ANALYSIS OF THE SUPPLY AND DEMAND SIDE DETERMINANTS OF MAIZE FOOD SECURITY IN KENYA

BY

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DECLARATION

I ascertain that this research paper is my work and has not been presented for any award in any other university.

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Dr. Martine Odhiambo Oleche

DEDICATION

This research project is dedicated to God Almighty, my family for the strength, love, and financial support given. Special thanks go to Mr. Francis Kibira and Mr. Eliud Mureithi . Their contribution to the successful completion of this project cannot be overstated.

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ABBREVIATIONS

AfDB	African Development Bank
ADF	Augmented Dickey Fuller
ECM	Error Correction Model
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GoK	Government of Kenya
IFPRI	International Food Policy Research Institute
KARI	Kenya Agricultural Research Institute
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
MDGs	Millennium Development Goals
NCPB	National Cereals and Produce Board
OLS	Ordinary Least Squares
PP	Phillips-Perron
SDGs	Sustainable Development Goals
UN	United Nations

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ABSTRACT

This research paper examines maize food security in Kenya by analyzing the supply and demand-side factors. The objectives of the study include: scrutinizing the prevailing trends of maize food security; establishing the determinants of maize food security; and providing policy implications and recommendations. Secondary time series data for the period 1970-2019 collected from the World Bank and the Food and Agriculture organization was used to achieve these objectives. The methodology used conceptualizes food security as being determined by factors which can be categorized either as supply or demand sided, and are informed by the dimensions of food security - availability, access, and stability. The ordinary least squares approach was applied to evaluate the impact of these factors. Results indicated that maize production and gross national per capita income were significant and positively related to maize food security. The study recommends that the government should enhance access to improved seeds and also increase the land area equipped with irrigation infrastructure, as measures to boost maize production. Likewise, the government should adopt the gross national income per capita as an alternative indicator or trigger for initiating maize subsidy programs to increase maize food security.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Concerns over food security date back to the Second World War, prompted by inter-governmental delegations from forty-four countries which met in 1943 in Hot Springs, Virginia, USA to discuss the rising fears of a European population distressed by severe hunger resulting from the war (FAO, 2012). The meeting underlined food security as “freedom from want” with regard to the supply and accessibility of food. To combat the hunger that shadowed the post-war period, the Hot Springs conference prioritized realizing “freedom from hunger”. As a result, policies on food and agriculture in the 1950s and 1960s, began to concentrate more on augmenting the production levels of key staple foods.

In the 1970s, there was a drastic decline in the global per capita availability of grains due to poor harvests. This resulted in a rise in food prices across many countries. A World Food Conference was subsequently convened in Rome in 1974 to discuss the situation. A universal declaration which propounded the inalienable right of each person to be free from hunger and malnutrition was embraced (United Nations, 1974). Additionally, a supply-oriented definition of food security which focused on availability and adequacy of basic foods was adopted to control price fluctuations and meet rising demand.

The evolution of the concept of food security was further progressed by Amartya Sen in his essay on entitlement and deprivation, in which he highlighted the insufficiency of food supply alone to warranty food security (Sen, 1981). Sen emphasized that while food deprivation was a major highlight of famines, inequalities that affect distribution and prices could also cause famine. He acknowledged that food insecurity could persist despite increased levels of production. His approach highlighted the significance of access, both physical and economic, in any attempt to comprehend issues of food security. It set the foundation for broadening the concept to encompass: adequacy, accessibility and stability (FAO, 2012).

The 1996 World Food Summit led to the adoption of the current, and broadly acknowledged definition of food security. Food security has since then been espoused as existing when “all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996).The aspect of social access became integrated into the 1996 definition later in 2002.In summary, it is apparent that the question of food security can be approached from either a supply or demand side aspect, and that its evolution over time has led to a broader concept which has bounded within it the dimensions of food security: availability, access, utilization and stability.

1.1.1 Food Security and the Transition from MDGs to SDGs

In 2000, the United Nations member states met in New-York, USA, and adopted the United Nations Millennium Declaration as a global strategy for combatting poverty in all its forms. Subsequently, eight overarching goals that would guide the development agenda until 2015 were embraced. These came to be known as the Millennium Development Goals (MDGs), comprising a monitoring and evaluation structure of 18 targets and 48 indicators. Food security was enshrined in: "goal 1 - to eradicate extreme poverty and hunger; target 1C - to halve the number of people suffering from hunger; captured by two indicators – the incidence of underweight children under-five years of age and the proportion of population below minimum level of dietary energy consumption" (United Nations, 2006).

By 2015, it was apparent that the MDGs had become pivotal in restructuring decision making that directed the concerted global effort against hunger. Significant strides were made in reducing global hunger levels and enhancing food security. In particular, the percentage of people who were undernourished in developing regions between 1990 and 2015 fell by almost half, and the ratio of underweight children declined from one in four children to one in seven(United Nations, 2015). Despite the noteworthy progress, the 2015 MDGs UN report underscored that approximately one in nine people across the globe lacked sufficient food to eat; one in four children remained stunted, and one in seven children were still underweight. In relation to this, the Government of Kenya through the Ministry of Devolution and Planning highlighted several challenges that were encountered while endeavoring to realize the MDGs. They included: climate change and extreme weather events that led to variation in production levels; rapid population growth; poor infrastructure that restricted market access; and loss of potential agricultural land due to urbanization(GoK, 2013).

Since 2015, the post-2015 development agenda has been steered by the Sustainable Development Goals (SDGs) which have become essential reference points for policy-makers. The SDGs build off of the MDGs and consist of 17 goals, 169 targets, and 230 indicators that are expected to direct the execution of the 2030 Agenda for Sustainable Development. They preserve the initial emphasis on eradicating poverty and are arguably considered to be more aspiring; uniformly pertinent to both developing and developed nations; and able to integrate the economic, social, and environmental dimensions of sustainable development. Food security is envisioned in goal 2 which aspires to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture"(Woodbridge, 2015). Goal 2 of the SDGs is intertwined with the Kenya Vision 2030 economic pillar, which aspires to attain an annual average economic growth of 10 percent. In other words, agriculture was identified by the Kenya Vision 2030 as one of the six key sectors - which collectively account for approximately more than half of Kenya's GDP - that are expected to help deliver annual economic growth of 10 percent(GoK, 2007). As a result, the Kenyan government has been implementing several projects such as subsidizing seeds and fertilizers, distributing drought-tolerant crops, and funding irrigation projects(Ogana, 2017). Correspondingly, the Kenya 2018 'Big four Agenda' goes the extra mile to highlight the significance of achieving food security in the country's development ambitions.

In terms of how close Kenya is to achieving Goal 2 of the SDGs, the 2019 SDGs progress report showed that the national poverty headcount rate had decreased by 13 percent between 2006 and 2016, with the decline being larger in urban areas than in rural areas (GoK, 2019). Six counties - Turkana, Mandera, Samburu, Busia, West Pokot, and Marsabit. - were noted to further in achieving food security and ending hunger, as more than half of their population was food poor. Child food poverty was also noted to be at 35.8 percent, with most of the children residing in rural areas. The International Food Policy Research Institute (IFPRI) estimates that Kenya suffers from a serious hunger level. This is despite the Kenyan global hunger index reducing from an alarming rate of 36.9 in 2000 to 25.2 in 2019 (IFPRI, 2019).

1.1.2 Decomposition of Food Security

Like any other component of an economy, food security can primarily be analyzed at both a micro and macro level. Specifically, the individual and the national aggregate level of food security. The former subsists when adequate food is accessible to all people in a country, while the latter is characterized by the presence of ample food supplies in a country to feed the population(AfDB, 2012). According to the African Development Bank (AfDB), national food security is crucial but it does not guarantee sufficiency at the household level. Despite the national strategic grain reserves being full, individual food security is not guaranteed if the supplies are inaccessible due to price volatility, poor distribution network, or any other socioeconomic factor. It subsequently becomes apparent that both provision and accessibility of food, are underlying forces of food security.

The notion of provision is entwined to the supply of the available food resources in a country. Desta (2016) argues that a nation should strive towards achieving sufficiency in supply by doing more research and by adopting new agricultural technology. This could be through the adoption of drought-resistant seed, as food production in many countries has been known to be affected by climate change which in turn affects yields which determine the food availability both locally and regionally (Hoolst, et al., 2016). Food availability is thus one of the elements that make up the supply side of food security. The Asian Development Bank underscores agricultural productivity, climate change, and water availability as some of the supply-side factors that encompass food security (Asian Development Bank, 2013). On the other hand, demand-side factors include food prices and urbanization among others. Hence, it is arguably apparent that food security can further be disintegrated accordingly into both a supply-side and a demand side.

In the 1960s through to 1980s, the international community was constantly alarmed by the imminent increase in global hunger levels, as growth in population had started to surpass agricultural production, particularly in Asia. As a result, food security was predominantly regarded as a problem of supply shortages that could only be solved by the perpetual availability of adequate food supplies(Fukuda-Parr & Orr, 2014). This view was later on disputed by policy-makers such as Amartya Sen, when hunger persisted in the face of increased agricultural production. Food security thus began to be appreciated as also encompassing both physical and economic access to food.

Amartya Sen analyzed poverty and famines and concluded that the absence of enough food to eat was merely one of the many probable reasons an individual may starve. He contended that although food supply shortages may lead to starvation, the direct reason for starving is attributable to the depletion of an individual’s entitlements(Sen, 1981).In other words, it is possible for individual hunger to exist regardless of abundant food supplies due to inequalities that may upset an individual’s wages, prices, and distribution of food. His emphasis on individual food security set precedent for the demand side conception of ‘entitlements’ to food, thereby showing that demand-side factors informing food security are equally as important as supply-side factors.

This then brings us to the dimensions of food security which have been hitherto mentioned briefly. The dimensions are alluded to in the description of food security proposed in the 1996 World Food Summit. To begin with, the physical existence of food is referred to as availability and is specified and informed by the levels production, storage and trade. Therefore, it is supply-side oriented.

Secondly, access signifies the economic and physical convenience of food supplies to bridge the national aggregate food security to individual food security. To enhance accessibility, policy-makers consequently focus on incomes, prices, rural infrastructure among other factors. Accessibility can be analyzing distribution infrastructure such as road networks; and trends in economic empowerment via the GDP per capita (Abbade, 2017). As a result, it is both supply and demand-side centered.

Thirdly, utilization denotes how the body uses the nutrients contained in consumed food (FAO, 2008), and by implication, the apportionment of food in households as food sufficiency does not guarantee the absence of nutritional deficiencies. This dimension entails a consumption, nutrition, and health component. Apart from being influenced by dietary intakes, utilization is likewise influenced by non-food factors such as the use of clean water and access to proper health care(Fukuda-Parr & Orr, 2014). Anthropometric indicators, such as the percentage of children suffering from stunting and wasting capture the nutritional component. The health status is easily mirrored by the number of deaths of children under the age of five years. Anthropometry is conventionally accepted as a proxy of utilization and has been linked to mortality, morbidity, and cognitive growth (Jones et al., 2013). Therefore, the utilization dimension is considered by some authors as a cogent measure of the outcomes of food security since it indicates how well individuals make use of the food that is available and accessible to them.

Finally, the three aforementioned dimensions must be stable over time against exogenous shocks of economic, political, or ecological nature. Stability as a concept captures the vulnerability of individuals to food insecurity due to disruptions in the other aforementioned dimensions (Barrett, 2010). It accounts for the fact that food insecurity can vary over time from transitory, to cyclical, to being chronic(McKay, et al., 2019). A study conducted in Ethiopia showed that although chronic food supply stems from inflationary pressures caused by budgetary deficits and misstatement of food harvest, transitory food insecurity does not (Desta, 2016). To achieve food security, synchronized execution of the dimensions is thus necessary.

1.1.3 Trends of Maize Food Security in Kenya

The Food and Agriculture Organization (FAO) propounds that "all hungry people are food insecure, but not all food-insecure people are hungry" as there are other varying reasons for food insecurity (FAO, 2008). In contrast to food security and for purposes of this study, food insecurity is regarded to exist when some people occasionally lack economic and physical access to safe and nutritious food that suitably meets their food preferences and dietary needs for an active and healthy life (Food Security Information Network, 2020). In other words, the definition of food insecurity directly derives from the non-existence of one or more of the stipulations in the broadly acknowledged 1996 definition of food security.

Historically, the Kenyan economy has largely been agricultural-based, with the sector averaging over 20 percent annually direct input to the country's GDP for the last decade. The agricultural sector in 2018 contributed approximately 52 percent to the GDP, and 56 percent to employment (AfDB, 2020). The Kenyan Vision 2030 identifies four sub-sectors within agriculture, namely: the industrial sub-sector that is characterized by production and processing of cash crops such as tea, coffee, sugar cane, and tobacco; the horticulture sub-sector that consists of both consumable foods and non-consumable products such as flowers; the food crops sector which comprises cultivation of staple crops intended for immediate consumption; and the livestock and fisheries sub-sector that provides meat and fish(GoK, 2007). Although all four sub-sectors have a role to play in alleviating poverty levels in Kenya, the food crops sub-sector has the most crucial role to play in achieving food security due to its direct influence on food consumption and its relatively small contribution to agricultural exports. The food crops sub-sector has over the years only been occasionally surpassed by the horticulture sub-sector – which has a larger focus on export growth - in terms of contribution to the agricultural GDP. A further breakdown of the food crops sub-sector shows that maize and legumes are the most produced food crops. Maize and legumes percentage input to agricultural GDP was 15 and 14 percent respectively (GoK, 2007). Traditionally, staple foods have been regarded as the most urgently demanded crops in times of great economic or political distress, particularly in the aftermath of World War II, when hunger levels became alarming. The rationale is that when attempting to combat hunger, an initial ample supply of staple foods will allow for subsequent diversification of diets. Whilst Kenya has a rich variety of food crops, maize is grown in over 75 percent of all farms in the country making it undoubtedly the main staple food. Approximately 78 percent of the populace reside in rural zones and contribute directly to the supply of maize, both for subsistence and marketing purposes.

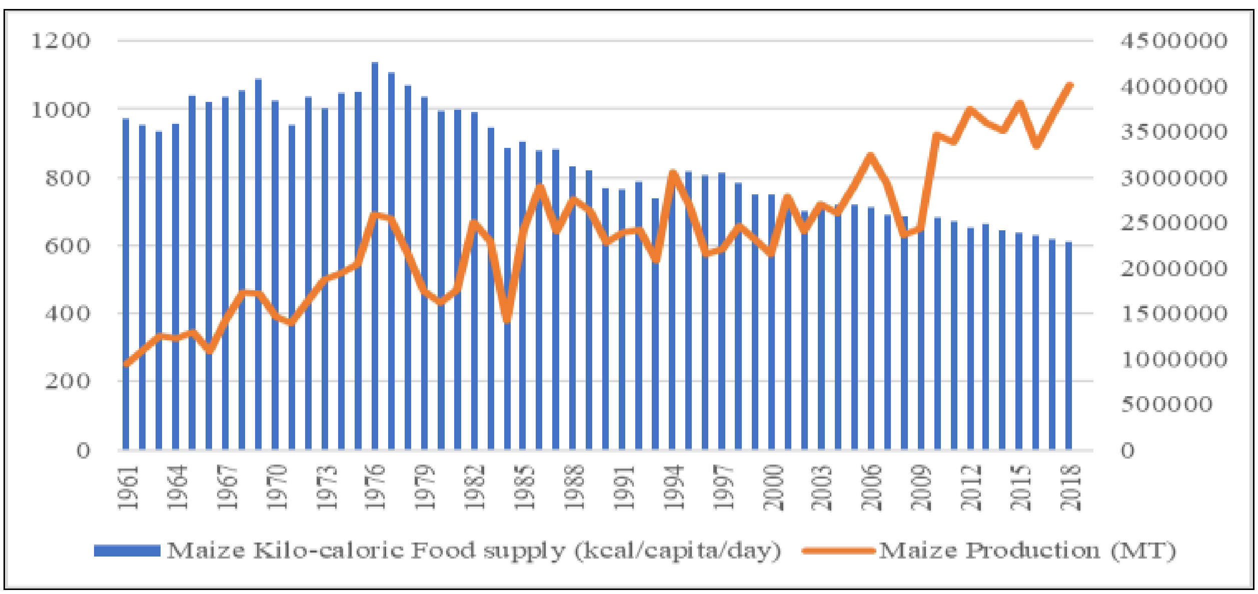
According to FAO 2016 estimates, maize comprised approximately 83 percent of the total area where cereals were harvested in Kenya. The Kenya Agricultural Research Institute (KARI) similarly recognizes the significance of maize by accordingly regarding it as a "strategic food security crop whose yields unavoidably affect the level of food shortage and famine in the country"(KARI, 2009). The most notable food shortages in Kenya have usually corresponded to a drastic decline in the amount of maize available in the market. FAO emphasizes the importance of maize in Kenya by noting a decline in consumption of other food groups in Sudan and Kenya, and a rise in the consumption of staples in the diet (FAO, 2020). Despite the key food crops in Kenya ranging from roots and tuber, pulses to vegetables, maize remains a key element of a typical diet which represents an estimated calories consumption apportionment of 36 percent, and a staple foods' calories apportionment of 65 percent (Kariuki, 2015).

A study by Dr. Joseph Kariuki (2015) identified six worrying trends that had a direct impact on food security in Kenya. It was noted that despite 43 percent of the Kenyan population being affected by food insecurity, the country had a growing food import burden occasioned by factors such as low production, population growth, and inadequate investment by the private sector. The study emphasizes the fact that the number of people residing in rural areas is expected to grow by 52 percent by 2050, putting pressure on land, food supply, and employment (Kariuki, 2015). He highlights that a high population will drive up the demand for maize in Kenya to approximately 8.6 million tonnes by 2050, which equals double the current demand. This being despite the fact that there was a decline in the intercensal population growth rate from 2.6 to 2.2 percent(KNBS, 2019).

Another disquieting trend identified is Kenya's growing food imports, which makes food security susceptible to volatile global prices which potentially drive up overall inflation in the country, thereby having a negative impact on income levels especially among the poor. A third trend identified was that growth in production was noted to be predominantly dependent on growth in land area. Low production and use of low quality and low yielding non-maize seeds by farmers was the fourth trend. Farmers were noted to be planting seeds that were unsuitable for particular agricultural ecological zones. A fifth trend was the large market share owned by the government leading to diminished private-sector research and investment. This is particularly clear in Kenya's seed sector dominated by 11 parastatals(Kariuki, 2015). The sixth trend analyzed in light of the other trends was Kenya's seemingly increasing food deficit situation. If the other trends persist, food insecurity in the country will undoubtedly worsen.

When measuring food security, there has been a bias towards focusing on calories based on assumption that other food requirements are met once caloric intake is adequate(Beyene & Muche, 2010). One concern noted has been that although maize productivity has been on an upward trend, the kilo-caloric food supply from maize has been declining since 1976-which had a per capita kilo-caloric supply of 1135 per day - as shown in figure 1 below.

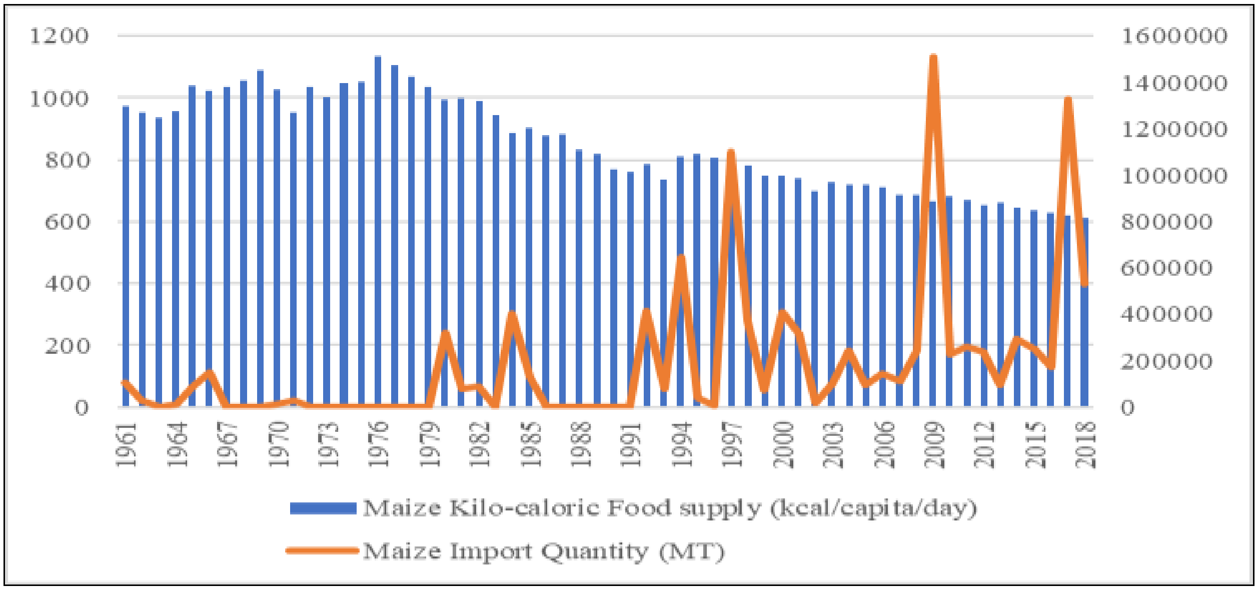
Figure 1: Trend of Maize Production and Maize Kilo-caloric Food Supply



Source: Data from Food and Agriculture Organization

This is despite the fact that Kenya has increasingly been importing maize to supplement the production deficit as shown in figure 2 below.

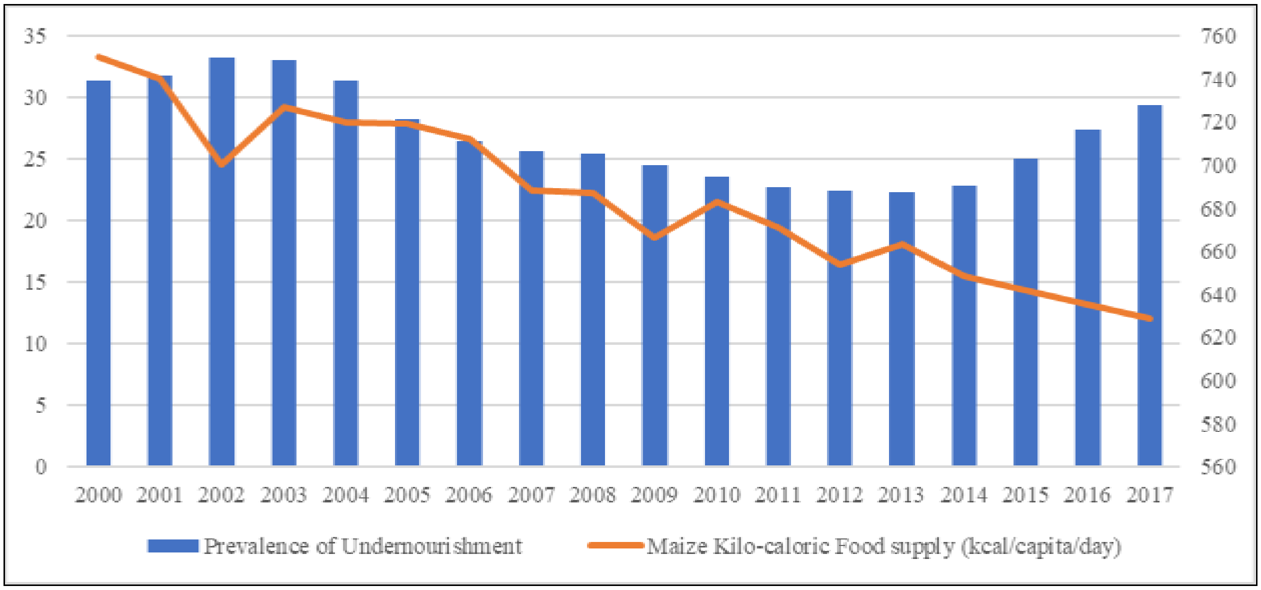
Figure 2: Trend of Imported Maize Quantity (MT) and Maize Kilo-caloric Food Supply



Source: Data from Food and Agriculture Organization

The rising trends in maize production and importation raise the question of whether people have access to the available food. Figures 1 and 2 above illustrate that food security had been declining despite efforts to increase production and supplement it through importation. A depiction of how the trend of kilo-caloric food supply compares to the prevalence of undernourishment is shown in Figure 3 below. The prevalence of undernourishment is used by FAO to gauge food security by calculating the percentage of a country's population suffering from hunger(Wanner, et al., 2014). Figure 3 shows that between 2000 and 2002 when the kilo-caloric food supply decreased the prevalence of undernourishment increased. However, between 2003 and 2012 both indicators declined simultaneously, although the slope of the decline of the maize kilo-caloric supply was steeper than that of the proportion of hungry people. Between 2013 and 2017, the two indicators contrasted in such a way that the prevalence of undernourishment rose from 22.3 percent to 29.4 percent, while the kilo-caloric supply of maize continued on a downward trend.

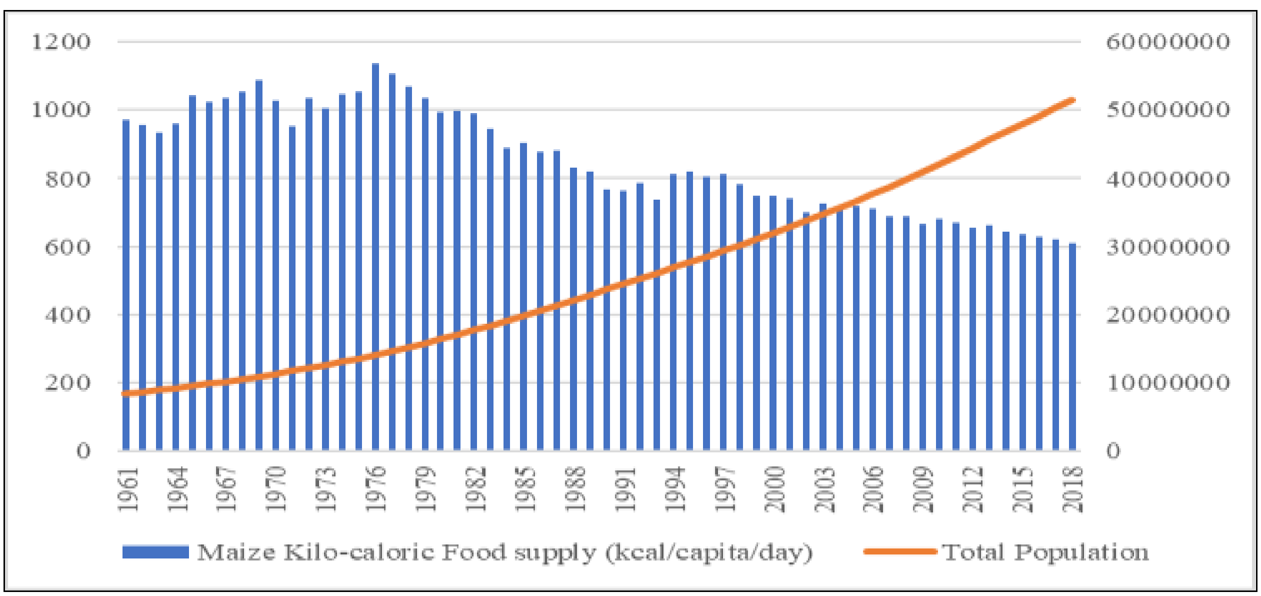
Figure 3: A Comparison Between Trend of Prevalence of Undernourishment and Trend of Maize Kilo-caloric Food Supply



Source: Data from the World Bank and Food and Agriculture Organization

Additionally, KNBS census data shows that the intercensal population growth rate in Kenya was 2.2 percent for the past decade (KNBS, 2019). This is in contrast to a decreasing kilo-caloric maize food supply. The contrast between the two indicators is shown in figure 4 below.

Figure 4: Trend of Population and Maize Kilo-caloric Food Supply



Source: Data from the World Bank and Food and Agriculture Organization

1.2 Research Problem

The prominence of maize over other food crops in Kenya has been apparent due to its large dietary caloric supply, and due to a decline in consumption of other food crops and a subsequent upsurge in the consumption of staple foods in Kenya (FAO, 2020). Despite its dominance in ensuring food security, the kilo-caloric supply of maize has been gradually declining despite the noted growth in various supply and demand-side determinants of food security. For instance, availability, particularly maize production, which is a supply-side dimension has been on an upwards trend and has regularly been supplemented by imports from abroad when Kenya experienced production deficits. Similarly, although population – a demand-side factor – has been on an upward trend, the kilo-caloric supply of maize has not grown to match the increased demand. This then raises the question of which dimension of food security has been neglected and which factors ought to be analyzed to solve the problem. If the kilo-caloric supply of maize continues in a downward trend while supply and demand-side indicators such as food production and population, respectively, continue in an upward trend, then that would imply that either there is a gap in availability and access, or there is a dietary shift to other food crops. However, the latter has been refuted by the recent shift towards consumption of staples in Kenya as indicated by FAO (2020).

According to the KNBS (2019), the population in Kenya grew from 28.7 million in 1999 to 47.6 million in 2019. Similarly, data from the FAO shows that maize productivity in Kenya grew from 23.2 metric tonnes in 1999 to 40.1 tonnes in 2018. However, the kilo-caloric maize supply declined from 750 to 688 between 1999 and 2017. This is despite the evidence from KARI (2009) and FAO (2020) regarding the prominence of maize in a typical diet in Kenya. This then raises demand-side policy issues of checking fertility rates, and supply-side policy issues of increasing per capita production (Burchi & Muro, 2015).

One issue that can be attributed to this discrepancy, is the lack of adequate storage facilities that leads to poor post-harvest handling. Data from the FAO indicates that maize food losses increased by 14000 metric tonnes between 2014 and 2017. Due to inadequate storage facilities, the National Cereals and Produce Board (NCPB) has over the years had to limit the amount of maize purchased from farmers because of the lack of adequate storage infrastructure thus tacitly contributing to losses as a result of poor post-harvest handling. Farmers are forced to hold onto the excess maize produce, thus increasing the urgency to sell it quickly to stem the risk of damage by rodents, termites, and high moisture content. The urgency by farmers to sell their produce before it spoils consequently has a drastic effect on maize prices. Fluctuations in maize prices are then mirrored by fluctuating income levels especially among the rural population engaged in agriculture.

Drought is another factor that severely affects the supply side of maize in Kenya by leading to a decline in yields per hectare. According to the economic report published by KIPPRA in 2017, Kenya experienced one of its worst droughts between 2008 and 2011, which led to a decline in the food self-sufficiency ratio from 78.9 percent to 63.7 percent in 2006 and 2009 respectively; the import dependency ratio also rose from 24.5 to 39.5 (KIPPRA, 2017). A worrying trend noted by KIPPRA (2017) report is that over the last 40 years, the drought cycle had reduced from 6-7 years to 2-4 years, meaning that droughts have become more regular. This implies that the stability of food production was at stake. Rising temperatures and variation in rainfall pattern were found to account for a 65.7 percent change in maize yields in Kenya (Mumo, et al., 2018).

Authors such as Amartya Sen (1981) have contended that food security is not a problem that is limited to agricultural productivity alone since an economy comprises of many interdependent sectors.This then shifted the focus from production to income which is demand sided because it asks the question whether an individual has sufficient income to buy food. Due to the strange way in which the kilo-caloric supply of maize fails to respond to supply side factors, then an examination of income might help shed light on the problem of food security.Income has been found to be positively related to the food security situation of a household (Kungu, 2014).

The 2020 study by the FAO clearly demonstrated that food security is still a puzzle that requires concerted effort to solve. The study estimated that hunger affected approximately 690 million people accounting for 8.9 percent of the global population; this number is expected to surpass 840 million people which represents 9.8 percent of the global population, by the year 2030 (FAO, 2020). Accordingly, 280 million of these people reside in Africa where the proportion of undernourished people was reported to be rising rapidly in contrast to the rest of the world. The report also highlights that the prevalence of undernourishment in the world has been on an upward surge since 2014 represented by a 0.3 percentage change. Consequently, the number of people affected by severe food insecurity in 2019 stands at approximately 746 million globally, at approximately 227 million in sub-Saharan Africa, and at approximately 107 million in East Africa (FAO, 2020). The proportion of people who are undernourished in Africa is noted to be graver, having risen from a rate of 17.6 percent of the population in 2014 to 19.1 percent in 2019, and is projected to rise to 25.7 percent by 2030. This prevailing rate (17.6 percent) is double the global average of 8.9 percent. Eastern Africa had an even higher prevalence rate in 2019 of 27.2 percent (approximately 117 million people), projected to rise to 33.6 percent (approximately 191 million people) by 2030. Data from the World Bank shows that the prevalence of undernourishment in Kenya was 29.4 percent in 2017, which had grown from 22.3 percent in 2013. The report shows that the increased food insecurity levels, particularly in sub-Saharan Africa, can be ascribed to various reasons such as economic decline, regional conflict and localized tension, and climate variability (FAO, 2020).

Although there have been studies on the food security situation in Kenya, and the likely determining factors around it, to the best of my knowledge, there has been no study that has critically analyzed maize food security and its dimensions while taking into account both the demand-side and supply-side. Different authors such as Kungu (2014) and Mumo, et al. (2018) have found positive and significant determinants of food security in Kenya. However, there has been no evidence provided as to why despite maize, being a widely consumed key staple food in Kenya, has had its kilo-caloric food supply continue to dwindle in the face of rising supply and demand-side factors. This study, therefore, strives to fill this gap in knowledge.

1.3 Research Objectives

The general objective of the study is to explore how demand-side and supply-side determinants affect maize food security in Kenya. The specific objectives are:

i. To identify trends of maize food security in Kenya
ii. To establish the determinants of maize food security with respect to the supply and demand side.
iii. To offer policy implications and recommendations as regards to supply and demand side determinants of maize food security in Kenya.

1.4 Significance of The Study

This research project strives to develop an innovative method of analysis that synthesis and builds upon existing literature on food security. The study proposes a system that attempts to accommodate the dimensions of food security and combines that with supply and demand features affecting the maize market. This approach, not only offers a new method of examination but also bridges a gap in the literature by linking supply and demand-side elements to the study of maize food security. This will expectantly deliver insights on the direction future food security policy should take, given that food security remains a moving target in terms of how it is measured, analyzed and the policies that are used to target it.

1.5 Organization of The Study

Chapter 2 explores the existing literature on food security and identifies key theories and results by different authors. A conceptual framework for this study is also illustrated. Chapter 3 explains the methods to be used to investigate the research problem identified herein. Chapter 4 presents the analysis and discusses the results of the study. Finally, chapter 5 provides policy recommendations and the areas that can be explored further.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A nation is termed as food secure when its total population has "at all times, physical and economic access to adequate, safe and nutritious food to meet its dietary needs and food preferences for an active and healthy life" (FAO, 1996). This definition is broken down to the four dimensions of food security: availability, access, utilization, and stability.

2.2 Theoretical Literature Review

2.2.1 Malthusian Theory of Population

The Malthusian theory is credited to Thomas Robert Malthus who published it in 1798, with its key defining principle being that growth in population had an exponential trend while growth in food production had a linear trend. Malthus' perspective on food security was simply a problem of food supply falling behind an explosive population in terms of growth. He firmly contended that it would be erroneous to believe that food and population grew by the same progressive ratio. His proposition was that unrestrained population grew by a geometric ratio, whereas food - given the fixed nature of land as an asset – grew by an arithmetic ratio (Barrus, 2004). Correspondingly, it was his supposition that prosperity fueled population growth (Wrigley, 1988); abundance of food supplies would encourage an increase in population.

The disparity in growth patterns inevitably meant that the population would outgrow food supply, necessitating what he referred to as preventive (e.g., celibacy and late marriages) and positive checks (e.g., war, pestilence, floods, and famine) to population intended to maintain a balance with the prevailing subsistence levels. The inference that hunger, war, and disease were a natural correcting tendency to uninhibited population growth had him labelled as a pessimist(Sen, 1982).

A critical addendum to the Malthus population theory, that this research paper intends to explore, is how the theory is also entwined with the argument that the nature of change in population dynamics will consequently affect the nature of the demand for food (Villarreal & Stloukal, 2005). Any changes in population dynamics lead to differences in food demand patterns. Particularly, urbanization due to rural-urban migration is a representation of population dynamics that affect the spatial distributions of people. This issue is arguably of significance to Kenya's focus on food security mostly because only 2 percent of urban consumption is from food produced in urban areas, while 98 percent is purchased; this is aggravated by the fact that roughly 30 percent of rural consumption is from purchased food (Gitu, 2006). This leaves policy analysts with the dilemma of determining whether the nature of rural to urban migration is helpful in reducing population pressure and enhancing commercial agriculture, or harmful in terms of depriving vital rural labor markets, and its subsequent impact on food production and consumption trends. Policy analysts are careful to highlight how rapid urbanization that deprives human resources in rural areas can potentially ultimately increase dependency on food imports.

2.2.2 Food Availability Decline Theory

The core hypothesis of this theory is that food insecurity is caused by a steep decline in the available food supplies. In other words, the theory equates the problem of food security to a problem of food availability. It overlooks any immediate reasons or conditions that could explain the insufficient supply of food and remains plausible as long as food insecurity is accepted to be as a result of a decrease in the available food resources (Sen, 1976).

This theory was widely popular prior to the world wars up to the food crisis of 1972-73. According to Harriet Friedmann, the political economy of food across Europe and the United States of America between 1947 and 1972, was characterized by ‘surplus regimes’ that had adopted protectionist agricultural policies meant to support domestic farm prices (Friedmann, 1993). The post-war agri-food relations were such that nations opted for import controls and export subsidies while still purchasing legislatively selected agricultural produce at set prices. These incentives ultimately led to an agricultural surplus that exceeded market demand, and also consequently to food aid policies intended to dispose of these surpluses.

Adverse weather conditions in the 1970s led to a drop in food output across the world, causing a shortfall of 55 million tons of food, which was further exacerbated by huge food import demands by the Soviet Union due to poor harvest(Shaw, 2007). The accruing challenges affecting production and availability subsequently led to an abrupt increase in food prices. Because of the preceding stability that had been experienced before the 1972-73 food crises, there was a consensus that the impending threat of hunger, starvation, and famine was a result of a decline in food supply across the world. Henry Kissinger, the United States of America Secretary of State, in 1973 addressed the UN General Assembly and urged for a World Food Conference centered around how to sustain a sufficient supply of food (Shaw, 2007).

It is also important to point out that by overlooking other immediate causes of insufficient food supply, the Food Availability Decline (FAD) theory essentially stipulates that any form of food production disruptions will most likely eventually lead to a decline in the food supply. FAD hence implicitly encompasses issues affecting factors of production, particularly land, such as the declining marginal returns on land. Classical economists in the analysis highlighted that given supply of land is fixed, production could only be augmented using technology and via an increase in inputs such as labor and capital, but the achieved gains would only be temporal as decreasing returns would eventually prevail (Wrigley, 1988). The law of diminishing marginal returns on available land highlights the need to examine the available land resource available.

Amartya Sen (1976) notes that the FAD theory is often intertwined with the Malthusian Theory of Population in that population has always grown to absorb additional food supply. Thus, when food supply rapidly drops hunger often follows. Moreover, Sen points out that the FAD theory is best applied when food that is consumed by a household is specifically grown by the household without requiring any form of trade. However, if the economy allows for food trade, then the capacity of the household to acquire food will also depend on possessions and assets such as labor which can be traded for food. This premise led to the formulation of the entitlement theory.

2.2.3 Sen's Entitlements Theory

The entitlement theory, developed by Amartya Sen and first published in 1981, provided an alternative framework in the analysis of famines by shifting the question of food security from a problem of decline and shortage of food supplies, to a problem of demand - particularly the inability by people to obtain food. Sen had observed famines across Asia and Africa and concluded that even though food shortage may expose an individual to hunger and starvation, famines could also be attributed to a decrease in an individual's exchange entitlements - all the alternative goods a person can attain (entitlement set) in exchange for what he already legally possesses (endowment set), whether tangible or intangible (Osmani, 1993). According to Sen, the endowment set that a person legally owns derives from either one of the following: production (farming); trade (purchasing food); labor (working for food); and transfer (through benefaction or bequest).

Sen's theory argues that hunger, famine, and starvation can occur despite the availability of enough food supplies. To him, food insecurity could be explained by either a decline in the value of an individual's exchange entitlements or a decline in direct entitlements; which could be caused by a fall in wages and a rise in food prices, or by a loss of food crops to floods or drought respectively(Devereux, 2001). The theory postulates that food insecurity results from entitlement failure - when a person's entitlement set no longer holds sufficient food to avoid starvation.

The entitlement approach reviewed the problem of food security from production and food availability to one of access and distribution. Sen established food availability as only one of the varied plurality of causes that potentially lead to famine and food insecurity. Other factors, such as reduced wages or monetary induced inflationary pressure, that negatively affect an individual's purchasing power can also cause hunger and famine.

Although some authors have proposed that the real contrast between the FAD approach and the entitlement approach is that, the former focuses primarily on aggregated availability while the latter focuses on disaggregated entitlements (Osmani, 1993); others have strongly upheld that it is apparent that the entitlement approach has a demand-side focus, while the food availability decline theory is has a supply-side focus(Ravallion, 1997).

2.3 Empirical Literature Review

A study by the Food Security Information Network (FSIN), reports that weather shocks, such as drought and floods, is one of the drivers of acute food insecurity that threatens people's lives and livelihoods. Extreme weather shocks are regarded as having a direct effect on crop harvests and animal stocks, and a succeeding indirect effect on stocks of food by closing off markets via cutting off roads (Food Security Information Network, 2020). Diminished food stocks ultimately push up prices. Such weather shocks are viewed as affecting pastoralists and small-scale farmers the most. Especially if shocks are frequent, these farmers and herders find it very difficult to adapt or scale. Similarly, a study by Mumo, et al. (2018) found a negative relationship between seasonal climate change and the yield of maize in Kenya over time. Their study analyzed time-series data gathered from the Meteorological Department of Kenya and the Ministry of Agriculture for the period between 1979 and 2012. Trend analysis showed that maize yield was dropping by 0.07 tonnes-per hectare-per decade; regression analysis also showed that a negative relationship existed between maize yield and climate change, as an estimated 67.53 percent of change in maize yields could be ascribed to change in seasonal climate such as increasing temperatures and declining rainfall(Mumo et al., 2018). They concluded that the rapid and harsh climate variation was a danger to food security.

Microeconomic shocks such as the increasing food prices and macroeconomic shocks such as high inflation and high unemployment are also observed as being determinants of food insecurity. According to the FAO (2009), while population and income are key drivers in long-run demand for food, price changes and dietary changes also have a part to play. A study conducted by Mkhawani et al. (2016) examined the effects of price changes for 60 households headed by women in South Africa and found that price increase had a negative impact on these households. Results revealed that 58 percent of the households had changed their food consumption patterns due to price changes. Specifically, 60 percent of the households preferred to purchase food in bulk as a short-term strategy, and 57 percent purchased generic food brands that were cheaper (Mkhawani et al., 2016).

However, food inflation can no longer be explained by traditional causes such as production deficits due to drought, because international agricultural commodity markets are faced with unprecedented factors which affect the general behavior of food prices. For instance, some policy analysts attributed the 2007-2008 food price crisis to fast economic growth from economies such as China, while other analysts ascribed the price spike to high oil prices which prompted the demand for biofuel and consequently a rise in demand for maize which is used to produce ethanol (FAO, 2009). To this effect, a study conducted on the effects of consumer price index on food security in sub-Saharan Africa found that a rise in the consumer price index had a negative effect on food security since higher commodity prices eroded a household's purchasing power and its capacity to acquire food (Abdoulaye et al., 2015).

According to the 2019 Kenya Economic Report, the Kenyan agricultural sector contribution to GDP had risen by 7.9 percent between 2012 (26.3 percent) and 2018 (34.2 percent). The sector was also estimated to be contributing roughly 45 percent of all government revenue, and to be providing sustenance to roughly 80 percent of the population (KIPPRA, 2019). However, due to its reliance on rain-fed methods of production, the sector is susceptible to weather shocks which lead to low growth. The crops sub-sector contributed the largest share to agricultural GDP, amounting to 81 percent which is equivalent to an estimated 27.8 percent of Kenya's GDP

(KIPPRA, 2019).In the same light, the report also points out that there was a decline in the average maize yield, from 8 bags-per-acre in 2015 to 6 bags-per-acre in 2017, against a national potential of 12 bags-per-acre. Such depressed productivity is viewed as slow down the overall growth of the agricultural sector.

Krystyna Świetlik(2018) examined the relationship, in various countries, between economic growth and food security. She analyzed data from the period between 2012 and 2015 collected from various sources such as the World Bank and Global Food Security Reports Index reports. A positive relationship was established between GDP and food security as nations with the largest growth in GDP per capita made the largest progress in achieving food security(Świetlik, 2018). A Pearson correlation test between the two indicators indicated a significant (0.78) level of correlation. Additionally, Świetlik discovered that geographical disparities in economic growth were consistent with geographical variances in food security (Świetlik, 2018).

Similarly, food insecurity is linked to poverty (income) and population. A study by Villarreal and Stloukal (2005) found that despite the world population doubling between 1960 and 2000, nutrition had been enhanced notably; food demand had been met and surpassed. Per capita food production in Asia, Latin America, and Africa had risen to cater to the growth in population. Moreover, their research points out that the successive growth in global incomes by 285 percent, measured by GDP per capita, surpassing a contrasting growth in the world population of 241 percent, also contributed to the improved nutrition by facilitating access to food (Villarreal & Stloukal, 2005). By implication, they note that because Africa and Latina America were not able to keep GDP per capita closely at par to population growth, they have not enjoyed the same level of food security compared to other regions in the world. They argue that food accessibility can be diminished by any hindrance or disturbance to purchasing power, local distribution, transport, and market infrastructure (Villarreal & Stloukal, 2005).

Research conducted by Omosa (2006) on food supply gaps in rural Kenya and their impact on food security, established a direct positive connection between land size and household food security. In other words, food-secure households increased with a relative increase in the quantity of land possessed. Omosa discovered that only 50 percent of the rural households that had equal to or less than three acres of land, were able to acquire enough food. The percentage then rose to 75 for households that owned 4 to 5 acres, and then to 81 percent for households that owned at least 8 acres or more of land (Omosa, 2006). Land size as a determinant of food security was found to be also entwined with the quantities harvested and income levels. Results showed that just 10 percent of households that harvested less than four bags of maize were food secure, compared to 94 percent that harvested more than 16 bags; 88 percent of households that had an annual income larger than Kshs. 40000 were able to meet their consumption needs compared to only 52 percent with an annual income less than Kshs. 5000 (Omosa, 2006).

Kungu (2014) conducted a micro-study that examined households in Lugari and Mukueni in Kenya, using secondary data collected in 2000 by the National Agricultural and Livestock Extension Program facilitated by the Ministry of Agriculture. Kungu used a probit model to perform a binary regression analysis of the data. The household size was found to be significant in explaining a household's food security, as bigger homes were increasingly insecure compared to smaller households. Additionally, a household's income was determined to be positively related to food security. Actual marginal results reflected that if other determinants are assumed constant, every new member added to the household reduced the probability of achieving food security by 3.5 percent, while a rise in a household's expenditure enhanced the probability of achieving food security by 6.5 percent(Kungu, 2014). However, land size per capita as a determinant of food security was found as not being significant.

In an attempt to establish an association between food security and six proposed determinants, Applanaidu, et al. (2013) used a vector autoregressive econometric approach to analyze the food security situation in Malaysia. They used time-series data for the period between 1980 and 2012, collected from the FAO, International Finance Statistics, and the Statistics Department of Malaysia. Their model had the food production index as the dependent variable and a proxy for food security in Malaysia. On the other hand, real gross domestic product, exchange rate, biodiesel production, government (rural development) expenditure, food price index, and population were treated as the independent variables that they construed as encompassing both the international and national supply and demand dynamics that could potentially inform the Malaysian food economy. They opted for the vector autoregressive model since deviations in a variable were attributable to deviations in individual lags, "deviations in other variables and the lags associated with those variables" (Applanaidua, et al., 2013). The results showed that only the food price index and the Malaysian population were statistically significant, despite the overall model being significant. Nevertheless, results from the variance decomposition showed that various variables had contributed to shocks in food security in Malaysia at some point in time. For example, government expenditure, exchange rate, biodiesel production, and population were shown to influence the variation of food security year after year, while GDP shocks had mixed (increase/decline) trends in its effects on food security(Applanaidua, et al., 2013).

2.4 Overview of the Literature

The theoretical literature review explores the Malthusian theory of population, the food availability theory, and Amartya Sen's entitlements approach to food security. Malthus argued that population will ultimately overtake food supply because the former grows geometrically while the latter grows arithmetically. Sen questioned the sufficiency of the food availability theory and proposed more focus to be given to peoples' entitlement.

In the empirical literature reviewed, Omosa (2006) found a positive relationship between land size and the number of bags harvested by a household. Villarreal and Stloukal (2005) and Świetlik (2018) also established a positive relationship between GDP per capita and food security. On the other hand Mumo, et al., (2018) found a negative relationship between climate change and maize yields. Similarly, Kungu (2014) found a negative relationship between the size of a household and its food security situation, while Abdoulaye, et al. (2015) confirmed a negative relationship between consumer prices and food security.

CHAPTER 3: METHODOLOGY

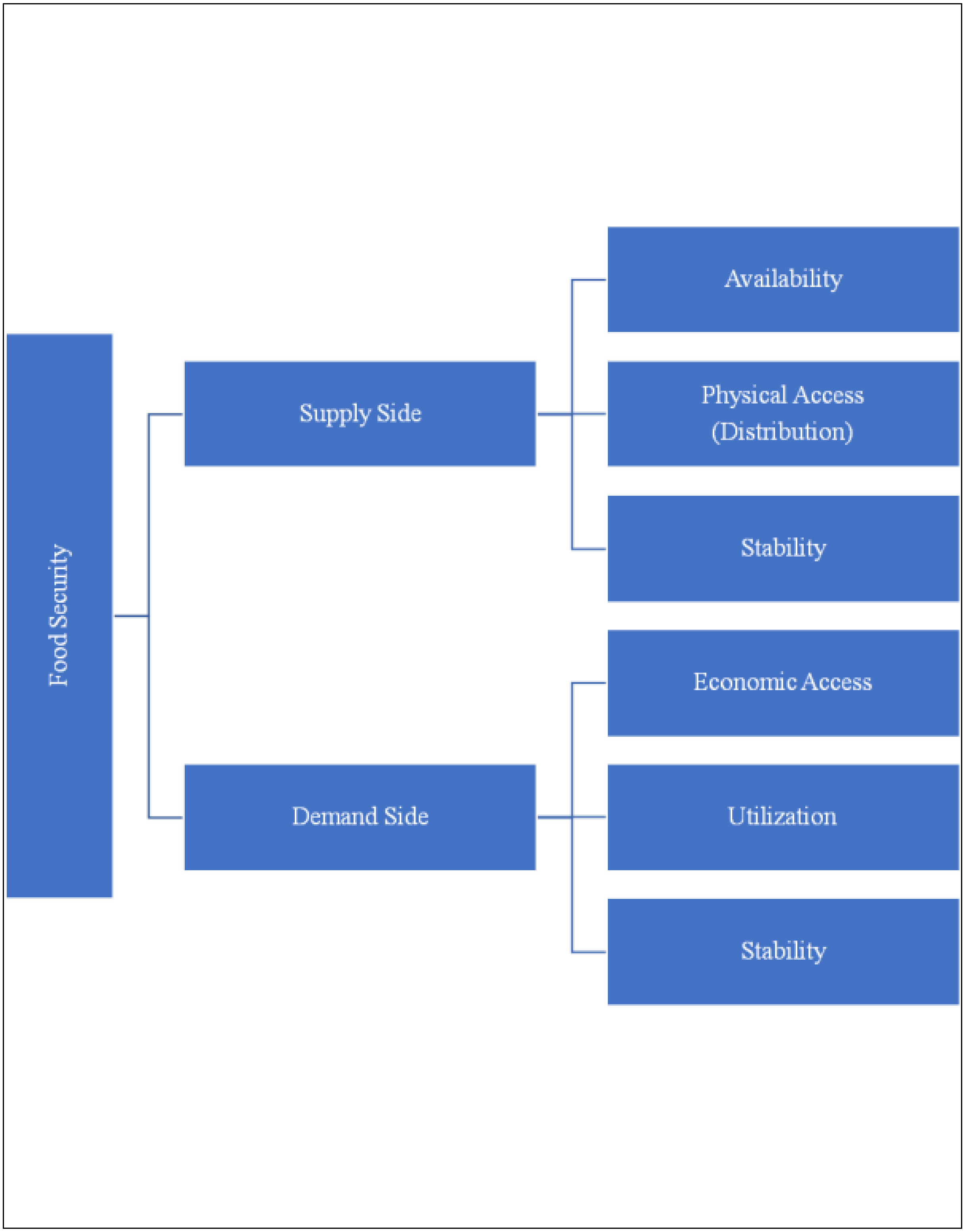
3.1 Introduction

This chapter discusses the procedures to be used in analyzing the research problem and the rationale for using particular techniques that help quantify, understand and analyze the available information pertinent to the research problem. In other words, the discussions revolve around how data was gathered and how it was analyzed so as to achieve the research objectives.

3.2 Theoretical/Analytical/Conceptual Framework

The theoretical framework used in this study is deduced from the 1998 work of Anne Thomson and Manfred Metz on food security. Their framework analyses food security as being heavily determined by only three dimensions of food security. Namely availability, access, and stability. They define food security as “a state in which food supply and demand are adequate to meet food requirements on a continuous and stable basis”, which applies at an individual level and at a national level(Thomson & Metz, 1998). This definition aligns with the previously discussed theoretical literature in the sense that, should supply and/or demand-side factors fall below the required individual or national level, food insecurity will prevail. Moreover, Thomson and Metz draw a distinction between a production deficit and a supply deficit, and how they relate to food security. A production deficit is a result of inadequate food production which can be supplemented by food imports to meet the aggregate food requirements. On the other hand, a supply deficit account for domestic production, export and imports, and thus cannot be supplemented. Because it cannot be augmented, it is referred to as a “food supply deficit or a national aggregate deficit”(Thomson & Metz, 1998). From this theoretical framework, the conceptual framework is thus indicated in figure 1.

Figure 5: The Conceptual Framework



Source: Author's own construction

3.3 Model Specification

The nine macroeconomic variables to be analyzed were chosen based on the theoretical framework developed by Thompson and Metz (1998), coupled with the theories of food availability, population growth, and entitlements. The amount of maize produced has a direct impact on consumption as per the food availability theory(Sen, 1976). Similarly, the population is postulated by Thomas Malthus is putting pressure on food resources (Barrus, 2004). By extension, the urban population is chosen because its productivity is mostly non-agricultural. A surge in urban population will lead to increased food demand(Villarreal & Stloukal, 2005). The inclusion of gross national income is based on Sen's work on entitlements, who underlines the importance of income in enabling households to demand food. Consumer prices Inflation was chosen due to its effect on income levels and purchasing power.

Sen highlights labor as one of the entitlements that households can exchange to acquire food (Devereux, 2001). Import quantity and land area harvested have been added to account for the trends identified by previous literature on food security in Kenya. Kenya is categorized as a food deficit country that is highly reliant on imports, and productivity has been marked as being reliant on the land area rather than yield per area. Temperature change has been included as a proxy for drought in Kenya due to its effect on yields when it varies (Mumo, Yu, & Fang, 2018). Due to the standing of maize in the Kenyan food economy, the kilo-caloric food supply of maize is chosen as the indicator of food security in Kenya. Again, policy analysts prefer to focus on calories when measuring food security based on assumption that other food requirements are met once caloric intake is sufficient (Beyene & Muche, 2010). Hence, the maize kilo-caloric food supply variable was analyzed as the dependent variable and the proxy for food security. The rest of the variables were added to the model as exogenous variables. The food security function can be written as follows:

$$KFS = f\,(MP, IQ, LAH, TC, GNI, TP, UP, INF) \quad \text{………………………………………} \quad (1)$$

The mathematical model can be written as follows:

$$lnKFS = \alpha + \beta_0 lnMP + \beta_1 lnIQ + \beta_2 lnLAH + \beta_3 TC + \beta_4 lnGNI + \beta_5 lnTP + \beta_6 lnUP + \beta_7 lnINF \quad \text{……………… (2)}$$

Where,

*ln*KFS = Kilo-caloric food supply

*ln*MP = Maize production

*ln*IQ = Import quantity

*ln*LAH = Land area harvested

TC = Temperature change

*ln*GNI = GNI per capita

*ln*TP = Total population

*ln*UP = Urban population

*ln*INF = Inflation in consumer prices

The variables discussed in equation 2 can be operationalized in table 1.

Table 1: Variable Description and A Priori Expectations

	Food security dimension	**Variable notation**	**Description**	**Expected Sign**	**Source**
Dependent Variable	**Maize food security indicator**	*ln*KFS	Log of kilocalories supplied annually by maize, per capita per day (Kcal/capita/day)	Dependent Variable	FAO
	Availability	*ln*MP	Log of amount of maize produced domestically annually measured in tonnes	Positive	FAO

Supply Side Variables	**Stability**	*ln*IQ	Log of amount of maize imported in a year measured in tonnes	Positive	FAO
		*ln*LAH	Log of land area where maize was harvested, measured in hectrares	Positive	FAO
		TC	Annual change in temperature in a meteorological year	Negative	FAO
Demand Side Variables	**Economic access**	*ln*GNI	Log of gross national income divided by population measured in Kenya Shillings	Positive	FAO
	Stability	*ln*TP	Log of total number of people in Kenya	Negative	World Bank
		*ln*UP	Log of number of people living in urban areas	Negative	World Bank
		*ln*INF	Log of percentage change in inflation, measured by consumer prices.	Negative	World Bank

Source: Author's own construction

3.4 Estimation Technique

Food security is reliant on time, in the sense that food supply and food demand should at all times, whether occasionally, repeatedly, or permanently, be adequate to meet requirements (Thomson & Metz, 1998). By factoring in the aspect of time in the supply-side and demand-side factors, the econometric model is written as follows:

$$KFS = \alpha + \beta_0 \sum_{i=1}^{k} MP_{t-i} + \beta_1 \sum_{i=1}^{k} IQ_{t-i} + \beta_2 \sum_{i=1}^{k} LAH_{t-i} + \beta_3 \sum_{i=1}^{k} TC_{t-i} + \beta_4 \sum_{i=1}^{k} GNI_{t-i} + \beta_5 \sum_{i=1}^{k} TP_{t-i} + \beta_6 \sum_{i=1}^{k} UP_{t-i} + \beta_7 \sum_{i=1}^{k} INF_{t-i} + u_t \qquad (3)$$

An interpretation of this model is that food security (KFS) is a function of the present values of the identified explanatory variables, as well as their values in previous time periods. This model specified in equation 3 is a distributed lag model. Since the explanatory variables are assumed to be uncorrelated with the error term (u_t), the method of Ordinary Least Squares (OLS) estimation, when used sequentially, is able to produce consistent and efficient estimates of the respective coefficients.

However, problems arise as the length of the lags (k) in the model is not specified and that sequential lags tend to be highly correlated. Furthermore, sequential estimation causes a decline in the degrees of freedom and consequently the confidence in statistical inferencing. It is also important to note that unrestricted or infinite lags might raise the errors in forecasts while having too few lags might exclude important information

These are some of the reasons why the study adopted the Koyck approach to transforming infinitely distributed distributed-lag models to finite models, which assumes that all the $\beta's$ decline geometrically, given that they all have the same sign. This assumption can be written as $\beta_k = \beta_0 \lambda^k,\ where\ k = 0, 1, 2, \ldots$ and $0 < \lambda < 1$. Where λ is the rate of deterioration. Taking this into consideration, the infinitely-lagged model can be written as follows:

$$KFS_t = \alpha + \beta_0 MP_t + \beta_0 \lambda^k \sum_{i=1}^{n} MP_{t-i} + \beta_1 IQ_t + \beta_1 \lambda^k \sum_{i=1}^{n} IQ_{t-i} + \beta_2 LAH_t + \beta_2 \lambda^k \sum_{i=1}^{n} LAH_{t-i} + \beta_3 TC_t + \beta_3 \lambda^k \sum_{i=1}^{n} TC_{t-i} + \beta_4 GNI_t + \beta_4 \lambda^k \sum_{i=1}^{n} GNI_{t-i} + \beta_5 TP_t + \beta_5 \lambda^k \sum_{i=1}^{n} TP_{t-i} + \beta_6 UP_t + \beta_6 \lambda^k \sum_{i=1}^{n} UP_{t-i} + \beta_7 INF_t + \beta_7 \lambda^k \sum_{i=1}^{n} INF_{t-i} + u_t \qquad (4)$$

By lagging equation 4 by one period the equation can be rewritten as follows:

$$KFS_{t-1} = \alpha + \beta_0 MP_{t-1} + \beta_0\lambda^k \sum_{i=2}^{n} \mathrm{MP}_{t-i} + \beta_1 IQ_{t-1} + \beta_1\lambda^k \sum_{i=2}^{n} \mathrm{IQ}_{t-i} + \beta_2 LAH_{t-1} + \beta_2\lambda^k \sum_{i=2}^{n} \mathrm{LAH}_{t-i} + \beta_3 TC_{t-1} + \beta_3\lambda^k \sum_{i=2}^{n} \mathrm{TC}_{t-i} + \beta_4 GNI_{t-1} + \beta_4\lambda^k \sum_{i=2}^{n} \mathrm{GNI}_{t-i} + \beta_5 TP_{t-1} + \beta_5\lambda^k \sum_{i=2}^{n} \mathrm{TP}_{t-i} + \beta_6 UP_{t-1} + \beta_6\lambda^k \sum_{i=2}^{n} \mathrm{UP}_{t-i} + \beta_7 INF_{t-1} + \beta_7\lambda^k \sum_{i=2}^{n} \mathrm{INF}_{t-i} + u_{t-1}$$

……………………………………………………………………………………………..… (5)

Equation 5 can then be condensed and rewritten as:

$$KFS_{t-1} = \alpha + \beta_0\lambda^k \sum_{i=1}^{n} \mathrm{MP}_{t-i} + \beta_1\lambda^k \sum_{i=1}^{n} \mathrm{IQ}_{t-i} + \beta_2\lambda^k \sum_{i=1}^{n} \mathrm{LAH}_{t-i} + \beta_3\lambda^k \sum_{i=1}^{n} \mathrm{TC}_{t-i} + \beta_4\lambda^k \sum_{i=1}^{n} \mathrm{GNI}_{t-i} + \beta_5\lambda^k \sum_{i=1}^{n} \mathrm{TP}_{t-i} + \beta_6\lambda^k \sum_{i=1}^{n} \mathrm{UP}_{t-i} + \beta_7\lambda^k \sum_{i=1}^{n} \mathrm{INF}_{t-i} + u_{t-1}$$

…………………………………………………………………………………….……… (6)

Equation 6 is then multiplied by λ to derive the following equation:

$$\lambda KFS_{t-1} = \lambda\alpha + \lambda\beta_0\lambda^k \sum_{i=1}^{n} \mathrm{MP}_{t-i} + \lambda\beta_1\lambda^k \sum_{i=1}^{n} \mathrm{IQ}_{t-i} + \lambda\beta_2\lambda^k \sum_{i=1}^{n} \mathrm{LAH}_{t-i} + \lambda\beta_3\lambda^k \sum_{i=1}^{n} \mathrm{TC}_{t-i} + \lambda\beta_4\lambda^k \sum_{i=1}^{n} \mathrm{GNI}_{t-i} + \lambda\beta_5\lambda^k \sum_{i=1}^{n} \mathrm{TP}_{t-i} + \lambda\beta_6\lambda^k \sum_{i=1}^{n} \mathrm{UP}_{t-i} + \lambda\beta_7\lambda^k \sum_{i=1}^{n} \mathrm{INF}_{t-i} + \lambda u_{t-1}$$

……………………………………………………………………………………………… (7)

Which can be rewritten as follows:

$$\lambda KFS_{t-1} = \lambda\alpha + \beta_0\lambda^k \sum_{i=1}^{n} \mathrm{MP}_{t-i} + \beta_1\lambda^k \sum_{i=1}^{n} \mathrm{IQ}_{t-i} + \beta_2\lambda^k \sum_{i=1}^{n} \mathrm{LAH}_{t-i} + \beta_3\lambda^k \sum_{i=1}^{n} \mathrm{TC}_{t-i} + \beta_4\lambda^k \sum_{i=1}^{n} \mathrm{GNI}_{t-i} + \beta_5\lambda^k \sum_{i=1}^{n} \mathrm{TP}_{t-i} + \beta_6\lambda^k \sum_{i=1}^{n} \mathrm{UP}_{t-i} + \beta_7\lambda^k \sum_{i=1}^{n} \mathrm{INF}_{t-i} + \lambda u_{t-1}$$

……………………………………………………………………………………………….. (8)

To obtain the Koyck model we subtract equation 8 from equation 4 to get the following equation:

$$KFS_t - \lambda KFS_{t-1} = \alpha(1-\lambda) + \beta_0 MP_t + \beta_1 IQ_t + \beta_2 LAH_t + \beta_3 TC_t + \beta_4 GNI_t + \beta_5 TP_t + \beta_6 UP_t + \beta_7 INF_t + (u_t - \lambda u_{t-1})$$

………………………………………………………………………………….…………… (9)

If rearranged, the model can be written as follows:

$$KFS_t = \alpha(1-\lambda) + \beta_0 MP_t + \beta_1 IQ_t + \beta_2 LAH_t + \beta_3 TC_t + \beta_4 GNI_t + \beta_5 TP_t + \beta_6 UP_t + \beta_7 INF_t + \lambda KFS_{t-1} + v_t$$

…………………………………………………………...…………………………………. (10)

The final derived koyck model to be estimated is written as follows:

$$lnKFS_t = \alpha^* + \beta_0 lnMP_t + \beta_1 lnIQ_t + \beta_2 lnLAH_t + \beta_3 TC_t + \beta_4 lnGNI_t + \beta_5 lnTP_t + \beta_6 lnUP_t + \beta_7 lnINF_t + \lambda lnKFS_{t-1} + v_t \quad \ldots\ldots (11)$$

Where: $\alpha^* = \alpha(1-\lambda)$, which can be written also as $\alpha = \alpha^*/(1-\lambda)$, and $(1-\lambda)$ is the speed of adjustment.

Also, $v_t = u_t - \lambda u_{t-1}$, and $0 < \lambda < 1$.

Equation 11 is an autoregressive model due to the presence of KFS as a regressand and among the regressors. This was the model estimated by this study. However, statistical problems were anticipated in estimating the autoregressive model because it violates the OLS assumption that explanatory variables should be non-stochastic. KFS_{t-1} is a stochastic variable. To satisfy the classical OLS assumption KFS_{t-1} should be distributed independently of the error term. Otherwise, correlation between KFS_{t-1} and v_t will lead to biased and inconsistent OLS estimators, and hence false results. Consequently, because the statistical properties of v_t depend on u_t,a correlation problem is anticipated. v_t is a moving average of u_t and u_{t-1}.

3.5 Estimation Procedure

3.5.1 Stationarity Test / Unit Root Test

Stationarity in time series means that the statistical properties of the data remain constant over time. That is the variance and the mean do not differ systematically across time. When mean and variance are not constant then the OLS assumption of constant mean and variance is not met, which leads to biased estimators. A change from one period to another should not change the distribution shape of the series, hence stationarity. The presence of unit roots (stochastic or deterministic trends) indicates non-stationarity, and by extension a systematic pattern that is erratic and hence unpredictable. In other words, there is more than one trend in the data series. A spurious regression is one of the analysis issues that could be caused by unit roots. The augmented Dickey-Fuller test and the Phillips-Perron test were used to test for stationarity. The former is used in the event there is autocorrelation in the error terms, while the latter is applied because it corrects for serial correlation and heteroskedasticity in the error terms.

3.5.2 Cointegration Analysis

If our data is non-stationary, then checking for cointegration is necessary. Cointegration is identified when two or more non-stationary series have a similar stochastic trend or long-run relationship, such that even when one variable is regressed on the other the regression not spurious (Gujarati & Porter, 2009). In other words, two cointegrated variables that are linearly combined will be integrated of a lower order as compared to their individual orders of integration. Pre-testing for cointegration helps avoid spurious regression. The cointegration test applied in this study was the Engle-Granger test.

3.5.3 Structural Breaks Test

Checking for structural breaks was equally crucial because it helps identify any significant and abrupt changes in our data. This check helps us to know whether, at any particular time over the span of the series, there was a break in the regression coefficients which would then indicate parameter instability in our model, which in turn leads to forecasting errors. The Wald test was chosen as the best for this study because any anticipated breaks are unknown. Another advantage of using the Wald test is its ability to be done even if heteroskedasticity is present. These are qualities that the alternative Chow test does not have. The null hypothesis is that there are no structural breaks.

3.6 Diagnostic Tests

3.6.1 Normality Test

The normality test was conducted because knowing the nature of the distribution of the OLS estimators is key to enabling us to draw proper conclusions from the data on population values. One prevailing supposition of the Classical normal linear regression model is that the stochastic disturbance term is normally and independently distributed. The implication of normal distribution of u_t on OLS estimators is that they are unbiased, they have minimum variance (efficient), and that they are consistent. One key reason for carrying out this test is the presence of KFS_{t-1} among the explanatory variables. Hence, to test for normality, the Shapiro-Wilk test was used. Although one weakness of the Shapiro-Wilk test is that it is not best for duplicated data and large sample sizes, it was used because the data used has neither of the identified weaknesses.

3.6.2 Serial Correlation Test

The autocorrelation test is also important in this study due to the presence of v_t in the model. v_t is described as a moving average of u_t and u_{t-1}. Serial correlation or autocorrelation occurs when the error term of one period is correlated with that of another period. This can lead to inefficient OLS estimates; overstated goodness of fit; standard errors that are very small; t-statistics that are very big; and spurious regression estimates. Ordinarily, the Durbin-Watson test would be used to test for autocorrelation, however, because the model is autoregressive in nature the d-statistic computed from the test has a bias against determining first-order serial correlation due to its general tendency towards 2. Hence the test employed for this study is the Durbin h test, which is more suited for analyzing the autoregressive model. The null hypothesis is that the error terms are serially uncorrelated.

3.6.3 Multicollinearity Test

Checking for multicollinearity was also paramount to avoid redundancy of explanatory variables, which in effect might skew estimation results since telling how different correlated regressors will ultimately affect the regressand becomes hard and comparatively indistinguishable. In brief, multicollinearity is a result of there being a set of two or more highly correlated explanatory variables in the model.

One way to identify multicollinearity is when there is a relatively high R2 but the number of significant t-ratios is few. However, multicollinearity was tested using the variance inflation factors (VIFs) which examine the margin by which the variance of an estimated coefficient rises given that the regressors are correlated. The variance inflation factors measure the strength of the identified correlation. If none of the factors are correlated, the variance inflation factors will all be 1.

3.7 Data Type and Sources

The study utilized secondary time series data, covering the period 1970-2019, collected from the Food and Agriculture organization, and the world development indicators which are compiled by the World Bank databases. Because of the recursive nature of the research problem, time-series data was applied to achieve the research objectives.

CHAPTER 4: DATA ANALYSIS AND RESULTS

4.1 Introduction

This section reports the findings of the study derived from a critical analysis of the data using the methodological procedures discussed in chapter 3. Interpretation of the results is also discussed.

4.2 Descriptive Statistics

Table 2 depicts the summary of the variables included in the model. The variable Kilocaloric Food Supply (-1), has 49 observations due to the fact that it represents the values of Kilocaloric Food Supply lagged by one time period. In this case, one year. The mean shows the central tendency of our variables, while the minimum and maximum show the smallest and largest values in each variable respectively. The minimum and maximum values are used to compute the range which is a measure of the dispersion of the variables. The standard deviation captures information about the distribution spread of our variables. It shows how close a variable's distribution is to the mean. Imported maize quantity has the largest standard deviation compared to all other variables, which shows that variance in the quantity of maize imported is larger as it may depend on factors such as domestic maize production and international food prices.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Kilocaloric Food Supply	50	6.703457	.1669767	6.483108	7.034388
Maize Production	50	14.73493	.2678181	14.15198	15.28987
Import Quantity	50	9.935516	3.687538	.6931472	14.22657
Land Area Harvested	50	14.25953	.1993362	13.8004	14.66463
Temperature Change	50	.5685	.4631393	-.217	1.74
GNI per capita	50	6.354865	.5190921	5.373486	7.530163
Total Population	50	17.07682	.4599019	16.24044	17.77754
Urban Population	50	15.37349	.7109586	13.96693	16.48732
Inflation	50	2.210755	.7403016	.3176656	3.828182
Kilocaloric Food Supply (-1)	49	6.707644	.1660336	6.483108	7.034388

Source: Author's own computation

4.3 Pre-estimation Tests

4.3.1 Stationarity Test

This procedural test employs both the augmented Dickey-Fuller test (ADF) and the Phillips-Perron (PP) test to check for the presence of unit roots in our series that captures trends in the mean and variance. The null hypothesis for both tests is that a unit root is present in the examined variable. This step helps avoid spurious regression and hence helps avoid estimating biased coefficients. The results of the test are shown in table 3.

Table 3: Unit Root Test Results

	ADF		**PP**		**ADF (1st Difference)**		**PP (1st Difference)**	
Variable	**Test Statistic**	**p - value**	**Test Statistic**	**p - value**	**Test Statistic**	**p - value**	**Test Statistic**	**p - value**
Kilocaloric Food Supply	-1.163 (-2.944)	0.6894	-0.860 (-2.933)	0.8008	-3.394 (-2.947)	0.0112	-8.610 (-2.936)	0.0000
Maize Production	-0.340 (-2.944)	0.9196	-2.018 (-2.933)	0.2785	-4.170 (-2.947)	0.0007	-8.825 (-2.936)	0.0000
Import Quantity	-2.390 (-2.944)	0.1445	-2.617 (-2.933)	0.0895	-4.198 (-2.947)	0.0007	-7.263 (-2.936)	0.0000
Land Area Harvested	-0.421 (-2.944)	0.9066	-1.379 (-2.933)	0.5921	-3.153 (-2.947)	0.0229	-10.962 (-2.936)	0.0000
Temperature Change	0.427 (-2.944)	0.9825	-1.593 (-2.933)	0.4870	-4.988 (-2.947)	0.0000	-12.334 (-2.936)	0.0000
GNI per capita	0.147 (-2.944)	0.9691	-0.443 (-2.933)	0.9027	-3.352 (-2.947)	0.0127	-5.539 (-2.936)	0.0000
Total Population	-4.115 (-2.944)	0.0009	-10.386 (-2.933)	0.0000	*	*	*	*
Urban Population	-0.944 (-2.944)	0.7733	-4.588 (-2.933)	0.0001	-2.783 (-2.947)	0.0607	-2.001 (-2.936)	0.2861
Inflation	-2.226 (-2.944)	0.1968	-4.508 (-2.933)	0.0002	-3.843 (-2.947)	0.0025	-9.761 (-2.936)	0.0000
Kilocaloric Food Supply (-1)	-1.195 (-2.947)	0.6756	-0.909 (-2.933)	0.7852	-3.332 (-2.950)	0.0135	-8.532 (-2.938)	0.0000

Source: Author's own computation.
Note: The parenthesized values are the ADF and PP 5% critical values.

The ADF results show that we do not reject the null hypothesis for all variables except for the total population which has a p-value that is significant at the 0.05 level at a 5 percent critical value of -2.944. Additionally, the fact that the absolute values of the test statistic are less than those of the critical values also points to there being evidence of unit roots in our variables. Hence, all variables are non-stationary except for the natural log of the total population.

Nonetheless, the ADF results contrast to the PP results in such a way that we reject the null hypothesis that there is a unit root present in total population, urban population, and inflation in consumer prices for the Phillips-Perron test. While there is harmony between the two test results when it comes to the total population, the lack of consistency in urban population and inflation compels us to first-difference both variables coupled with the rest of the non-stationary variables, where the ADF and PP tests concur. The first difference results reveal that all variables have a p-value that is lower than 0.05 at the prescribed critical values, except for the natural logarithm of the urban population. Also, the absolute values of the test statistic are larger than the absolute critical values pointing to the stationarity of our variables, except for the urban population. Therefore, after first differencing, we can reject the null hypothesis for all variables except for the urban population. Second differencing the urban population gives an ADF test statistic of -4.587, checked against a 5 percent critical value of -2.94 and a p-value of 0.0001, meaning that we can reject the null hypothesis. The PP test confirms this by giving a significant p-value of 0.0000 and a test statistic of -5.856 (-2.938). It should thus be noted that except for the urban population which is integrated of order I(2), all other variables are integrated of order I(1).

4.3.2 Cointegration Test

Cointegration analysis helps establish whether a linear interaction or a combination of the variables in our model depicts a long-run relationship or equilibrium. If cointegration is detected we will accordingly estimate an error correction model. The results of the Engle-Granger cointegration analysis are shown in table 4 below.

Table 4: Cointegration Analysis Test Results

Engle-Granger test for cointegration				N (1st step) = 49
				N (test) = 48
	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-7.032	-7.131	-6.317	-5.917
Critical values from MacKinnon (1990, 2010)				

Source: Author's own computation

The null hypothesis is that cointegration exists in our model. The results show that there is evidence of cointegration at the 5 percent critical value since our test statistic (-7.032) is smaller than the critical value (-6.317). Hence, we do not reject the null hypothesis.

4.3.3 Structural Breaks Test

To test if our estimated coefficients are stable, we need to ascertain that there are no breaks in our data over the period of analysis, which may lead to biased coefficients. The null hypothesis is that there are no structural breaks in our model. The test results are depicted in table 5 below. Because our p-value is not significant - it is larger than 0.05 - we do not reject the null hypothesis since the test does not detect a break in 1994.

Table 5: Wald's Structural Breaks Test

Test for a structural break: Unknown break date		Number of obs = 48
Full sample: 1972 - 2019 Trimmed sample: 1993 - 1999 Estimated break date: 1994 Ho: No structural break		
Test	Statistic	p-value
Swald	10.9114	0.6894

Source: Author's own computation

4.4 Koyck Model Estimation Results

Figure 6 shows the OLS regression results and the estimated coefficients determining maize food security in Kenya.

Table 6: OLS Regression Results

Kilocaloric Food Supply	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Maize Production	.1006998	.0325218	3.10	0.004	.034863	.1665367
Import Quantity	-.0005205	.0021497	-0.24	0.810	-.0048723	.0038313
Land Area Harvested	.0066176	.0536779	0.12	0.903	-.1020475	.1152828
Temperature Change	.0092396	.0141901	0.65	0.519	-.0194868	.0379661
GNI per capita	.1011972	.0423046	2.39	0.022	.0155561	.1868383
Total Population	-.0048184	.0107065	-0.45	0.655	-.0264926	.0168559
Urban Population	.9439731	1.086287	0.87	0.390	-1.2551	3.143046
Inflation	.0075797	.0063049	1.20	0.237	-.0051839	.0203433
Kilocaloric Food Supply (-1)	-.1822178	.1254106	-1.45	0.154	-.4360983	.0716626
_cons	.0670819	.1833518	0.37	0.716	-.3040944	.4382581
Number of obs = 48 *F(9, 38) = 3.20* *Prob > F = 0.0056* *R-squared = 0.4314* *Adj R-squared = 0.2968* *Root MSE = 0.0309*						

Source: Author's own computation

An overall examination of the results shows that analysis was done for 48 years of data, which is equivalent to the number of observations. Secondly, the probability of the F-statistic shows that we can reject the null hypothesis that R-squared is equal to zero – our model lacks explanatory power – with 95 percent confidence. The p-value of our F-statistic is smaller than 0.05, hence we can conclude the alternative hypothesis that our model has some explanatory power. Secondly, the R-squared gives us the coefficient of determining how well our model explains variations in the consumption of maize in Kenya. As a result, we can conclude that 43.14 percent of the variation in maize food security can be explained by the explanatory variables included in our model.

By examining the p-values of the t-statistics in our model, we notice that that only maize production and gross national income per capita are significant at the 95 percent confidence level. In other words, only maize production and GNI per capita have coefficients that have a p-value that is less than 0.05. The rest of the variables are not statistically significant and do not explain variance in maize food security at the 95 percent confidence level. It is also important to note that both maize production and GNI per capita are positively related to the kilo-caloric food supply. Table 6 shows that a percentage increase in maize production leads to a 0.1007 percentage increase in maize food security, ceteris paribus. Similarly, a percentage increase in GNI per capita leads to a 0.1012 percentage increase in the kilo-caloric food supply, ceteris paribus.

4.4.1 Error Correction Model

Because the lagged value of kilocaloric food supply is not significant as shown in table 6, we cannot use the long-run multiplier specified by the Koyck model as follows:

$$\sum_{0}^{\infty} \beta_k = \beta_0 \left(\frac{1}{1-\lambda}\right) \quad \ldots\ldots (12)$$

Where the λ is simply the coefficient of *kilocaloric food supply (-1)*.

Therefore, we proceed by estimating the error correction model instead, which captures the convergence of the cointegrating equation to long run equilibrium. The results are presented in table 7 below. The residuals generated in Engle-Granger estimation of the long-run equation are used to estimate the ECM.

Table 7: ECM Regression Results

Kilocaloric Food Supply	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf. Interval]**	
Maize Production	.1102131	.0300823	3.66	0.001	.0492606	.1711655
Import Quantity	.0006828	.0020213	0.34	0.737	-.0034128	.0047784
Land Area Harvested	.0294532	.0499973	0.59	0.559	-.071851	.1307574
Temperature Change	.008178	.0130486	0.63	0.535	-.018261	.0346169
GNI per capita	.0827374	.0394307	2.10	0.043	.0028432	.1626315
Total Population	-.0044582	.009842	-0.45	0.653	-.0243999	.0154836
Urban Population	.7526144	1.000781	0.75	0.457	-1.275161	2.78039
Inflation	.0077723	.0057957	1.34	0.188	-.0039709	.0195155
Kilocaloric Food Supply (-1)	.2005002	.1779053	1.13	0.267	-.1599701	.5609705
ECT	-.6669922	.2361588	-2.82	0.008	-1.145495	-.188489
_cons	.0645562	.1685343	0.38	0.704	-.2769268	.4060391

Number of obs	*= 48*
F(10, 37)	*= 5.22*
Prob > F	*= 0.0001*
R-squared	*= 0.5323*
Adj R-squared	*= 0.4059*
Root MSE	*= 0.0284*

Source: Author's own computation

The ECM is better due to the higher R-squared value. The number of observations is 48. The p-value of the F-statistic is less than 0.05, hence we can reject the null hypothesis that all the coefficients in our model are zero. Our ECM does have explanatory power. We conclude that 53.23 percent of the variation in maize food security can be explained by our model.

Maize production is positively related to kilocaloric food supply in such a way that a percentage increase in production would lead to a 0.1102 percentage increase in maize kilocaloric food supply. The t-statistic 3.66 which is larger than the 1.96 critical value, is determined as being significant. This is confirmed by the p-value of 0.001 which is less than 0.05. Hence, variations in maize production are positively linked to variations in consumption and by extension, variations in maize food security. Producing more maize will ultimately lead to enhancement in food security. This result is in line with Villarreal and Stloukal (2005), who had highlighted the importance of increasing per capita food production as a measure of improving food security.

Import quantity has a positive coefficient of 0.0007 and a t-statistic of 0.34, meaning that it is not significant at the critical value of 1.96. Its p-value confirms this since it has a value of 0.737 which is greater than 0.05. This result implies that despite importing maize to supplement recursive food shortages in Kenya, the quantity imported fails to have a significant impact in improving maize food security in Kenya.

Land area harvested is positively related to kilocaloric food supply, marked by a coefficient of 0.0295. The accompanying t-statistic is 0.59 means that the variable is not significant at the 95 percent confidence level since it is less than 1.96. This is confirmed by a p-value of 0.559 which is greater than 0.05, indicating that it is insignificant. This means that although increasing maize productivity in Kenya has in the past been heavily reliant on increasing the land area harvested, maize food security is not linearly determined by the land area harvested. This result conflicts with Omosa's (2006) finding that land area had a significant impact on household food security.

Temperature change is positively related to the consumption of maize in Kenya. The t-statistic (0.63) is less than the critical value (1.96), indicating that temperature change is not significant. The p-value (0.535) is also greater than 0.05, thus confirming the conclusion. The rise in maize kilocaloric food supply when temperature increases can be attributed to a dietary preference for relatively cheaper staple foods. Hence people will consume more maize when faced with drought. However, temperature change is determined as not being critical to enhancing maize food security. This result is contrary to the Food Security Information Network (2020) findings that climate change has a negative impact on food security.

GNI per capita also had a positive relationship with maize food security. That is, a percentage increase in GNI per capita leads to a 0.0827 increase in maize kilocaloric food supply, ceteris paribus. The t-statistic of 2.10 is larger than 1.96 hence it is statistically significant and is verified by a p-value of 0.04. Therefore, the more income people have the more they will consume maize albeit the percentage increase is relatively small. This result reinforces Świetlik (2018) finding that GDP per capita and food security are positively related.

The total population is negatively related to maize food security. Growth in the total population is accompanied by a decline in the consumption of maize. Its t-statistic (-0.45) is statistically insignificant and this is verified by a large p-value of 0.653. Although general growth in population points to a worsening food security situation, it is not critical in determining maize food security. The negative association between the two support Kungu (2014) findings that a household's size is negatively related to its food security situation.

Urban population is positively related to kilocaloric food supply. The t-statistic of 0.75 is less than the critical value of 1.96, indicating that it is not significant. Its p-value (0.457) confirms this since it is larger than 0.05. The positive relationship indicates that urbanization provides additional demand for maize. However, variations in the urban population do not help determine the level of maize food security in the country.

Inflation in consumer prices had a positive relationship to maize kilocaloric food supply. The t-statistic of 1.34 associated with it indicates that it is not significant, and is backed by a p-value of 0.188. This result reflects that maize consumption increases when there is a general rise in inflation. However, despite causing a preference for maize, general variations in consumer prices do not lead to help explain variations in maize food security. This finding is contrary to the conclusion made by Abdoulaye et al. (2015) that consumer prices were negatively related to food security.

The kilocaloric food supply (-1) is positively related to the current period kilocaloric food supply. This implies that enhancing maize food security in the current period positively enhances maize food security in the following period. However, the t-statistic (1.13) is less than 1.96 indicating that it is not significant at the 95 percent confidence level. The p-value of 0.267 confirms this point. Despite having a positive association with current kilocaloric food supply, the kilocaloric food supply (-1) does not significantly impact kilocaloric food supply in the long-run. In other words, the previous records of food security do not determine how food secure people are in the long run.

The error correction term (ECT) coefficient has a negative sign which corrects for both positive and negative deviations from the long-run equilibrium. The coefficient (-.667) indicates that deviations from the long-run equilibrium are corrected at a relatively high speed of 66.7 percent in the next year. Likewise, it is statistically significant at the 95 percent level of confidence. This is shown by a t-statistic of -2.82. Its modulus is greater than 1.96. The p-value (0.008) confirms this point.

4.5 Post-estimation Tests

4.5.1 Normality Test

Table 8 below shows the Shapiro-Wilk test results for the normality of our model residuals.

Table 8: Normality Test Results

Shapiro-Wilk W test for normal data					
Variable	Obs	W	V	z	Prob>z
residuals	48	0.97704	1.046	0.095	0.46229

Source: Author's own computation

The null hypothesis is that the residuals are normally distributed, while the alternative hypothesis is that the residuals are not normally distributed. Our results show that we cannot reject the null hypothesis since the p-value (0.46229) of the z-statistic (0.095) is well above the 0.05 critical level. Hence, we conclude that our data is normally distributed.

4.5.2 Autocorrelation Test

The null hypothesis of the durbin *h* test for autocorrelation is that our model residuals are not autocorrelated. The results are shown in table 9 below.

Table 9: Autocorrelation Test Results

Durbin's alternative test for autocorrelation			
lags(p)	*chi2*	*df*	*Prob > chi2*
1	2.271	1	0.1318

Source: Author's own computation

We have a chi-square value of 2.271 which has a p-value that is above the 0.05 critical level. Hence we do not reject the null hypothesis of no autocorrelation.

4.5.3 Multicollinearity Test

The redundancy of explanatory variables is determined through this test, which helps identify highly correlated variables. The test results are presented in table 10 below.

Table 10: Multicollinearity Test Results

Variable	**VIF**	**1/VIF**
Land Area Harvested	1.60	0.625851
Maize Production	1.55	0.644849
Import Quantity	1.53	0.653821
Urban Population	1.33	0.752283
Inflation	1.29	0.773123
Temperature Change	1.16	0.861582
Kilocaloric Food Supply (-1)	1.12	0.892298
GNI per capita	1.10	0.911948
Total Population	1.08	0.928599
Mean VIF	**1.31**	

Source: Author's own computation

Generally, since none of the relative variable VIFs is above 5, and the mean VIF is small at 1.31, we conclude that multicollinearity is not a problem for our model.

CHAPTER 5: CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

Food security in Kenya and the consumption of maize are highly correlated as the most notable food shortages have corresponded to a drastic decline in maize supply (KARI, 2009). Food security has hitherto remained a big problem in Kenya. The proportion of people suffering from hunger rose to 29.4 percent in 2017 from 22.3 percent in 2013, according to data from the World Bank. The research problem sought to explore why there exists a disconnect between the most consumed food crop in Kenya and the various defined supply and demand-side factors.

To do this, food security was framed as a problem that was a function of time, and hence it was specified using a distributed lag model. Similarly, food security was framed as a problem that could be solved by determining the impact of supply and demand-side variables, according to the theoretical framework offered by Thomson and Metz (1998). To define these supply and demand-side variables, the study further applied the decomposition of food security as stipulated by FAO. Hence, variables included in the model were chosen based on the dimension they could arguably and reasonably be referred to. To this effect, maize production was chosen to represent the availability of food; import quantity, land area harvested, and temperature change represented stability of the supply-side determinants; GNI per capita was chosen to represent economic access to food; total population, urban population and inflation in consumer prices represented the stability of the demand side determinants. The study applied time series data covering the period 1970 to 2019, collected from the FAO and the World Bank, to explore the research problem.

5.2 Summary of Key Findings

Results from the data analysis found that all the variables examined, except for the total population were non-stationary. The urban population was integrated I(2) while the rest were I(1). Additionally, the variables were found to be cointegrated. Consequently, two variables were found to be significant by directly determining the level of maize food security in Kenya, both in the short and long run. To be precise, maize production and gross national income per capita were found to be positively linked to the consumption of maize in Kenya. All other variables that were intended to measure stability were all not found to be significant in determining maize food security in the country. No structural break, serial correlation, or multicollinearity was detected by the various diagnostic test conducted.

5.3 Policy Recommendations

Results presented in this study lead us to ask two policy-related questions. Namely, how can the Kenyan government enhance availability via maize production, and economic access via income as an entitlement to food? An unanticipated reduction in either of the two increases the likelihood of worsening the maize food security situation in the country. Hence, preventive measures to curb any anticipated decline, need to revolve around reducing production costs, increasing maize yields, and subsidizing maize and its associated products. Provision of such relief to the key staple food would arguably lead to subsequent diversification of diets over time. Consequently, these actions would provide relief to both farmers and consumers.

Our results point to the fact that increasing land area harvested or importing more maize is not enough to guarantee an improvement in maize food security. Hence the focus is placed on increasing yields of the available land and improving cost-efficiency in terms of inputs applied to maize production. This can be achieved via increasing farmer access to improved seeds and by equipping more land with irrigation infrastructure.

Whilst agricultural research has led to the development of hybrid seeds which give require less fertilizer application, hence reducing costs and boosting yields, the protracted reliance on rain-fed agriculture leaves a potential for increasing yields. The FAO notes that only 150,600 hectares were equipped with irrigation infrastructure in 2017. This contrasts with the 2,092,459 hectares where maize was harvested in the same year. Therefore the government should start equipping available land with appropriate irrigation infrastructure to complement the newly researched crop seeds.

The study results confirm that income is an important aspect of food security. However, it should be noted that the distribution of income is also as important in determining that the poor have economic access to food. Thus, a substantial reduction in GNI per capita should prompt the government to provide a subsidy to cushion consumers. The government has usually only availed a subsidy program following a sharp decline in maize production due to drought or uncontrolled pest infestation.

5.4 Study Limitations

Variables included in the model only analysed availability, economic access, and the pertinent proposed stability measures. The study was unable to capture physical access which would have measured the impact of Kenya's distribution network which consists of road and/or railway networks. Similarly, utilization as a dimension of food security was also not represented in the analysis. This was due to a lack of sufficient data.

5.5 Areas for Further Research

Going by the results of the study, it is evident that modelling the determinants affecting stability or vulnerability of maize food security was difficult. An examination of factors affecting maize food security might shed light on recursive shocks that lead to maize shortages. Stability analysis would help establish a predictive maize food security risk analysis method that would help understand shocks and how they impact food needs. Food aid has also not been explored herein under the availability dimension, hence studying the integration between food aid and stability of food security could also provide insight as to how to continue tackling the problem.

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