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Int. J. Food System Dynamics 13 (1), 2022, 69-84

DOI: https://dx.doi.org/10.18461/ijfsd.v13i1.A6

INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Food Security: An Analysis of Food Systems within Africa

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Received May 2021, accepted November 2021, available online January 2022

ABSTRACT

Globally, Africa's food security is the lowest but an in-depth quantitative analysis on its food system is still lacking. To achieve this, food production is used as the indicator for food availability and food price, as the proxy for food access at the continental and regional level respectively. The different dimensions studied focused on the crop production-population (cpp) system and food price correlations/tail dependence. The cpp was found to be stable and the preservation of this stability under a reduced (constant) crop production (population) was verified by the Vasicek model. In contrast, an increase in the population destabilized the system. Given that food insecurity is much more prevalent in East Africa (EA), the extreme quarterly maize prices in Kenya, Ethiopia and Somalia were analyzed using rank correlation measures, copulas, univariate and bivariate generalized extreme value theory. For all years (2006-2019), Kenya-Ethiopia exhibited the highest correlation while Somalia-Kenya, the lowest. Across different periods, the global food crises (global stressor) stimulated a higher correlation between price-pairs than the widespread drought (local stressor) in EA. Tail dependence is present but asymptotic dependence is absent for all pairs.

Keywords: *Crop production; Food insecurity indicators; Extreme value; Copulas; Tail dependence; Vasicek model.*

1 Introduction

The UN Food and Agriculture Organization (FAO) in 2009 identified the four pillars of food security as availability, access, utilization, and stability. It is when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996; Ken, 2020). Some factors or a combination of factors can affect anyone or all of these pillars at any given time. For example, climate change can lead to severe drought which could trigger famine (a drastic reduction in food production). This can, in turn, raise food prices and decrease the ability of households to have access to food.

In 2018, about 821.6 million people in the world were estimated to have been undernourished and the prevalence of undernourishment worldwide was 10.8%. Within the latter category, Africa ranks highest at 19.9% and the situation is being worsened by the novel Coronavirus pandemic (FAO et al., 2019; FAO, 2021). This is a critical issue that requires all hands to be on deck in Africa as this threatens our very existence.

The drought that occurred between 2011 and 2012 affected the entire Horn of Africa. The UN Office for the Coordination of Humanitarian Affairs (OCHA) noted that this widespread drought that led to many deaths was worsened by the severe food crisis that accompanied the event (OCHA, 2011; Bertelli, 2020). Given that high food prices threaten food security, there is a compelling need for consumers and policymakers to understand the different characteristics of food prices and how they relate under different conditions. These price signals may provide insights into how price transmissions react in periods of stress when compared to normal periods and it will enable policymakers to put in place mitigation strategies to curtail the degree of the transmission. For instance, Egypt and South Africa have adopted aquaponics and large scale irrigation productions to mitigate the challenges posed by scarcity of land and erratic rainfall patterns. Ghana also instituted a government policy dubbed “planting for food and jobs” in which the capacities of small holder farmers are enhanced to improve food production. Under this scheme, farmers are given agricultural inputs at subsidized prices. These efforts were negatively impacted by the COVID-19 pandemic especially, during the lockdown periods (Obirikorang et al., 2021; Ayanlade and Radeny, 2020). Giller (2020) also highlighted other innovative means by which cheap, nutritional agricultural produce can be achieved. These types of strategies tend to relieve the stress on food prices thereby reducing the impact of the shocks that sudden food price hikes have on food access and low-income households' livelihoods (Willenbockel, 2012, Bonuedi et al., 2020).

Many studies have investigated the effect that extreme weather events have on agricultural production, we mention a few. Van der Velde et al. (2012) evaluated the impacts of extreme weather on wheat and maize in France. Ciais et al. (2005), Sanchez et al. (1996), Rosenzweig et al. (2002) and Bertelli (2020) also carried out studies on how food production is affected by specific climate extremes such as heatwaves, droughts, hail storms, excessive cold and prolonged precipitation. The case for Ethiopia was accomplished by Hill and Fuje (2018). With the aid of data on district-level weather shocks and monthly grain prices, they quantified the impact of drought on local prices.

In the area of food price volatility, Kalkuhl et al. (2016) and Bertelli (2020) examined the causal relationships between the price volatility drivers and extreme price events and further looked at the implications it has on food and nutrition security. Bonuedi et al. (2020) focused on the effect of easing cross border trade on food security while Willenbockel (2012) studied the potential impact of climate change on food price volatility in Sub-Saharan African regions using the global dynamic multi-region computable general equilibrium model. The transmission of price signals from the world market to domestic markets was investigated by Brunelin (2014). The motivation stemmed from the issues that were raised about the impact of the prices of imported food by developing countries especially, given the global food crises that took place between 2006 and 2008. A similar study by Rapsomanikis (2011) on six developing countries including two in Sub-Saharan Africa indicated that although domestic markets are integrated with the world market, there is a slow rate of adjustment of domestic food prices to world market changes.

From the foregoing, the analysis of the nature of food price correlations and tail dependence within African countries has hardly received any attention in literature. Moreover, the study of the behavior of the crop production-population relationship in Africa under stress conditions has not been undertaken. This study aims to narrow this research gap. We believe that this type of simulation will provide researchers and policymakers with a much more vivid picture of the dynamics of crop production and population interactions within different scenarios.

The paper is organized as follows. The mathematical principles underlying the applied models are presented in section 2. Section 3 and 4 provide details of the empirical study on food systems within Africa. While the former examines the correlation between Africa's population growth and its crop production in a regression analysis as well as investigates the behaviour of their relationship under conditions of stress, the latter has to do with the modelling of the maximum quarterly maize prices in East Africa. Finally, conclusions are provided in section 5.

2 Methodology

2.1 Linear regression model

A simple way to model the relationship between two variables is to use the linear regression model. This is done by fitting a linear equation to the observed data. The linear regression line is of the form

$$E(Y) = E(a) + E(b)X \tag{1}$$

where X is the explanatory variable and Y is the dependent variable. The slope of the line is b and the intercept is a (that is, the value of y when $x = 0$)

2.2 Vasicek model: modelling the mean reverting process

The general stochastic differential equation (SDE) used to represent a mean reverting process is:

$$dX_t = b(X_t)dt + \sigma(X_t)dW_t, \ t \geq 0 \tag{2}$$

where the drift $b(x) = \gamma + \lambda x = (-\lambda)(-\gamma/\lambda - x), x \epsilon I, \ \gamma \epsilon R_-, \ \lambda \epsilon R$ and the variance of the process, $\sigma > 0$ for all $x \epsilon I$. I indicates the state space, λ determines the speed of convergence to the mean reversion level which is denoted by $-\gamma/\lambda$.

If we set $b(X_t) = \theta_1 - \theta_2 X_t \, and \, \sigma(X_t) = \theta_3$ then the SDE becomes a Vasicek process given as

$$dX_t = (\theta_1 - \theta_2 X_t)dt + \theta_3 dW_t, \ t \geq 0 \tag{3}$$

where $\theta_1, \theta_2 \epsilon R$ and $\theta_3 \epsilon R_+$. When $\theta_1 = 0$ we have an Ornstein-Uhlenbeck process and a positive θ_2 indicates that the process is mean reverting.

2.3 Dependence measures

The Kendall tau (τ) and Spearman's rho (ρ) are rank correlation measures that are commonly used to measure the level of dependence in bivariate extremes. They lie between -1 and 1. They are denoted as

$$\tau = \frac{n_c - n_d}{\frac{1}{2}n(n-1)} \tag{4}$$

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \ldots\ldots\ldots \tag{5}$$

where d is the difference between ranks and n is the number of observations. n_c and n_d are the number of concordant and discordant observations respectively.

2.4 Copulas

A copula C is a joint distribution function of standard uniform random variables

$$C(u_1, \ldots u_n) = P(U_1 \leq u_1, \ldots, U_n \leq u_n) \tag{6}$$

where $U \sim U(0,1)$ for $i = 1, \ldots, n$. Copulas allow one to characterize the dependence structure of a set of random variables separately from the marginal distributions.

The Clayton and Gumbel copulas are used for modelling the lower and upper tail dependence respectively. They are represented as:

Clayton copula:

$$C(u_1, u_2) = (u_1^{-\theta} + u_2^{-\theta} - 1)^{-1/\theta}, \ \theta > 0 \tag{7}$$

Gumbel copula:

$$C(u_1, u_2) = \exp\{-((-ln u_1)^\theta + (-ln u_2)^\theta)^{1/\theta}\}, \ \theta \geq 1 \tag{8}$$

2.5 Generalized extreme value model: the univariate case

The Block Maxima (BM) method involves dividing the data into blocks and fitting the generalized extreme value (GEV) distribution to the maxima. The GEV distribution is given as:

$$G(z) = \exp\left\{-\left(1+\xi\frac{z-\mu}{\sigma}\right)_+^{-\frac{1}{\xi}}\right\} \tag{9}$$

with μ, the location, $\sigma > 0$, the scale and ξ, the shape parameters. $z_+ = max\{z, 0\}$.

2.6 Bivariate extreme value models

The information on the inter-relationships between two or more extremes can be deduced when we study their joint behaviour. Making use of the bivariate case, suppose $(X_1, Y_1), (X_2, Y_2), \ldots$ is a sequence of vectors that are independent and identically distributed (*iid*) with distribution function $F(x, y)$, then the vector of component wise maxima is

$$M_n = (M_{x,n}, M_{y,n})$$

and its limiting behaviour as n tends to infinity is $G(x, y)$ which has the form

$$G(x, y) = \exp\{-V(x, y)\}, \qquad x, y > 0$$

with

$$V(x, y) = 2\int_0^1 \max\left(\frac{w}{x}, \frac{1-w}{y}\right) dH(w)$$

H is a distribution function on [0,1] satisfying the mean constraint

$$\int_0^1 w dH(w) = 0.5$$

The bivariate EV approach applied in this study is the Logistic model. Precisely, the Pickands dependence function α is used to test if asymptotic dependence is present in the extreme quarterly maize prices. The bivariate logistic distribution function with dependence parameter α has its stable tail dependence function given as

$$G^l(x, y) = exp\left\{-(x^{-1/\alpha} + y^{-1/\alpha})^{\alpha}\right\},\ 0 \le \alpha \le 1 \tag{10}$$

The margins x and y are the Fréchet-transformed variables. The parameter α measures the strength of dependence between the coordinates. When α approaches zero in the limit, perfect dependence is obtained. Independence is obtained when $\alpha \rightarrow 1$. This model is a symmetric model implying that the variables can be exchanged.

3 Food Availability in Africa

According to the United Nations, it is estimated that by the year 2050 the population of Africa is expected to double especially the Sub-Saharan region. This implies a population growth to approximately 2.5 billion. It is therefore important to study how the food produced in Africa relates to the growth in population on the continent. This is because if there is no corresponding increase in food production, this could trigger a deadly food crisis and may lead to civil unrest assuming other external forces such as climate change are held constant. The food production dataset used is obtained from the FAOSTATS portal. The total crop production in Africa has the area code 5100. It is extracted for the years 1961 to 2017. The plot (Figure 1) shows that crop production in Africa has steadily increased through the years with a steep increase observed after 1980.

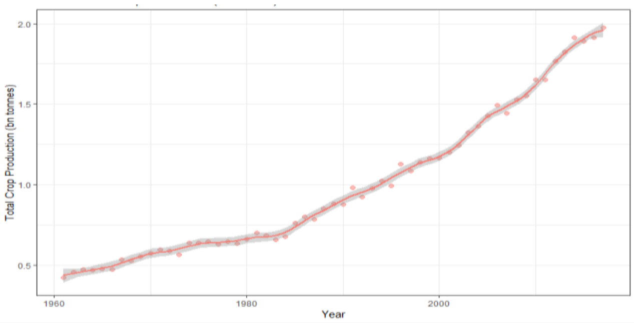

Figure 1. Africa's total crop production (1961-2017)

In Figure 2, it indicated that sugarcane was the highest produced crop in Africa with South Africa and Egypt being the highest producers (in 2017).

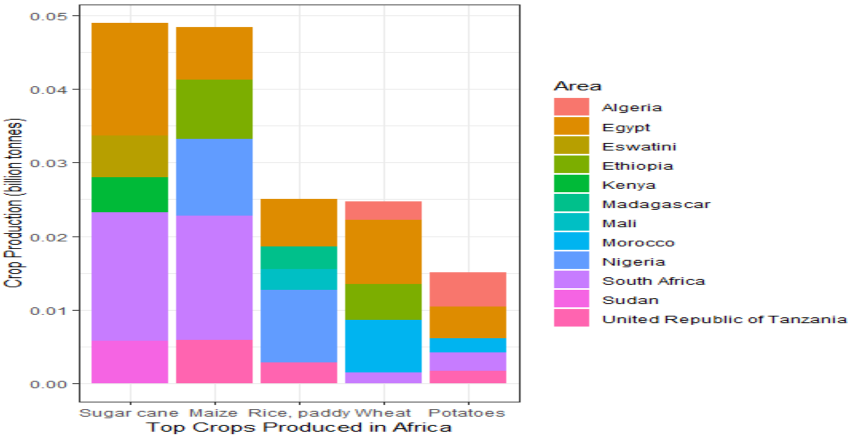

Figure 2. Top crops produced in Africa

Maize followed closely with South Africa still leading in the production process. It can also be noted that Kenya is among one of the top five producers of maize on the continent. There are 22 countries in the world where maize forms the highest percentage of calorie intake and 16 of them are found in Africa of which the Eastern and Southern Africa are the highest consumers of maize in Africa. It is the top-most important cereal on the continent (Macauley, 2015).

3.1 Crop production in Africa and population growth

As Africa's population size increases, the demand on food systems will likewise increase. Figure 3 shows the year on year rate of change of crop production and that of the population of Africa separately.

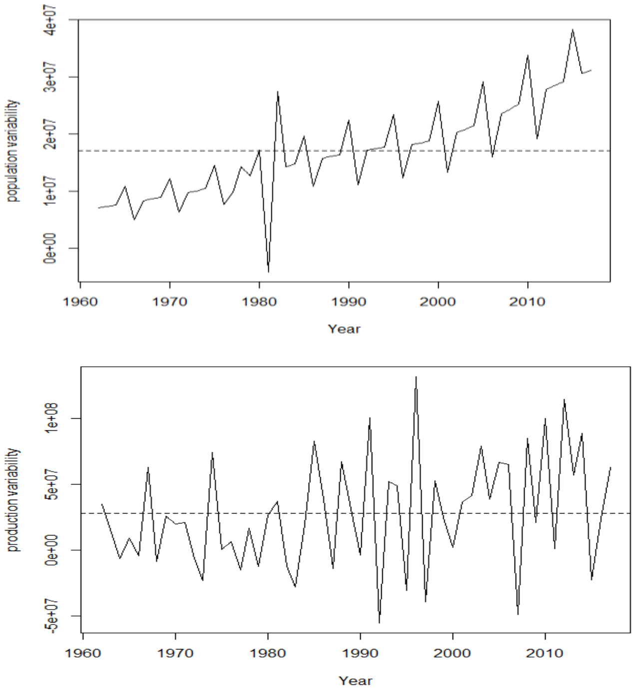

Figure 3. Year on year change in population (above) and crop production (below).

The linear regression model is applied to analyze the correlation between the population of Africa and its crop production. Here, population represents the explanatory variable while crop production is set as the dependent variable. The fitted regression line (Figure 4) indicates a good fit implying that a strong relationship exists between crop production and population growth in Africa.

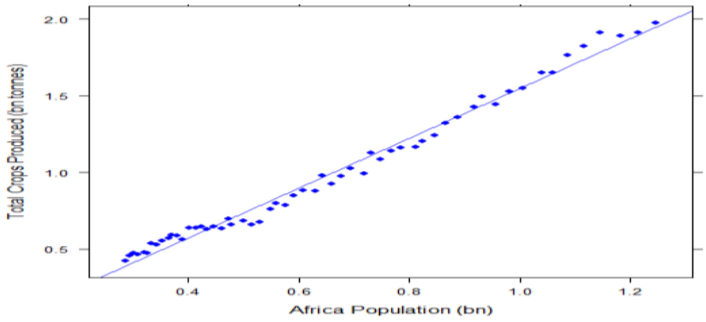

Figure 4. Africa's total crop production vs population growth

From the coefficient of the regression analysis, the model equation obtained is

$$\mathit{Crops\ production} = 1.625691 * \mathit{Population} - 74929470$$

This implies that for every additional billion people in Africa, the total crops produced needs to increase by approximately 1.6 billion tons.

Stress testing the crop production - population system

To further show the need for a corresponding increase in food production as population increases, we carried out a stress test on the crop production-population (cpp) rate of change system (simply referred to as the cpp system) based on their historical values. The rate of change of production with respect to population is plotted in Figure 5. This is obtained using the expression:

$$cpp = \frac{\mathit{rate\ of\ change\ in\ crop\ production}}{\mathit{rate\ of\ change\ in\ population\ growth}}$$

The system is stationary given that there is a temporary deviation from the equilibrium which is the long run mean and a reversion to the equilibrium value. In other words, the system is characterized by a mean reversion property implying that an internal balance mechanism exists in the relationship between crop production and population growth in Africa. In order to capture the change in behavior of the cpp system, the Vasicek model is fitted to the data and the parameters are estimated using the maximum likelihood estimation method giving us θ_1 = 23.11, θ_2 = 15.95 and the variance of the process or the volatility is θ_3= 17.44.

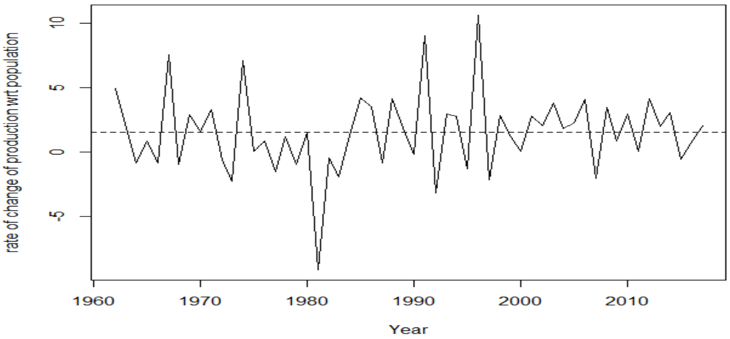

Figure 5. Rate of change of crop production with respect to population growth

In Figure 6, a single path is plotted based on the parameters obtained. When crop production is reduced but population is kept constant, the cpp system reflects no significant change; it still retains its stability as indicated in Figure 7. However, the equilibrium level shifts upwards (from 0.15 to 0.76) as production level decreases (from 10% to 50% of production). This scenario can represent a situation in which flood destroys crops or where the crops are attacked by a harmful bacteria or fungi. This can lead to a loss in crop production.

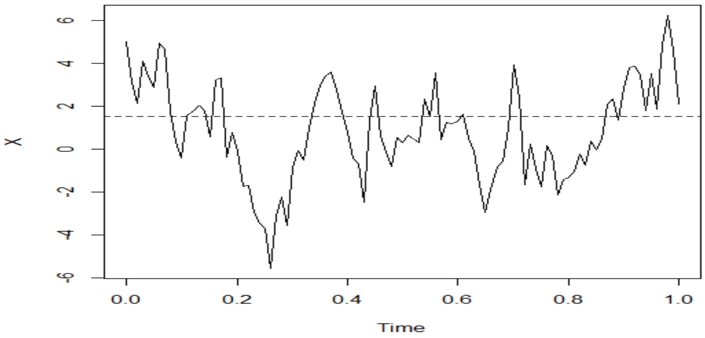

Figure 6. A single simulated path of cpp system using the Vasicek model

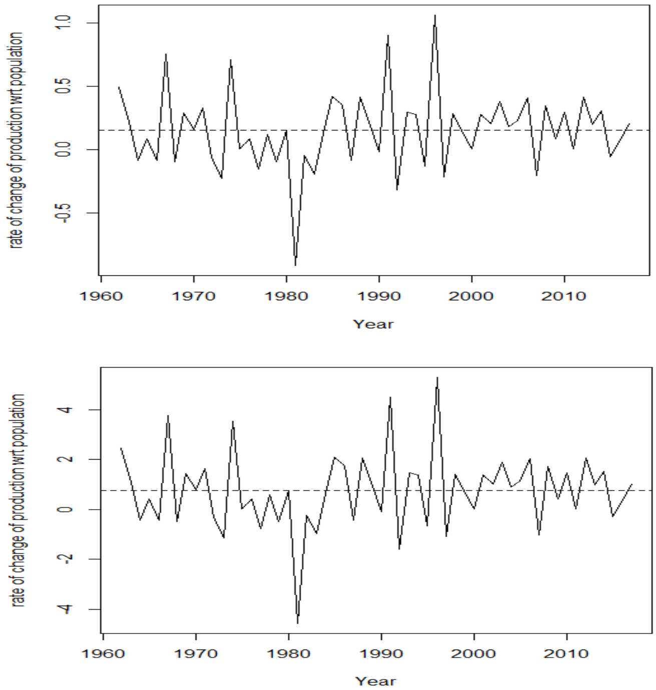

Figure 7. The cpp system shows no significant change when population is kept constant as crop production is reduced (10% of production (above) and 50% of production (below)).

The volatility dynamics, although not initially noticeable, is also seen to be affected when the Vasicek model is fitted (Table 1). A different observation is made when there is a simultaneous decrease in crop production and an increase in population by the same proportion.

Table 1.
Volatility dynamics associated ith only a decrease in production

Proportion of production	Volatility
0.1	17.44
0.2	3.55
0.3	5.32
0.4	6.96
0.5	8.75
0.6	10.54
0.7	12.06
0.8	14.16
0.9	15.65

The cpp system becomes unstable and the volatility changes significantly (increasing rapidly) with time (Figure 8). Similar observation is made when the production is kept constant and the population is increased.

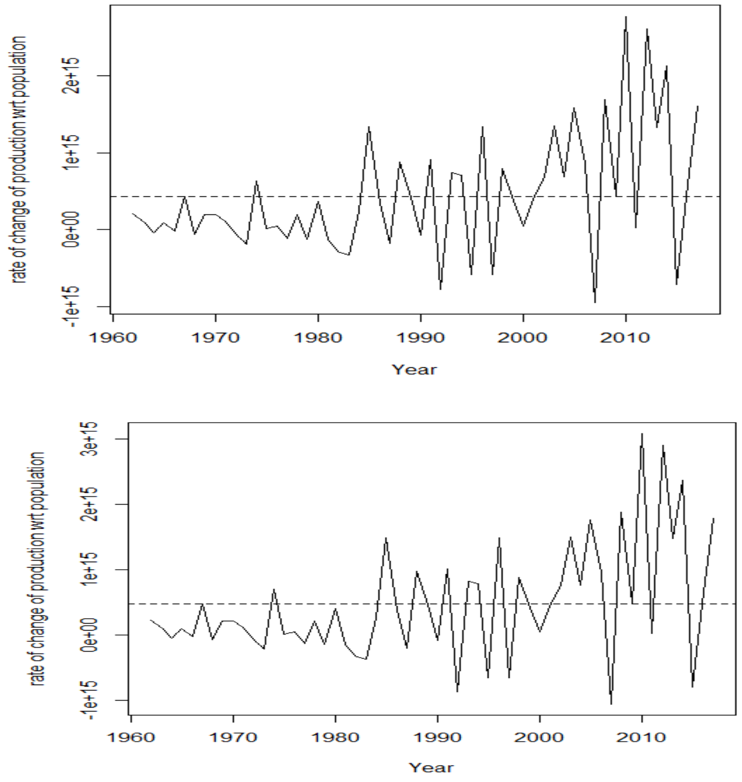

Figure 8. The cpp system becomes unstable once the population is increased, either with the same proportion (10%) as that applied to the reduction in crop production (above), or when crop production is kept constant (below).

This shows that, to maintain the balance in the cpp system and hence, guard against food insecurity, food production has to increase in like manner as the population increases. This will enable Africa achieve the sustainable development goal on food security.

3.2 Food insecurity indicators

In this section, Africa is subdivided into different regions - Western Africa, Southern Africa, Northern Africa, Eastern Africa and Middle Africa following the nomenclature of the dataset. The aim is to focus narrowly on regions that are performing well and those that are not based on the food insecurity indicators (FSI) highlighted by FAO. Three FSI have been selected for this purpose. They are the number of undernourished people (in millions), the prevalence of undernourishment (in %) which is an indicator combining moderate and severe levels of hunger. The third indicator is the average value of food production (constant $1 per person). Their respective item codes in the FAO dataset are 21001, 21004 and 21011. All the indicators come as three-year averages.

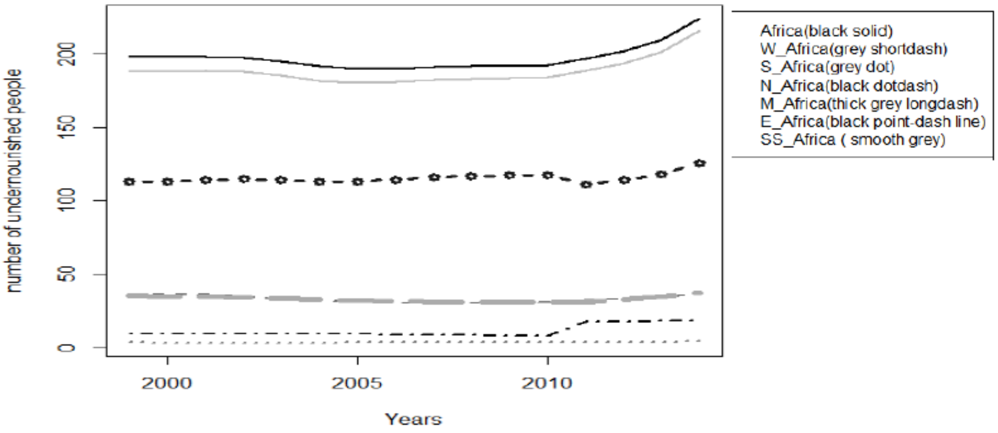

Figure 9. Number of undernourished people per region (1999-2014)

The region with the highest number of undernourished people is the East African region (Figure 9). This covers the period 1999-2014. Southern Africa ranks the lowest in this category.

A similar observation is made when the data for the prevalence of undernourishment is studied (Figure 10), East Africa again ranks number one indicating that more people are extremely hungry in that region than in other regions in Africa (1999-2014). It is way above the continent's average. On a sad note, Figure 10 reveals that the drop in the proportion of the prevalence of undernourished people has stopped and an increase in this proportion has taken off for all regions almost at the same time (the year 2010)

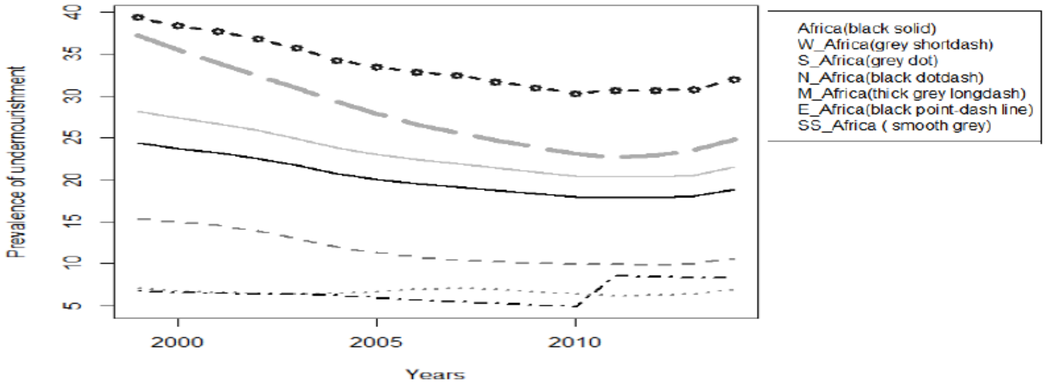

Figure 10. Prevalence of undernourishment in African regions (1999-2014)

The average food production (1999-2012) in East Africa is also below the continent's average (Figure 11) although this time it ranks next to the region with the lowest food production (Middle Africa). North Africa rose to the highest position in this category within the studied period and then began dropping to merge with Southern Africa.

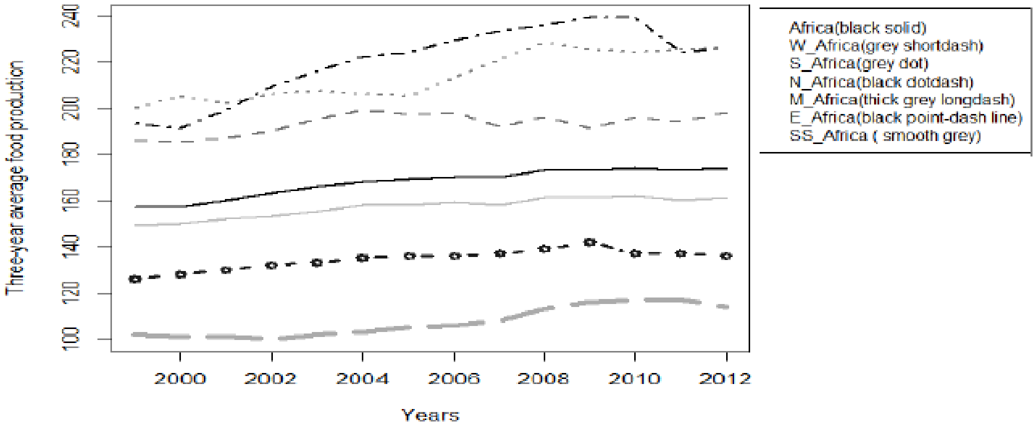

Figure 11. Average food production in African regions (1999-2012)

4 Food Access in East Africa: Analyzing the Quarterly Extremes of Maize Prices

The analysis in section 3 has demonstrated that the East African region ranks high on the food insecurity scale (FIS). This is a region that suffers from frequent drought occurrences. In this section, food access is explored specifically in this region and maize prices are used as the proxy. The aim is to find out whether a contagion effect occurs in the prices across the region.

Given the region's performance on the FIS, the existence of a contagion effect of the price of maize during stressed periods may worsen the situation in terms of increasing the frequency and intensity of food scarcity. This will in turn cause fewer people to have access to this staple grain, thus leading to more undernourished people in the region. Specific attention is paid to only three countries: Kenya, Ethiopia and Somalia.

In each case, the average of the maize prices from at least four markets in the chosen country is made use of. Details of the respective markets in each country and their prices can be seen in the UN Humanitarian data exchange global food price database. Figure 11 displays the maize price history for each country in their specific currencies. An eye inspection of this figure reveals a jump in prices between the year 2007-2010 and around the year 2012 after which it maintains this same level (for a while) for Kenya and Ethiopia but it falls in the case of Somalia. The rise between 2007-2010 may have been caused by the global food crises which began in 2006 and stretched to 2008 and that of 2012 may have been triggered by the widespread drought that occurred in that region during that period. The quarterly extremes which is represented by the highest maize price in each quarter are shown in Figure 13.

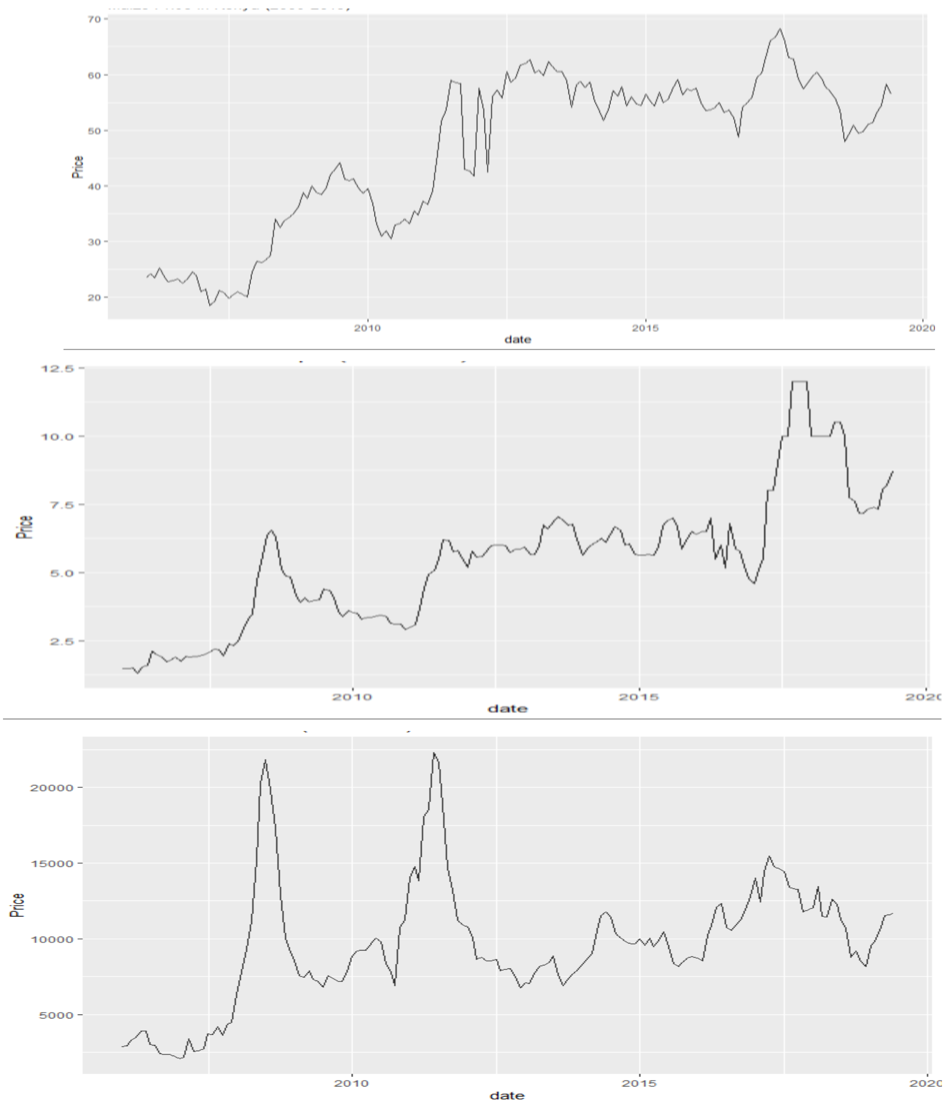

Figure 12. Maize prices in Kenyan shillings (top), Ethiopian Birr (middle) and Somali shillings (bottom) (2006-2019).

4.1 Dependence structure of extreme maize prices

A common platform is required to study the correlation structure of these monthly quarterly maize prices (MQMP), hence all the prices were converted to their dollar equivalents. This was done using the quarterly average exchange rates for each country within the period of study. The correlation was investigated using the Kendall tau and Spearman rho measures (Table 2) and this was compared to the result obtained using the Clayton and Gumbel copula tail dependence measures (Table 3). A further examination is carried out based on the Kendall tau measure where the years are broken into three periods - the global food crises period (2006-2009), the widespread drought period (2011-2012) and the normal period (2013-2018) in Table 4.

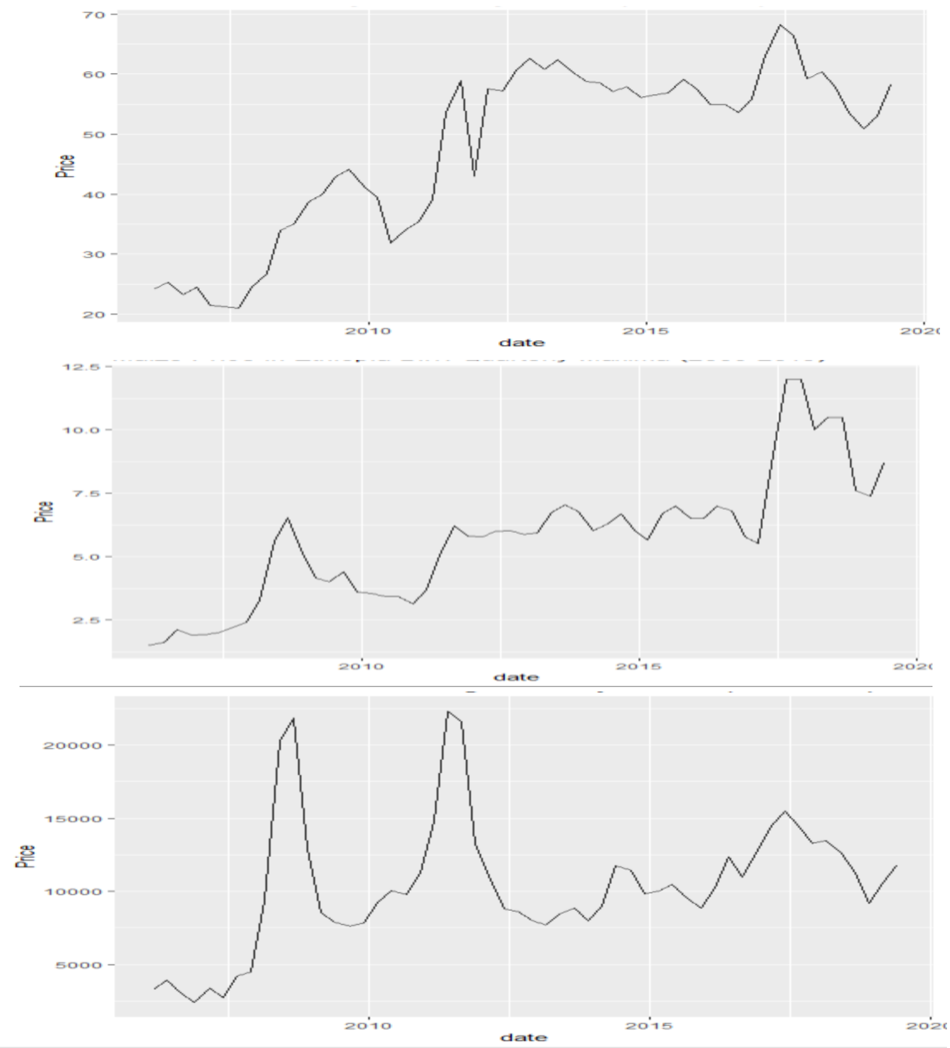

Figure 13. Extreme quarterly maize prices in Kenyan shillings (top), Ethiopian Birr (middle) and Somali shillings (bottom) (2006-2019)

A generally low to medium correlation structure of the extreme quarterly maize prices for all years (2006-2019) is observed. Spearman's rho measure is higher than the Kendall tau values. Table 2 reveals that Kenya-Ethiopia exhibits the highest correlation while the lowest is the Somalia-Kenya prices.

Table 2.
Kendall tau correlation

	Kendall tau	Spearman rho
Kenya-Ethiopia	0.36	0.51
Somalia-Ethiopia	0.27	0.40
Somalia-Kenya	0.19	0.29

Table 3.
Tail dependence of MQMP using copulas

	Clayton	Gumbel
Kenya-Ethiopia	0.53	0.44
Somalia-Ethiopia	0.40	0.34
Somalia-Kenya	0.23	0.25

The Clayton (lower tail dependence) and Gumbel (upper tail dependence) copulas also indicate some degree of tail dependence in the price pairs. The lower tail dependence persists more in the Kenya-Ethiopia and Somalia-Ethiopia pairs than in the Somalia-Kenya pair. This implies that a drop in maize prices in Kenya is more likely to trigger a drop in Ethiopia than in Somalia. In Table 4, the correlation structure is examined across different time periods.

Table 4.
Correlation structure across dates

	2006-2009	2010-2013	2014-2018
Kenya-Ethiopia	0.53	0.44	0.15
Somalia-Ethiopia	0.75	0.025	0.23
Somalia-Kenya	0.44	-0.28	-0.095

During the period covering the global food crises, a higher positive correlation is observed across all pairs. This, however, changes as the period comprising of the regional widespread drought steps in. A general drop in correlation occurs. This is indicative of the influence a global stressor has over the region's food prices than a local stressor. This drop is quite significant in the case of Somalia-Ethiopia (approximately zero) and it even becomes negative for Somalia-Kenya. Although there may be other forces at play to cause this negative relationship, considering only a widespread drought, this will imply that if maize prices rise in Kenya, it is more likely that a drop will ensue in Somalia and vice-versa given a drought occurrence that sweeps across the region. A slight rise in correlation begins to emerge for the last two pairs (in Table 4) after the drought-stress period.

Asymptotic dependence

The asymptotic behaviour of these extremes is checked by first fitting the generalized extreme value (GEV) distribution to the data and then performing a Monte Carlo simulation ($n = 1000$) using the parameters obtained (Table 5). The log plots of the simulated data for each pair is shown in Figure 14.

Table 5.
GEV parameters

	μ	σ	ξ
Kenya	0.52 (0.019)	0.13 (0.016)	-0.55 (0.10)
Somalia	7.51 (0.93)	5.26 (0.76)	0.13 (0.19)
Ethiopia	0.28 (0.01)	0.071 (0.01)	0.005 (0.09)

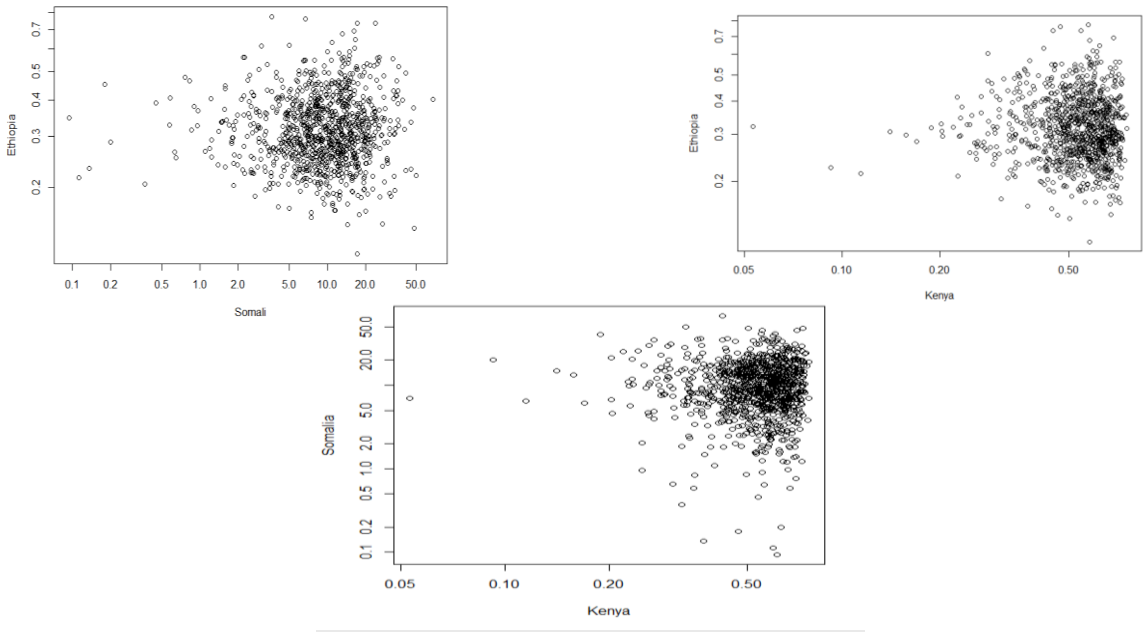

Figure 14. Monte Carlo simulated data from GEV parameters: Somalia-Ethiopia (top-left), Kenya-Ethiopia (top-right) and Kenya-Somalia (bottom))

A distinct pattern can be seen in only the Kenya-Somalia in which higher values of extreme maize prices in Kenya corresponds to extreme maize prices in Somalia. This is in line with the results gotten from the copula approach. It is only in the Kenya-Somalia case that the upper tail dependence (Gumbel) is higher than the lower tail dependence (Clayton). However, the fitted logistic model at the empirical 90% quantile corresponding to threshold vectors (20.47,0.45), (0.68,0.45) and (0.68,20.47) for the pairs Somalia-Ethiopia, Kenya-Ethiopia and Kenya-Somalia respectively, indicates that there are no extremal dependence existing in each pair (Table 6). This is because the Pickands dependence function α is approximately one in each case implying no asymptotic dependence.

Table 6.

Dependence parameter for the logistic model

	α
Kenya-Ethiopia	0.99 (0.00)
Somalia-Ethiopia	0.98 (0.03)
Somalia-Kenya	0.98 (0.03)

5 Summary, Conclusions and Policy Implications

Food systems as they relate to food availability and food access was examined in this paper. It was realized that Africa needs to increase its food production by about 1.6 billion tons to cater to each one billion increase in population. The stress test analysis indicated that if there is no corresponding increase in crop production as population increases the balance that exists between crop production and population will be lost. There was evidence to show that the East African region performs poorly when weighed on the food insecurity scale. This region exhibits some degree of tail dependence in the quarterly extreme prices of maize and this dependence is influenced more during stressed periods that are driven by global crises than by local crises.

5.1 Policy Implications

Although the African centre for strategic studies (2021) has stated that conflict is the primary driver of food crises in Africa and Dodo (2020) has highlighted six more reasons as to why Africa's food insecurity problems are chronic, they have failed to draw attention to the crop production-population (cpp) system. We therefore take this into account and further argue that the sustaining underlying cause may be attributed to bouts of shocks emanating from short periods of instability in the cpp system at localized levels which if sustained over longer periods, could result in multi-layered adverse effects. For instance in Nigeria, the desertification of the parts of the northern region is drastically affecting food production which inevitably is pushing pastoral communities down south in search of food for their cattle and for themselves, in a bid to sustain their rapidly growing population. At this juncture, the cpp system temporarily loses its equilibrium state, leading to the battle for highly limited resources particularly land, down south. Thus conflict ensues as a consequence.

This, therefore, throws lights on the dire need for African governments to pay close attention to the girl child in a bid to control excess population growth. It has been noted that many under-aged girls are still forcefully married off in Africa, ladened early in life with the burden of child bearing with little or no support in terms of family planning and healthcare.

Additionally, food insecurity feeds the fault lines of socioeconomic inequalities (Lukwa et al., 2020; Seligman et al., 2010; Sharpe et al., 2016; Whitaker et al., 2006; Shankar et al., 2017). Issues bordering on public health, malnutrition and poverty are made worse in regions like East Africa which ranks the lowest on the scale of the food insecurity indicators. Botreau and Cohen (2019) specifically highlighted that the devastating impact of the 2007-2008 and the 2010-2011 food price crises, ten years after, was still being deeply felt especially by women farmers who account for more than half of the workforce in the agricultural sector within Africa. Thus we can conclude that gender inequality is a major offshoot of food insecurity. They also pointed out that the decreased public investments in the agricultural sector and the inability of women to have easy access to adequate loans exacerbates the problem. This again emphasizes the fact that women will have to be prioritized when policy decisions are taken.

Furthermore, attention must also be given to other aspects of the food system. Global and local transport disruptions as experienced during the lockdown due to the COVID-19 pandemic or due to localized conflict eruptions usually aggravate food insecurity. Therefore, a much more efficient transport system is needed in order to reduce the transit time of food delivery. This will in turn positively impact on the prices of the foodstuffs and significantly reduce food spoilage.

Most importantly, climate change emergencies must be given utmost priority. For example, although water is vital for crop production, many strategic rivers are already drying up in Africa as a result of climate change, lake Chad being a very visible example (Climate Home, 2013). Hence climate as well as food and nutrition activists and stakeholders need to join their voices in calling for a more sustainable water irrigation system that makes use of new, available and reliable technologies since agriculture is a major contributor to Africa's economic growth. In the interim however, food aid may provide temporary relief but this is not a viable solution for Africa. Africa must work towards finding long-lasting, self-sustaining solutions by educating her population and engaging in the promotion of impactful policies.

Given that sustainable solutions are a product of evidence-driven policies, more indepth, critical research on the food systems in Africa needs to be carried out. One of such future studies could focus on the prediction of extreme quarterly maize prices particularly in the east African region.

Acknowledgement:

No acknowledgements to declare.

Funding:

This research did not receive any funding.

Conflict of interest:

The authors declare no conflict of interest.

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