Nations Food and Agriculture Organization and World Bank development indicators between 2000 and 2016.

The other indicator for food security in this study is undernourishment, and population growth rate would be examined against some climatic indicators as below:

$$\begin{aligned} \text{LogUP}_{it} = & \tau_0 + \tau_1 / \text{LogUP}_{it-1} + \tau_2 / \text{Loglabour}_{it} + \tau_3 / \log \text{Arable\_land}_{it} + \tau_4 / \text{Logtemp\_change}_{it} \\ & + \tau_5 \text{rainfall}_{it} + \tau_6 \text{Logagro\_value\_output} + \tau_7 \log \text{land\_use\_irrigation} + \alpha_i + \mu_{it}, \dots (5) \end{aligned}$$

Where UP denotes the undernourishment population growth rate in the region. Other variables remain as defined earlier above.

## 5. DATA ANALYSIS AND DISCUSSIONS

Dynamic panel outcome in the study proved to be an improvement of the static panel result. The challenge insight lies in the determination of and the validity of the instrumental variable. The judgment on the validity of the instruments as well as the model precision determination is based on several tests like Sargan, Hansen, AR(1) and AR(2). According to Blundell, Bond and Windmeijer (2001), a dynamic panel is preferred over other long panels, especially in a large cross-section and short time (T). Results from a static panel data model, one step and two-step scheme of GMM were compared, and the discussion of this study mostly focused on the model with a consistent estimate and less spurious output based on the Sargan, Hansen, first difference autoregressive term AR(1) and second difference of the autoregressive term AR(2). The finite sample bias of the static and first difference for the AR(1) model is improved by the system GMM, Blundell et al. (2001), as mentioned by (Blundell, Bond & Windmeijer, 2000). The Sargan and Hansen test null hypothesis states that the instruments are efficient against the alternative that the instruments are not efficient. The null hypothesis is to be accepted over the alternative hypothesis according to *a priori* expectation.

It is against this background that this study's discussion would be based on the estimates of the two-step difference of the GMM from the model I represented in the model 3 estimate column on food security while the one-step system of the GMM estimation represented in model II and DGMM1-CL result column would be discussed for the nutritional security objectives. From the model I result, the time-influenced effects on the log of food production were revealed to have an increasing impact of 0.59%. This implies that the effect of the first lag of log of food production increases the current outcome of log of food production for every 1% increase. Likewise, the effects of temperature has a decreasing impact of -3.1% on a log of food production for every degree increase in the temperature in the short run, but the elasticity effects in the long run for the temperature has -7.5% decreasing effect on food production for every 1% degree increase in the temperature. This implies that food production decreases as the temperature degrees increases. In contrast to the effects of temperature on the log of food production, the expansion or increase in the size of arable land for agriculture has expansionary effects on a log of food production. This further opines that the increase in the size of the arable land for agriculture purposed, especially crop production by 1%, increases food production log by 3.9% in the short run.

Observing the impact of a rise in temperature and the effect of the expansion of arable land for agriculture on the log of food production, it could suggest that expansion of arable land for agriculture could be a measure of adaptation to the exogenous nature of temperature against the associated effect of rising temperature on food production. The

findings above thereby supported Bellouni (2014) to show that temperature has an inverse effect on the log of food production as in Bellouni (2014) but further revealed that the expansion and or increase in arable land for agriculture could cushion the negative impact of the temperature on food production.

From the model II result, on the other hand, the climatic variation effect on the undernourished population growth rate is strong and positively correlated with the first lag of the undernourished population growth rate as high as 0.80%. This opines that the first lag on the undernourished population growth rate increases the current undernourished growth rate. Temperature was also not significant in determining the undernourished population growth rate although positive as opposed by (Bellouni 2014). This further suggests that although temperature negatively affects food production, its impact on undernourishment is determined by the nutritional content and composition of the available food produced. Therefore, food products that are rich in vitamins should be substituted with the sole promotion of food production. Similarly, the log arable land after the first lag has a -8.55% inverse effect on the undernourished population. The lag effect of log of arable land further suggests that the expansion of the arable land for agricultural activities without combining with nutrient-rich food production would still not respond rightly on the immediate response. Therefore, following the outcome, the expansion of arable land for agriculture further reduced malnutrition and the rate of growth of the undernourished population in the region. Likewise, the population growth in the region increases the undernourished population growth rate with a corresponding increase in the rate of growth of the undernourished population in the region as high as 11.95%.

**Table 2: Model 1**

Variables	(Model 1)	(Model 2)	(Model 3)
			-a
L.logfood	0.603*** (0.0787)	0.390* (0.220)	0.590** (0.290)
Temp	-0.0362*** (0.0124)	-0.0304** (0.0154)	-0.0311* (0.0178)
L.temp	0.00202 (0.0113)	0.00865 (0.0165)	0.0179 (0.0165)
Arable	0.0318*** (0.00753)	0.0367*** (0.0101)	0.0396*** (0.00839)
L.arable	-0.0240*** (0.00640)	-0.0152 (0.0181)	-0.0207 (0.0182)
Logagrovalue	0.203** (0.0800)	0.257** (0.116)	0.151 (0.126)
L.logagrovalue	-0.103 (0.0733)	-0.238 (0.449)	-0.454 (0.523)
Labour	0.000596 (0.000934)	0.00241 (0.00209)	0.000188 (0.00242)
Logpopulation	0.281*** (0.0920)	0.574 (0.670)	0.958 (0.709)
Observations	412	412	412
Number of crossed country effect	29 YES	29 YES	29 YES
year effect	NO	NO	NO
Hansen_test	22.19	9.244	9.244
Hansen Prob	1	0.599	0.599
Sargan_test	298.6	8.870	8.870
Sargan Prob	0.592	0.634	0.634
AR(1)_test	-3.332	-2.910	-2.264
AR(1)_P-value	0.000862	0.00361	0.0236

AR(2)_test	1.694	1.831	1.425
AR(2)_P-value	0.0902	0.0670	0.154
No. of Instruments	314	20	20

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Model 1& Model 2 denote One-Step & Two-Step GMM respectively. Model 3 follow Roodman (2009b) and collapse the instrument matrix. a & b denote lag (1 5) & lag(2 4) respectively.

**Table 3: model II**

VARIABLES	(1) DGMM1	(2) DGMM1-CL-a	(3) DGMM2-CL-a
L.unr	0.808*** (0.0421)	0.803*** (0.105)	0.915*** (0.0819)
Temp	0.236* (0.140)	0.0459 (0.116)	0.0775 (0.0728)
Logarable	-1.967*** (0.732)	-1.492 (1.377)	-1.215 (1.194)
L.logarable	-2.943 (2.050)	-8.554** (3.984)	-7.770* (4.031)
Logagrovalue	-4.399*** (1.668)	-2.164 (1.426)	-1.127 (1.124)
Loglanduse	-0.417 (1.491)	-3.297 (2.104)	-0.0408 (2.430)
Loglabour	-1.699 (1.169)	-0.0318 (0.801)	-0.195 (0.820)
Logpopulation	10.34** (4.281)	11.95*** (4.314)	8.598* (4.495)
Observations	416	416	416
Number of crossed country effect	29 YES	29 YES	29 YES
year effect	NO	NO	NO
Hansen_test	21.78	7.467	9.193
Hansen Prob	1	0.877	0.758
Sargan_test	874.7	19.53	29.43
Sargan Prob	0	0.108	0.00568
AR(1)_test	3.175	2.529	2.296
AR(1)_P-value	0.00150	0.0114	0.0217
AR(2)_test	1.524	0.649	0.0892
AR(2)_P-value	0.127	0.516	0.929
No. of Instruments	126	21	21

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Definition is as in the above result

## 6. CONCLUSION

The efforts to ascertain the time impact of regional profiling of climatic change the realization of food and nutritional security in sub-Sahara Africa shows that climate variation proxy with temperature change is consistent with a negative impact on food production both in the long term and short term using a cross-section of 29 countries over a short period of 2000-2016. The method of system Generalized Method of Moment revealed an improved output from the static panel data model to differs from similar studies. In contrast to this major impact of temperature change on food production in the region, its corresponding effect on nutrition security remains insignificant. The revelation of the control variables on arable land and population shows that the expansion of arable land for agriculture reverses

the effects on food and nutritional security positively as opposed by the temperature change. Population increase also influenced an increase in the growth rate of the undernourished populace. Therefore, evidence opined that since the negative impact of the temperature change is significant on food production, the expansion of arable land has shown to be an efficient adaptation measure for the harsh effect of temperature change on food production in the region. The negative impact of population growth on undernourished population growth also reaffirmed population control's essence as an effective policy measure. The study, therefore, recommends the preservation and extension of more arable land to negate the inverse effects of temperature on food and nutritional security. Likewise, population control policies like childbirth control measures are encouraged to reduce the high population of the undernourished population growth rate.

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## References

- Abdullahi, H. I., & Oyinlola, O. A. (2020). Flood disaster and national security: A criminologists exploration of Lagos metropolis, Nigeria. *African Social Science and Humanities Journal*, 1(1), 71-81.
- Adu-Boahen, K. (2020). Evaluation of sustainable management practices of water resources in Ghana: Perspectives from the Fosu and Essei Lagoons. *African Social Science and Humanities Journal*, 1(1), 82-100.
- Al, W., Orking, G., & Clima, O. (2008). Climate change and food security: a framework document. *FAO Rome*.
- Alemu, T., Emanu, B., & Legesse, G. (2014). Smallholder wheat production efficiency in selected agroecological zones of Ethiopia: a parametric approach. *J. Econ. Sustain. Dev.*, 5.
- Amujoyegbe, B. J., & Alabi, O. S. (2012). Cropping system analysis of two agro ecological zones of Southwestern Nigeria. *Journal of Agricultural Extension and Rural Development*, 4(14), 396-401.
- Appendini, K., & Liverman, D. (1994). Agricultural policy, climate change and food security in Mexico. *Food Policy*, 19(2), 149-164.
- Baietti, A., Shlyakhtenko, A., La Rocca, R., & Patel, U. D. (2012). *Green infrastructure finance: leading initiatives and research*. The World Bank.
- Baltagi, B. H., & Kao, C. (2001). Nonstationary panels, cointegration in panels and dynamic panels: A survey. In *Nonstationary panels, panel cointegration, and dynamic panels*. Emerald Group Publishing Limited.
- Belloumi, M. (2014). Investigating the linkage between climate variables and food security in ESA countries. *Regional Environmental Change*, 42(1), 172-186.
- Belloumi, M. (2014). Investigating the linkage between climate variables and food security in ESA countries. *Regional Environmental Change*, 42(1), 172-186.
- Blundell, R., Bond, S., & Windmeijer, F. (2001). *Estimation in dynamic panel data models: improving on the performance of the standard GMM estimator*. Emerald Group Publishing Limited.
- Claudia, R., Tingju, Z., Ximing, C., Jawoo, K. and Dingbao, W.,(2011). Climate Change Impact on Food security in Sub-Sahara Africa: Insight from Comprehensive Climate Change Scenarios. *International Food Policy Research Institute (IFPRI). Sustainable Solution for ending hunger and Poverty. Discussion Paper*. countries. *Regional Environmental Change*, 42, 172-186.
- Di-Falco, S., Veronesi, M., & Yesuf, M. (2011). Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. *American Journal of Agricultural Economics*, 93(3), 829-846.

- Edreira, J. I. R., Mourtzinis, S., Conley, S. P., Roth, A. C., Ciampitti, I. A., Licht, M. A., & Naeve, S. L. (2017). Assessing causes of yield gaps in agricultural areas with diversity in climate and soils. *Agricultural and Forest Meteorology*, 247, 170-180.
- Gitz, V., Meybeck, A., Lipper, L., Young, C. D., & Braatz, S. (2016). Climate change and food security: risks and responses. *Food and Agriculture Organization of the United Nations (FAO) Report*, 110.
- Hanjra, M. A., & Qureshi, M. E. (2010). Global water crisis and future food security in an era of climate change. *Food policy*, 35(5), 365-377.
- Jeuffroy, M. H., Casadebaig, P., Debaeke, P., Loyce, C., & Meynard, J. M. (2014). Agronomic model uses to predict cultivar performance in various environments and cropping systems. A review. *Agronomy for Sustainable Development*, 34(1), 121-137.
- Kabasa, J. D., & Sage, I. (2009). Climate change and food security in Africa. *Climate Change in Africa*, 21.
- Kenga, R., Njoya, A., & Mbiandoum, M. (2005). Analysis of constraints to agricultural production in the Sudano savanna zone of Cameroon and implication for research priority setting. *Tropicicultura*, 23(2), 91.
- Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., ... & Torquebiau, E. F. (2014). Climate-smart agriculture for food security. *Nature climate change*, 4(12), 1068-1072.
- Mendelsohn, R., Nordhaus, W. D., & Shaw, D. (1994). The impact of global warming on agriculture: a Ricardian analysis. *The American economic review*, 753-771.
- Nakai, J. (2018). Food and Agriculture Organization of the United Nations and the Sustainable Development Goals. *Sustainable Development*, 22.
- Ogbuabor, J. E., & Egwuchukwu, E. I. (2017). The impact of climate change on the Nigerian economy. *International Journal of Energy Economics and Policy*, 7(2), 217-223.
- Ogungbile, A. O., Tabo, R., Van Duivenbooden, N., & Debrah, S. K. (1998). Analysis of constraints to agricultural production in the Sudan Savanna zone of Nigeria using multi-scale characterization. *NJAS wageningen journal of life sciences*, 46(1), 27-38.
- Okoruwa, V. O., Ogundele, O. O., & Oyewusi, B. O. (2006). *Efficiency and productivity of farmers in Nigeria: A study of rice farmers in North Central Nigeria* (No. 1004-2016-78475).
- Olarinde, O. L. (2011). Analysis of Technical Efficiency Differential among Maize Farmers in Nigeria. African Economic Research Consortium, Nairobi, AERC Research Paper 232.
- Oni, O. A., Nkonya, E. M., Pender, J. L., Phillip, D., & Kato, E. (2009). Analyzing drivers of food crop productivity in Nigeria. *Journal of Rural Economics and Development*, 18(1623-2016-134889), 36-45.
- Opaluwa, H. I., Otitoliaye, J. O., & Ibitoye, S. J. (2014). Technical efficiency measurement among maize farmers in Kogi State, Nigeria. *Journal of Biology, Agriculture and Healthcare*, 4(25), 240-244.
- Patel, N. R., (2002). Remote sensing and GIS application in agro-ecological zoning. *Satellite Remote Sensing and GIS Applications in Agricultural Meteorology*, 213.
- Prasetyo, S. Y. J., Hasiholan, B. S., & Hartomo, K. D. (2012). The Agroecological Zone using Fuzzy Logic for Land Suitability and Regional Sustainable Food Insecurity in Boyolali, Central of Java Indonesia. *International Journal of Computer Science Issues (IJCSI)*, 9(6), 191.
- Rai, R. K., Singh, V. P., Lal, R., & Stewart, B. (2012). Global water balance and agronomic production in relation to food security. *Advances in soil science: Soil water and agronomic productivity*. Taylor & Francis, Boca Raton, FL.
- Ringler, C., Zhu, T., Cai, X., Koo, J., & Wang, D. (2010). Climate change impacts on food security in sub-Saharan Africa. *Insights from Comprehensive Climate Change Scenarios*, 2.
- Sava, C., Flowers, K., & Man, C. (2019). Climate Change and Food Security: A test of Us Leadership in a fragile World. Center for Strategic and International Studies(CSIS). Retrieved from: [www.csis.org](http://www.csis.org)
- Sivakumar, M. V. K., & Valentin, C. (1997). Agroecological zones and the assessment of crop production potential. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 352(1356), 907-916.

Sowunmi, F. A. (2010). Effect of climatic variability on maize production in Nigeria. *Research Journal of Environmental and Earth Sciences*, 2(1), 19-30.

Van Wart, J., van Bussel, L. G., Wolf, J., Licker, R., Grassini, P., Nelson, A., ... & Cassman, K. G. (2013). Use of agro-climatic zones to upscale simulated crop yield potential. *Field crops research*, 143, 44-55.

