Chapter

Regime Switch and Effect on Per Capita Food Security Issues in South Africa

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Abstract

This paper examines whether the food security situation in South Africa is sensitive to the past and present governance systems. The study was aimed at reviewing the performance of key indicators: per capita land utilization, price index and consumption of a major staple food commodity (maize) in the pre- and post-apartheid periods. It also aimed at validating the application of population growth and food advocacy theories on South African food security. Time series analysis involving variables such as per capital land cultivation, consumption/tons and price/tons of maize within the period of 1970 to 2010 was conducted. Threshold autoregressive model (TAR) approach was used to capture per capita food security status of South Africans and to monitor trends under apartheid and post-apartheid eras. We found that there is a declining trend in per capita land cultivation and mixed results of per capita consumption of maize. The study revealed that population growth in South Africa has not been harnessed and there is possibility of worsening food security in the country. The long-run effect between the variables was established. The study recommends per capita targeting policy strategies for the improvement of staple food production and dietary balancing to ensure sustainable food security.

Keywords: agriculture, maize, population targeting, threshold autoregressive model

1. Introduction

Food security has different dimensions and so has been defined by many authors from different angles [1]. However, food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preference for an active and healthy life is globally accepted [2].

Estimates show that out of 7.3 billion people in the world, approximately 795 million people or 1 in 9 were suffering from chronic undernourishment in 2014–2016 [3]. Almost all the hungry people, 780 million, live in developing countries, representing 12.9%, or 1 in 8, of the population of developing countries. Some 232 million people in Africa struggle with undernourishment daily [4]. This figure is about 29.3% of the total undernourished population and approximately 21% of the continent's population. Among all the regions of the world, sub-Saharan Africa is the only region that recorded a 10% (17.4–27.8%) increase in the number of hungry people between the periods of 1990–1992 and 2014–2016. Currently, 220 million people in sub-Saharan suffers hunger daily [4].

The continued population growth in Africa has rendered the per capita domestically grown food unchanged despite some improvements in agriculture with the resultant persistent hunger and poverty [5]. Although there has been tremendous growth in food production leading to a dramatic decrease in the proportion of the world's people that are hungry in the past decades, global food security situation still indicates that more than one out of seven people today still do not have access to sufficient protein and energy from their diet and even more suffer from some form of micronutrient malnourishment [6]. With the fastest population growth rate, Africa's population is projected to grow from about 796 million in 2005 to 1.8 billion by 2050 [7]. Despite urban migration, the number of rural dwellers will also continue to grow [8]. However, there are projections that parts of Africa, Asia and Central and Southern America will experience substantial declines in per capita cereal production if yields continue to grow slowly than per capita harvested areas [9]. Per capita food production in Africa declined by almost 20% between 1970 and 2000 [10].

Agriculture in African countries is widely seen to have performed worse than in Asia and Latin America. Production data per capita (of the total population) indicate that the amount of food grown on the continent per person rose slowly in the 1960s, then fell from the mid-1970s and has recently just recovered to the level of 1960 [5]. Comparatively, per capita food production increased by 102% in Asia and 63% in Latin America during the same period [5]. Studies have identified reduced investment in agricultural research, extension services and production systems by both the government and donor agents as the reasons for this [11–14]. Africa derives about 25% of its GDP from agriculture which provides jobs for 70% of the labour force, as well as a livelihood for more than 65% of the population [8]. It is however important to note that the level of local agricultural production will be determined by the amount and quality of arable land, the amount and quality of agricultural inputs (fertilizer, seeds, pesticides, etc.) as well as farm-related technology, practices and policies [9].

Interestingly, while some countries in Africa have witnessed growth in production [15], it has not necessarily improved the household food security status in the continent. South Africa produces enough food to feed its population; however, the country is increasingly experiencing worsening household food insecurity [16]. Despite the rise in employment in the country [17] and introduction of social grants by the government [18], the country has known little respite in terms of household food insecurity. About 35% of South African's population (14.3 people) experience hunger and undernutrition of which the majority are women and children [19]. Issues of ever-increasing food prices, lack of access to production resources and increased cost of electricity and oil prices are expected to make many more becoming food-insecure in South Africa [20, 21].

South African per capita land cultivation cannot be separated from the past dichotomous land ownership during the apartheid era where the white had ample access to land due to several discriminatory policies [22]. Effectively, many households in the so-called rural areas were and remain landless, while many others were left with tiny amounts of land. There are a few local black farmers that have private tenure of certain areas. Despite the abolition of the former homeland systems and subsequent redistribution of several commercial farms to emerging black farmers through leasing, access of other villagers to these lands for cultivation or collection of resources has been restricted under this arrangement [23].

South Africa is believed to have enough food supplies at a national level adequate to feed the entire population. However, a number of studies have revealed evidence of undernutrition among certain segments of the population [24]. There are evidence of undernutrition among certain segments of the population [25]. Inadequate nutrient intakes are often caused by household food insecurity, defined as a household's lack of access to amounts of food of the right quality to satisfy the dietary needs of all its members throughout the year [26]. Similarly, land requirements for food are determined by the production system, e.g. yields per hectare and efficiency in the food industry, which are also the resultant of consumption patterns [27].

1.1 Theoretical framework/theory underpinning the study

This study is underpinned by the Malthusian theory advanced by Thomas Malthus (1806) and the theory of food sovereignty promoted during the recent food crises of the 2007–2008 period. Malthusian theory is characterized by the views that there are too many mouths chasing too few calories as the population increases, lack of capacity to meet our food needs due to significant structural constraints, water and land degradation, distributional conflicts, and widespread, chronic food insecurity. Malthus in his prediction failed to conceive the development of important variables such as birth control and technology advancement in Agriculture. Although Malthus's theory promulgated in more than 220 years ago has been proven to be wrong, the question in the developing nation is how this growing population can be harnessed to produce enough food for all the population. The food sovereignty theory, unlike the Malthusian theory, believes that population growth is not the problem but the over-bearing power of international trade systems. Proponents of national food sovereignty movements generally favor agricultural policies that promote domestic production as an alternative to reliance on food imports. The theory of food sovereignty was first mentioned in 1996 when it became obvious that the global food organizations have no idea on how to ensure a food-secured world. Since then, the idea has gained prominence most especially in South America. Proponents of food sovereignty believe that all people have a right to healthy and culturally produced food through sustainable methods with local farmers having control over their own agricultural system [28]. The activists of food sovereignty are rallying cry against global agribusiness that stifles livelihood of smallholder farmers [29]. Food sovereignty theory rejects dependence on heavy chemical input for crop production that breed disparity in food access in the midst of growing food production [30]. It revolves around the concept of prioritizing local and household producers with opportunity of fair prices with the emphasis of community having control over productive resources like water, land and seed [31–33]. This theory believes that if they strive for a food-secured world, most go beyond the definition of the food security that revolved around sustenance of global food stock through international trade but do everything to empower the community with the right to produce for themselves rather than depending on the international market [29].

Finally, the trajectories by both theories speak to household food security and form a strong basis for analyzing per capita food status in South Africa. Although the Malthusian theory leans towards the far right on the outstripping tendencies of population growth based on limited resources, the theory of food sovereignty went too far to the left by opposing improved inputs most especially the chemicals and having nothing to do with international trade system. Considering the duality and capital-intensive agricultural sector of South Africa, a balanced food sovereignty theory will not only lead to local economic growth; it will also help engage the youthful population into productive farming activities, thereby improving per capita food security in South Africa.

Since the democratic dispensation in 1994, South Africa has undergone immense policy interventions aimed at improving the production capacity and food security situation of the citizenry. One of these policies, the Integrated Food Security Strategy (IFSS), was targeted mainly at increasing access to productive assets, including credit; increasing access to technologies, including food processing; supporting agriculture extension services; and improving infrastructure and trade regulations [34]. Another policy action, the Comprehensive Agriculture Support Programme, aimed at providing post-settlement support to the targeted beneficiaries of land reform and to other producers who have acquired land through private means and are engaged in value-adding enterprises for the domestic or export markets [35]. The programme was developed to benefit the hungry, subsistence and household food producers, farmers and agricultural macro-systems in the consumer environment. However, all these good policies have not really achieved the desired post-apartheid South African dream as the country's Human Development Index is ranked 118 among 135 countries and Human Poverty of 13.4% and ranking of 85 amidst all policies and strategies of improving the agriculture and food security (Global Food Security Index) [36].

This paper seeks to explore three main questions of South African food security systems. These questions are: is South African food security status sensitive to the past and the present governance regimes? Is the nationally acclaimed food sufficiency reflected in the household level? What effect does population growth in South Africa have on the food security status, is it positive or negative? These research questions are expected to generate inherent information on food security situations among South African households during the past apartheid era and the current black-dominated governance systems. This paper is set to determine per capita food security situation among South Africa households during the apartheid and post-apartheid eras. Specifically, the study seeks to determine the trend in per capita land cultivated, the price index and consumption level of maize staple foods. Various approaches have been followed to assess the world food situation. These include the development of large econometric models or the computation of technical indicators such as the population carrying capacity of the planet [37]. Within the South African context, many studies have focussed on food security status with different methodologies [20, 38, 39]; among others is a study that presents a policy impact analysis of South African food security [34]. However, this paper explores a new route, a simple-time series indicator approach. We used the indicator approach to capture food security status because it aids the process of monitoring trends and provides practical decision-making processes for enhanced policy-making processes and intervention strategies to cater for the most vulnerable individuals. We build on the theory of population growth as well as the food sovereignty theory for the comparison of per capita food security situation in apartheid and post-apartheid eras of South Africa. The analysis was undertaken to provide macro level trend information on the three main indicators: per capita land access, per capita staple food production and per capita consumption of staple food during the two important eras of South Africa. The insight and knowledge generated will be required for future policies formulation and interventions towards achieving sustainable food systems and security in South Africa.

2. Methodology

This study falls under post-positivism paradigm which believes that there is an empirical reality but that our understanding of it is limited by its complexity and by the biases and other limitations of researchers who conduct such research. Post-positivism holds that the goal of science is to achieve intersubjective agreement among researchers about the nature of reality rather than rely on the objective reality perceive through methods. In essence, issues should be viewed through the contributions of community of researchers rather than any individual researcher. Therefore, to address the research question, a quantitative approach was undertaken involving a time series data analysis. Similar to the approach by the FAO and USDA, a series data on Food Availability (Per Capita) Data System (FADS) include three distinct indicators which are land cultivated, price per ton and total food consumed of the selected staple food (maize). The study uses the threshold autoregressive model which is a nonlinear approach of representing time series data as suggested by practitioners who describe the basic proponents of the model [40].

2.1 Data collection

Secondary (times series) data on Production of the main staple food crops were sourced from National Agricultural Marketing Council (NAMC) from the period of 1970 to 2010. This paper focused on maize as the main staple food in South Africa. We believe the data are viable and reliable because NAMC is established by acts; it is recognized to offer advice to the government on food and trade issues. The data covered land cultivation, total production and consumption of these food crops. Corresponding national population for the same period (1970–2010) was also obtained from NAMC. It is worthy to note that the study was limited to the available and complete data on food commodity.

We undertake series data to determine food and dietary intakes of South Africans because it provides a pattern of food and dietary evolution over time, as a result of many factors and complex interactions. The factors are historical political change, income, prices, individual preferences and beliefs, cultural traditions as well as geographical, environmental, social and economic factors which all interact in a complex manner to shape dietary consumption patterns. Data on the national availability of the main food commodities provide a valuable insight into diets and their evolution over time [41].

2.2 Data analysis

Per capita land cultivation (ha), price index per tonne and capita consumption per tonne of the selected food crops were estimated by dividing total land cultivated and total consumption by the total population of South Africa. The percentage change in these food security indicators was also calculated to determine whether there have been positive or negative changes over the period under analysis.

The estimation of past and present (1970–2010) South African food security indicators for the selected staple foods was done through the equations below similar to the one used by the FAO:

$$PLCi\ (t) = TArabi\ (t)/Tpop(t) \tag{1}$$

where PLC is the per capita land cultivated of commodity i at time (t), $TArab$ is the total arable land of commodity i at time (t) and $Tpop$ is the total population at time (t).

The equation is expanded and modified into a multivariate regression by including the following explanatory variables that affect cultivated per capita land, namely, consumption per tonne and price index of maize. The regression is as follows:

$$LCUL\_CAP_t = \beta_0 + \beta_1 PRCE_t + \beta_2 CONSUMPTION_t + \varepsilon_t \tag{2}$$

where $LLCUL\_CAP_t$ is the ratio of the per capita land cultivated of the maize divided by the total population which is the dependent variable, $PRCE_t$ represents the price index of maize, $CONSUMPTION_t$ is the consumption per tonne of maize and $\mathcal{E}_t$ is the residual value for the regression. The TAR model in the following regression equation was adapted from a nonlinear approach study [42] based on Turkey's debt distress status [41]. The equation therefore for the purposes of the study is inscribed with threshold variables as price per tonne and consumption per tonne, with the dependent variable as per capita land cultivated:

$$\Delta y_t = \theta'_1 x_{t-1} 1_{(Z_{t-1} < \lambda)} prce + consumption + \theta'_2 x_{t-1} 1_{(Z_{t-1} \geq \lambda)} prce + consumption + e_t \tag{3}$$

where $x_{t-1} = \left(y_{t-1} r'_t \Delta B_{t-1}, \ldots, \Delta y_{t-k}\right)'$, and Z_{t-1} is the threshold variable per capita land cultivated of the maize to the total population which is the dependent variable ratio (LCUL_CAP) and includes explanatory variables, PRCE and CONSUMPTION for $t = 1, \ldots, T$, e_t is an iid error and $1_{(.)}$ is the Heaviside indicator function represented as follows:

$$1_{(.)} = \begin{cases} 1 & if\ Z_{t-1} < \lambda \\ 0 & if\ Z_{t-1} \geq \lambda \end{cases} \tag{4}$$

The threshold λ is given as unknown; this means the values in the interval $\lambda \in \Lambda = [\lambda_1, \lambda_2]$ where both threshold values are observed so that $P(Z_t \leq \lambda_1) = \pi_1 > 0$ and $P(Z_t \leq \lambda_2) = \pi_2 < 1$; the specification of the threshold variable Z_{t-1} assists as a framework of analysis of results that the variable is predetermined, strictly stationary and ergodic with a continuous distribution function [40].

The vectors θ_1 and θ_2 are distinguished according to specific components and are discussed as follows:

$$\theta_1 = \begin{pmatrix} \rho_1 \\ \beta_1 \\ \alpha_1 \end{pmatrix}, \quad \theta_2 = \begin{pmatrix} \rho_2 \\ \beta_2 \\ \alpha_2 \end{pmatrix} \tag{5}$$

With scalar quantities represented by $\rho_1$and ρ_2 as the slope coefficients on y_{t-1}, β_1 and β_2 which have the same dimensions as r_t represent the slope on the deterministic components, α_1 and α_2 are the slope coefficients on $\left(\Delta y_{t-1}, \ldots\ldots., \Delta y_{t-k}\right)$ for the observed regimes.

The threshold estimates of the model are carried out with the use of least squares technique (more specifically, in this study we use the Huber-White covariance method in order to adjust the variance–covariance matrix of a fit from least squares, for heteroscedasticity and correlated responses). Each of the threshold value intervals $\lambda \in \Lambda$ is estimated by least squares (LS) as follows:

$$\Delta y_t = \hat{\theta}_1(\lambda)' x_{t-1} 1_{(Z_{t-1} < \lambda)} prce + consumption + \hat{\theta}_2(\lambda)' x_{t-1} 1_{(Z_{t-1} \geq \lambda)} prce + consumption + \hat{e}_t(\lambda) \tag{6}$$

where we let $\hat{\sigma}^2(\lambda) = T^{-1}\sum_1^T \hat{e}_t(\lambda)^2$ be the LS estimate of σ^2 for a fixed λ. The threshold estimate of the threshold value is found by minimizing $\sigma^2(\boldsymbol{\lambda})$ which are represented as

$$\hat{\lambda} = \underset{\lambda \, \epsilon \, \Lambda}{argmin} \, \hat{\sigma}^2(\boldsymbol{\lambda})$$

To find the least squares estimates of other parameters, a point estimate $\hat{\lambda}$ is used in relation to.

$\hat{\theta}_1 = \hat{\theta}_1(\hat{\lambda})$ and $\hat{\theta}_2 = \hat{\theta}_2(\hat{\lambda})$; thus the least squares estimated threshold model is as follows:

$$\Delta y_t = \hat{\theta}'_1 x_{t-1} 1_{(Z_{t-1} < \hat{\lambda})} prce + consumption + \hat{\theta}'_2 x_{t-1} 1_{(Z_{t-1} \geq \hat{\lambda})} gsr + prce + consumption + \hat{e}_t \tag{7}$$

Eq. (7) shows the least squares residuals $\hat{e}_t$ and denotes the residual variance from the least squares estimation as $\hat{\sigma}^2 = T^{-1}\sum_{t=1}^T \hat{e}_t^2$, this equation is used in this study to draw standard Wald statistics and t-statistic inferences on parameters from Eq. (3) which can test the possible presence of nonlinearity.

Threshold effects

This examination utilizes the Wald test measurement to address the subject of whether the parameters of condition (3) have the nearness of limit impacts and the likelihood of general nonlinearity. This strategy is utilized in application to help the investigation of nonlinear time arrangement [40]. The limit impact vanishes under the joint theory where

$$H_0 : \theta_1 = \theta_2 \tag{8}$$

Condition (8), is a limitation that is tested through the observation of the standard Wald test written as: $W_T = T\left(\frac{\hat{\sigma}_0^2}{\hat{\sigma}^2} - 1\right)$; with $\hat{\sigma}^2$; speaking to the leftover difference from condition (6) and $\hat{\sigma}_0^2$ characterized as the remaining change from OLS estimation in condition (7) of the edge model. The dismissal of the invalid theory in condition (8) implies that there is factual importance of the logical factors of the model and that edge impacts exist.

Unit root test, asymmetry and cointegration

To test for stationarity, the test statistics are observed for the parameters ρ_1 and ρ_2 since they control the stationarity process of y_t in Eq. (3); as such, the null hypothesis is represented as follows:

$$H_0 : \rho_1 = \rho_2 = 0 \tag{9}$$

Eq. (3) is then rewritten as a stationary threshold autoregression in the variable Δy_t also implying y_t is $I(1)$ and therefore has a unit root.

Moreover, in a situation where $p = 1$, the model becomes stationary if $\rho_1 < 0, \rho_2 > 0$ and $(1 + \rho_1)(1 + \rho_2) < 1$. Hence this suggests an alternative to H_0 represented as $H_1 : \rho_1 < 0$ and $\rho_2 < 0$.

Unit root test can also be observed in a partial case where the alternative hypothesis reads as:

$$H_2 : \begin{cases} \rho_1 < 0 \; \frac{and}{or} \; \rho_2 = 0, \\ \rho_1 = 0 \qquad \rho_2 < 0. \end{cases}$$

Given that H_2 holds, then y_t will be observed as a unit root process in a single regime and a stationary process in another regime. Thus, in this case, a nonstationary process is observed, which is not a classic unit root process.

2.2.1 Augmented Dickey-Fuller (ADF) test

The ADF is the improved expansion of the condemned DF methodology and in that capacity is improved by including the slacked estimations of the reliant variable ΔY_t. The ADF test comprises of assessing the relapse as pursues [43]:

$$\Delta Y_t = \beta_1 + \beta_2 + \delta y_{t-1} + \sum_{i=t}^{m} \propto_i \Delta y_{t-1} + \varepsilon_t \tag{10}$$

where ε_t represents the pure white noise term, $\Delta y_{t-1} = (y_{t-1} - y_{t-2})$, which shows the number of lagged differences which are often determined empirically. ADF also tests whether the unit δ is equal to zero and thus largely determines the trend stationarity and nonstationarity.

2.2.2 Phillips-Perron test

The Phillips-Perron (PP) test is a non-parametric methodology with the thought of disturbance parameters and consequently takes into account heterogeneous information circulation and pitifully subordinate factors [44]. The test is depicted to be increasingly vigorous regarding unspecified sequential relationship and heteroscedasticity in the model. Other studies legitimize the utilization of non-parametric test with regard to ordinariness suspicions being disregarded and affirm that non-parametric test like the Phillips-Perron test does not accept symmetry or any fundamental conveyance and is considerably more productive and incredible than parametric techniques [45].

The regression for the PP test as proposed by Phillips and Perron is represented as follows:

$$y_t = \alpha + \rho y_{t-1} + e_t \tag{11}$$

where e_t is the Heaviside pointer I(0) and takes into account heteroscedasticity and all things considered the PP test revises for sequential connection and heteroscedasticity mistakes in e_t. The test insights under this model are appeared as $t_{p=0}$ and $T_{\hat{p}}$ which are changed and communicated as Z_t and Z_p measurements.

2.2.3 When threshold is unknown

For this situation, asymptotic conveyance is tried when there is no edge impact, implying that the limit esteem is obscure and hence the p esteems are additionally obscure for the given parameters. This is as indicated by hypothesis 5 by [40] where $\theta_1 = \theta_2$; therefore, $(t_1, t_2) \overset{\cdot}{\Rightarrow} (t_1(u*), t_2(u*))$ and $R_T \overset{\cdot}{\Rightarrow} R(t_1(u*), t_2(u*)) \leq \sup_{u \in [\pi_1 \pi_2]} R(t_1(u), t_2(u))$ where $u* = \underset{u \in [\pi_1, \pi_2]}{argmax} T(u),$.

This means that t-statistics are distributed by the functions $t_1(u)$ and $t_2(u)$ at random argument u^*. The trimming range represented as $[\pi_1, \pi_2]$ is free from nuisance parameters. The simulation of Monte Carlo experiment critical values of the 5% significance level is approximated to 10,000 replications. In summary, when there is no threshold effect observed, then the threshold value λ is not identified, and thus $\hat{\lambda}$ will remain the random sample, causing R_T to be random.

An Enders and Siklos test for cointegration and edge alteration is utilized [46] and is an expansion of the Engle-Granger test in light of the fact that it shows great power and size property over the Johansen test which accepts symmetric change in long-run balance [47], while, actually, Enders and Siklos test catches the topsy-turvy nature of long-run equilibrium modifications.

2.2.4 When threshold is known

In the case where the threshold effect is observed, this means that a threshold value (λ_0) is identified and thus the parameters of Eq. (3) are not equal, $\theta_1 \neq \theta_2$; it is also assumed that $E\Delta y_t = 0$ which is observed in model (3) given that assumption 1 by Caner and Hansen which shows $\mu_1 P(Z_{t-1} < \lambda) + \mu_2 P(Z_{t-1} \geq \lambda) = 0$ holds. However if $E\Delta y_t \neq 0$, then a time trend is included in model (3), and Δy_t is replaced with $\Delta y_t - E\Delta y_t$; therefore, a long-run variance and long-run correlation are defined given that the Δy_t remains stationary and ergodic; hence, we let

$$\sigma_y^2 = \sum_{k=-\infty}^{\infty} E\left(\Delta y_t \Delta y_{t-k}\right) \tag{12}$$

According to Theorem 6 by Caner and Hansen, if the parameters from Eq. (3) are not equal, and if $E\Delta y_t = 0$ and the variance $\sigma_y^2 > 0$, then the t-statistic function is given as

$$-t_1 \dot{\Rightarrow} \left(1 - \delta_1^2\right)^{1/2} Z_1 + \delta_1 DF \ll DF \;\; and \;\; -t_2 \dot{\Rightarrow} \left(1 - \delta_2^2\right)^{1/2} Z_2 + \delta_2 DF \ll DF$$
$$Given\ that \begin{pmatrix} Z_1 \\ Z_2 \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \sigma_{21} \\ \sigma_{21} & 1 \end{pmatrix}\right) \tag{13}$$

Along these lines, this is autonomous of the negative of the traditional without pattern Dickey-Fuller t-circulation. Additionally, the Dickey-Fuller gives a preservationist bound on asymptotic dispersion, yet in addition the two-sided Wald test measurement has a valuable articulation and bound which is accounted for under hypothesis 6. In outline, when an edge impact is watched, this implies λ is distinguished, and for extensive examples, λ will be close to the true value of the threshold λ_0; this means that the asymptotic distribution of R_T is similar to the case where the threshold value λ_0 is known.

The threshold adjustment for cointegration uses the Enders and Siklos test for a case when the threshold value is known. The null hypotheses $P_1 = 0$ and $P_2 = 0$ along with the joint hypothesis are $P_1 = P_2 = 0$, while t-Max is the maximum threshold with the largest test statistic, with F statistic denoted by ϕ, and thus the ϕ statistic can reflect a rejection of the null hypothesis $P_1 = P_2 = 0$ at the point when just a solitary one of the qualities is negative. In any case, on the off chance that both the p esteems are negative in measurement nature, at that point the invalid theory comes up short conceivable dismissal. Furthermore, the ϕ measurement rejects the invalid speculation of no cointegration at the 1% criticalness dimension, and t-Max measurement rejects the invalid theory at 5%, yet not the 1%, centrality level, in this manner inferring that the disseminations of ϕ and t-Max will rely upon test estimate and the quantity of factors incorporated into the cointegration relationship. Be that as it may, the outcome is controlled by the utilization of the Enders and Siklos test approach and Monte Carlo basic qualities that additionally depend on the dynamic idea of the threshold adjustment process.

3. Results and discussion

3.1 TAR model results

LLCUL_CAP is the threshold variable and is separated into two regimes with observations. The TAR model shows the threshold value for both regimes to be −2.09%, with the first regime consisting of 16 observations ($Z_{t-1} < \lambda$) and the second regime having 22 observations ($Z_{t-1} > \lambda$). The threshold level is negative in the analysis because arable land is a fixed asset that cannot be increased, while the South African population growth is increasing. The relationship between the threshold variables and the explanatory variables (price per ton and consumption per ton) is differentiated into the different regimes. In the first regime with 16 observations, the price per ton shows a coefficient of −0.1365 and carries a negatively related coefficient against the cultivated land/area, which means that an increase in LPRCE_TON has the effect of decreasing LLCUL_CAP (per capita maize-cultivated land) with a margin of 13.7%; this is shown in **Table 1**.

Consumption per ton (LCONSUPTION_TON) also carries a negatively related coefficient of −0.8236 against the threshold variable (cultivated land) which suggests that increases in consumption per ton put downwards production pressure on cultivated land area, with a margin of 82.4%. The denoted relationship therefore resulted in 16 observations that are less than the threshold value which suggests that during the pre-1994 apartheid era, the negative relationship was sustainable and did not go past the threshold level of −2.09%; in the first regime, the LPRCE_TON is not statistically significant with t-statistics and p-value that are above the 5% significance level, while LCONSUPTION_TON is reported to be statistically significant as p-values are less than 5%; this is shown in **Table 1**.

In the case of the second regime, both explanatory variables are statistically significant, with p-values that are below 5%. The threshold variable (cultivated land) has 22 observations that are below the threshold value indicating unsustainable per capita food security. The coefficient for both price per ton and consumption per ton is still negatively related in the regime, with LPRCE_TON shown as −0.265 and LCONSUPTION_TON as −0.6907. These values suggest that an increase in LPRCE_TON and LCONSUPTION_TON results in decreasing cultivated area/land of maize. The results suggest the cultivated land area of maize was not sustainable at the threshold value of −2.09% for food security and imply that the cultivated land area has diminished beyond the negative threshold value with at least 22 observations.

A more descriptive observation of the result is shown by **Figure 1** for actual, fitted and residual model for the transformed data. More specifically, attention is given to the actual and fitted model in the figure. As from 1970 to 1988, the first regime is observed, while the second regime continues from 1989 to 2010, where the first regime with 16 observations shows the cultivated land remains sustainable even though it negatively slopes and decreases. However, in the second regime, as located from 1989, the behaviour changes, because the actual and fitted models show a further decline in cultivated land area beyond the threshold value at 22 observations; this makes the second regime unsustainable.

The results of per capita consumption and the change in consumption trend over the period of analysis from 1970 to 2010 are indicated in **Figure 1**. The food security indicators (per capita land cultivated and per capita consumption) presented in **Figure 1** indicate the validity of food sovereignty theory with the evidence that

Threshold variables								
	LLCUL_CAP(−3) < −2.09 with 16 observations $Z_{t-1} < \lambda$ (first regime)				LLCUL_CAP(−3) = > −2.09 with 22 observations $Z_{t-1} > \lambda$ (second regime)			
	Coefficient	**Std. error**	**t-statistics**	**p-values**	**Coefficient**	**Std. error**	**t-statistics**	**p-values**
LPRCE_TON	−0.136533	0.085868	−1.590037	0.1214	−0.265049	0.042998	−6.164189	0.0000
LCONSUPTION_TON	−0.823665	0.280937	−2.931847	0.0061	−0.690729	0.257767	−2.679666	0.0114
	Non-threshold variable							
C	5.621432	2.146702	2.618636	0.0132				

Table 1.
TAR model estimates.

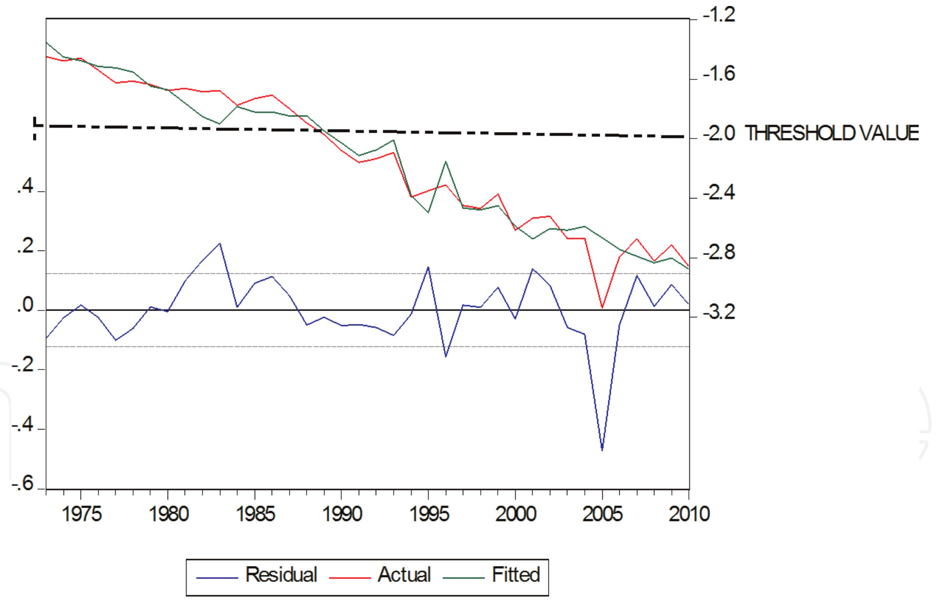

Figure 1.
Actual, fitted and residual models.

growth in income and productivity captured by gross domestic products (GDP) of South Africa has not necessarily translated to a food-secured country, and at the same time, the evidences that households have not been put to their optimum productivity in agriculture, hence the declined per capita food security within the household level. The dynamics of the past era coupled with interaction between increasing population growth, lack of employment, and food prices have really affected food security status of South African households. The increase in poverty and food insecurity in South Arica has opened up debate and focussed the attention of the governments and researchers towards the development of strategies that will rediscover issues on vital production such as land ownership, natural resources renewal and conservation and holistic revamping of support systems. In a similar study, a reported decline in land cultivated of staple foods in South Africa is a result of population growth, land use changes and reduction in yields per hectare [48]. Available evidence indicates that most African nations are facing increasing rural population densities and person-to-land ratios, as well as increasing agricultural labour force amidst decreasing area under crop cultivation [49].

Global and regional per capita decline has been projected [9]. However, it was estimated that per capita cereal production in Southern Africa will increase annually by 8% till 2030. Our analysis showed that maize per capita production has had a turbulent increase in the recent past with the tendency of dropping (**Figure 1**). Climate change and substantial water scarcity intensified by anthropogenic increases in air temperature and evaporation [50]. It is also expected that rapidly growing populations and increasing temperature will place further demands on scarce water supplies [51]. Biofuels and rising demand by the global middle class will probably compete for global production, raising prices and reducing food access for rural and urban poor.

3.2 Emerging themes

We have used time series data to analyze per capita food security involving three main indicators: land utilized for cultivation of maize, price index of maize and consumption of maize during the apartheid and post-apartheid eras of South Africa. Below are some emerging themes that came out of the analysis:

3.2.1 Diminishing returns and unharnessed growing population

The case of diminishing returns on productive resources, especially in the agricultural sector, was evident in the analysis. While this cannot be pinned to a specific factor due to the nature of the study, it suffices to say here that great attention must be paid to the environmental factors that surround agricultural resources such as land and water, most importantly in the face of the threatening global climate change. We also found that as the population grows, the per capita indicators declined. This shows that there are issues of unutilized segment of population and lays doubt on supporting systems to harness the population for productive works to avert the prediction of Thomas Malthus in South Africa as well as strengthen the involvement of household in national food security agenda.

Another factor that can explain this phenomenon is the lack of or slow assimilation of improved agricultural technology to enhance per capita yield of land. Although there are few large firms producing with improved technologies, their output is crowded out by the majority of small farming households that are not using improved technologies for an intensified agriculture.

3.2.2 Observed pressure of consumption and price of maize in both regime

The analysis showed that both tons of maize consumed and price per ton have had depressing impacts on per capita maize cultivation in both regimes. This speaks to maize price policy stability in South Africa mainly because prices for maize within the country are determined in international market. This can also be explained with the insensitivity of per capita maize cultivation to increase in consumption (demand). This can further be explained with lack of or low access to improved agricultural technologies among the growing South Africa populace which is a necessity for sustainable food security.

4. Conclusion

The aim of this study was to examine whether household food security situation in South Africa is regime sensitive by creating three basic food security indicators as well as validating the effect of population growth. We found that food security status in South Africa is regime insensitive because it has fallen below the threshold level in both regimes. However, the unsustainable food security observed in the apartheid era (noticed in 1987 thereabout) could be ascribed to political agitation for freedom from apartheid regime, sanctions and relocation of many white farmers. More importantly, the results also showed that post-apartheid policies and intervention actions involving land redistribution, expanded food production and security mostly targeting poor households have achieved little impact on their targets as the indicators showed reverse dire situations even with the regime changed and the country being led by black South Africans. Again, we attribute this to lack of access to new and improved agricultural technologies, not just access to land by many small farms in South Africa. In line with the findings of this study, the dire situation of lack of access to new and improved agricultural technologies can be improved when pragmatic land reform that will provide title documents to the majority of landless South Africans is achieved. This will serve as collateral and is expected to increase access to credit that is needed to acquire improved agricultural technologies and increase production frontiers. Another important factor is revamping access to agricultural extension services to the smallholder farmers as the case for precision agriculture increases for food security. Currently, there are only few white farmers that have access to quality agricultural extension services because they can pay for them.

Furthermore, the results showed that per capita land cultivation of maize has declined steeply in the post-apartheid era compared to the apartheid era. The situation showed that South Africa will be vulnerable to shock in the international markets and increase in price. There is no other important warning on food insecurity than this going by the fact that South Africa maize price is controlled by international market. Similarly, the result showed that the country has yet tapped on its increasing population as the per capita land cultivation of the important staple food are very low. South African land policies need to be readjusted to per capita land/productive resources targeting to improve food security. The percentage change in land cultivation showed the successes of agricultural policies are not sustainable.

Declining South Africa per capita agricultural output especially that of the staple foods is an indication that the country needs to expedite capacity building and readjust its agricultural internship programme to improve South African agricultural systems and household food security. There are indications that food value chain and franchise development in South Africa have affected the consumption pattern.

In relation to the theory of population growth and the food advocacy (theory of food sovereignty) for food security within South Africa, it is obvious that the population has grown, thanks to the innovations in birth control and child development, but it has not been harnessed to better food production. On the other hand, the depressing impacts of total consumption of maize and price per tons further indicate the exposure of South Africa food system to external factors which the proponents of food sovereignty are against. We recommend that agricultural policies should employ per capita targeting, revamp agricultural support systems, engage in aggressively improved agricultural technology transfer to empower domestic production systems and insulate smallholders from harsh international trade system in order to make South Africa a real food-secured nation.

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