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Article

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Reference: Ngwakwe, Collins C. (2019). Relating climate change-induced temperature with grain production : a financial implication framework. In: EuroEconomica 38 (1), S. 73 - 84.

This Version is available at:
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Relating Climate Change-Induced Temperature with Grain Production: A Financial Implication Framework

Collins C. Ngwakwe[1]

Abstract: Climate change continues to unleash wider negative ramifications on humans, including grain production with attendant economic consequences. This paper explored the relationship between climate-induced temperature and grain production in Southern African countries. It contributes to the literature by charting the financial implication framework. Maize production was used as a proxy for grain production and archival data on maize production were collected from a sample of five Southern African countries, where high temperature and drought has inflicted havoc on grain farming within the recent years. Hence, data on the five countries were collected over six years 2011 – 2016. Applying the panel data approach and the fixed effect OLS regression, results showed a high correlation between high temperature and low maize productivity in Southern African countries. Further analysis showed that high temperature and drought has led to high cost of production on farmers, increasing price of grain and overall increase in consumer expenditure on maize, which is a staple crop in Southern Africa. The paper prepared a framework of financial implication, which touches on how the poor consumers might be affected by climate change-induced temperature increases. The paper recommends further study, which should expand on the sample size to conduct future research on this relationship. It also provides an agenda for further research on the effect of climate change induced-temperature on food poverty gap in Southern Africa. This recommendation is significant since eradication of food poverty is a vital feature of the 2030 Sustainable Development agenda.

Keywords: Finance & drought; food prices; maize production; climate change; grain production; food poverty

JEL Classification: Q5; Q54; Q11; Q21;

1. Introduction

Amongst others, one of the dreaded threat of climate change is rising temperature and/or global warming on the one hand and erratic temperature on the order hand (Holmes, Woollings, Hawkins & De Vries, 2016; Teng, Branstator, Meehl & Washington, 2016). This has become evident in Eastern and Southern parts of Africa and has contributed to unprecedented heat waves with little or no rain in some areas of Africa mostly within the years 2014 – 2016. Climate change-induced temperature oscillation has negatively affected farm productivity due to the attendant drought. Hence, the president of Agri SA, laments that "*the agricultural sector in recent times, on the back of severely sub-normal rainfall and heat waves has met head-on with the drought*" (Möller, 2016, p. 2). The Intergovernmental Panel on Climate Change (IPCC) is currently refocussing its effort on critical areas to concentrate initiatives about climate change mitigation and adaptation within the next few years (Boucher et al., 2016; IPCC, 2016).

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The IPCC has therefore pitched its few years' target effort on *inter alia*, climate change at 1.5^0 C and food security (IPCC, 2016).

Previous researchers on climate change related temperature rise has approached this phenomenon from multifaceted dimensions, such as climate warming and food security, Conway et al. (2015); climate warming and health implications, Ngarakana-Gwasira et al. (2016); climate warming and the widening of economic and social inequality (Dennig et al., 2015). This paper contributes to the literature by looking at climate warming (rising temperature) and grain production in select Southern African countries and the relationship with maize production. It further contributes by initiating a conceptual framework of financial implications for consumers and farmers. Therefore, the main objective of this paper is to analyse the relationship between rising temperature and grain production and to propose a framework for understanding the financial implication of climate warming for farmers and consumers, hence the research question is whether climate warming has had impact on grain production in Southern African countries and what financial implications this may portend.

This paper has the following structure. Following the above introduction of the paper, the researcher reviews some related literature in the subsequent section. The method and result section follows immediately after the literature. The next section is the discussion and presentation of framework. The final section is the conclusion.

2. A Brief on Global Warming Theory

More than ever, in recent years, humans have acquired an unprecedented awareness and attendant phobia for the consequences of their insatiable exploitation and pollution of natural atmosphere (Vasseur et al., 2014; Seinfeld & Pandis, 2016; Leygraf, Wallinder, Tidblad & Graedel, 2016). The human contribution to the destruction of human habitat has largely been regarded as rooted in anthropocentric or homocentric inclination of humankind, in which humans believe they are the superior on earth and thus other creation is to be used for their utmost value satisfaction – hence the theory of anthropocentrism (Liu, Liu, Yang, Chen & Ulgiati, 2016). Consequent to anthropocentric dominance, the unbridled anthropogenic penchant of humans has propelled the rate of carbon emission to the level that has distorted the natural balance between energy flows – from and out of the climate earth. Accordingly, human activity, which is causing unusual increase in the level of carbon and other greenhouse gas emissions, shields the natural release of earth's infrared energy into the outer space – causing the earth to hold back more energy than it can tolerate – this has orchestrated the greenhouse effect aphorism (Spencer, 2017). The resulting effect has been the unprecedented rising of temperature on the planet earth. Temperature rise is not only affecting humans, its negative impact affects the entire natural system that supports human existence – including the flora and fauna.

Regardless of climate change denial in some quarters, scientists are adamant with indubitable evidence that the increasing carbon emission over the years have resulted in rising temperature in the 21st century – and perhaps beyond if no action is taken (NASA, 2017). Escalating carbon emission is seen as the culprit, pitching from 3.243 metric tons per capital in 1963 to 4.972 in 2014 with associated temperature rise peaking up at an annual average of 0.06 ^{o}C in 1963 to 0.99 ^{o}C in 2016, which is a massive and frightening escalation. Figures 1 and 2, depicts the worldwide CO2 emissions (metric tons per capita) and associated temperature rise between 1963 and 2016.

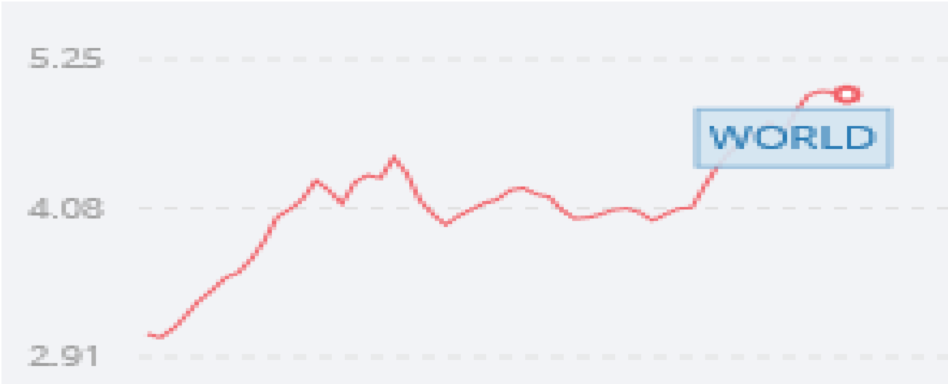

Figure 1. Worldwide CO2 emissions (metric tons per capita)

Source: World Bank (2017, p. 1)

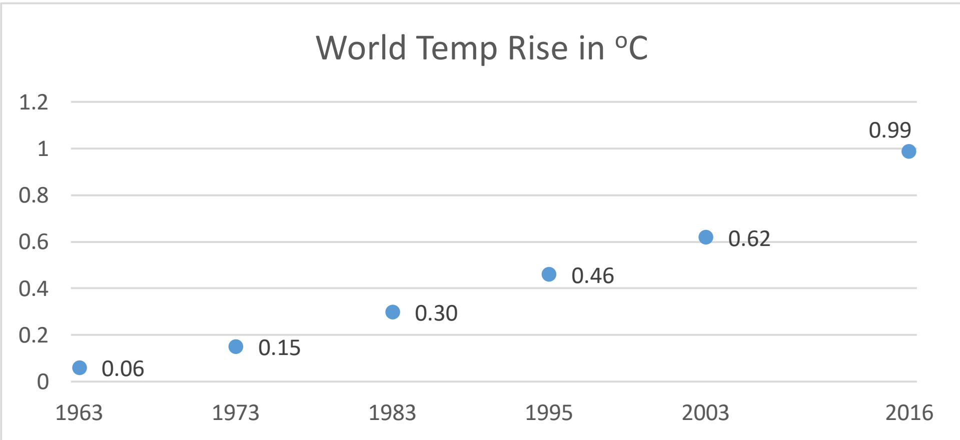

Figure 2. Worldwide Annual Temperature Average in °C

Source: Author's graph: Data from NASA (2017)

3. Literature Review

The agricultural regions of the world face vulnerability to climate change arising from increased drought and attendant food insecurity (Carrao, Naumann & Barbosa, 2016). This is aggravated by the apparent reactive approach to drought management in many parts of the world (Wilhite, Sivakumar & Pulwarty, 2014), such as in Sub-Saharan Africa (Vogel, Koch & Van Zyl, 2010; Baudoin et al., 2017). According to Hatfield and Prueger (2015), grain production such as maize could be reduced by 80 – 90% by warmer temperature when compared to production in normal temperature. The abnormal temperature impact on grain production is exacerbated by drought or water shortage (Hatfield & Prueger, 2015). Accordingly, many countries in Sub-Saharan Africa have had to deal with severe drought causing little grain production over the years (Fisher et al., 2015).

Climate warming has already started to inflict negative effect on food security in Africa with aggravating impact on the level of poverty (Conway et al., 2015). For instance, between 2015 and 2016, South Africa, an exporter of maize, experienced an unprecedented lowest output of maize due to extreme drought that hit the country between 2014 and early 2016 (Grain SA, 2016; Vogel & van Zyl, 2016). Thus, urban settlements and general quality of life has been affected (Mupedziswa & Kubanga, 2016).

Many countries in Africa rely on rain-fed agriculture, such as rain-fed grain crops and provide more than 50% of the calories intake in many countries such as in Sub-Saharan Africa (Msowoya et al., 2016). For instance, current research indicate that given the current pace of climate change and the attendant shortage of rainfall, maize production is likely to decrease by fourteen percent by the middle of twenty first century (Msowoya et al., 2016). According to Grain SA (2016), South Africa had its highest drought during the 2015 and 2016 fiscal year since 1992 and this caused the country to shift its position from a maize exporting country to maize importing country, with negative economic consequences on general economy, consumers and farmers.

Researchers are thus worried on another important front, which is that the persistent warming of the continent is worsening the health problems of Africa especially regarding the vulnerable poor and children (Ngarakana-Gwasira et al., 2016; Hanna & Oliva, 2016). This is because the intensifying heat fast-tracks the incubation of malaria-carrying mosquitoes, which thus reduces the gains made on malaria reduction in Africa (Sande et al. 2016). Lamentably, whilst it might be celebrated, in the recent past, that the spread of malaria is being contended in some areas in Africa; but the warming up of some other areas incubate the Anopheles mosquitoes. Yet as if this is not enough plague to deal with, scientists are recently warning that rising temperature in Africa makes Africa an unfortunate host to deadly mosquito spreading zika virus – which thrives more in warmer climate (Guilbert, 2017). For instance, the East African countries have begun to experience malaria spread in the low-lying areas. Yet one could bemoan the shocking estimate that out of about a global 430 000 to 438 000 fatal victims of malaria in 2015, ninety percent of this figure come from Africa, with only 7% from Asia region and 3% from Mediterranean area (Guilbert, 2017; WHO, 2017).

Furthermore, whilst the social and economic development focus of many countries in Sub-Saharan Africa is on narrowing existing level of inequality, climate change seems to be worsening the efforts on reducing inequality – given increasing shortage of certain crop production due to climate change. Hence, researchers lament that the warming of the continent is reversing the gains on inequality as women and children suffer the brunt of warming effects including food insecurity and displacement (Dennig et al., 2015; Shackleton et al., 2015). Climate change threat, mostly to humanity, requires dynamic strategies to increase the momentum of alleviative actions and approaches to avoid appalling future consequences, which the World Bank warns as follows:

“Climate change is an acute threat to global development and efforts to end poverty. Without urgent action, climate impacts could push an additional 100 million people into poverty by 2030” (World Bank, 2015, p. 1)

This is no longer a forecast as many vulnerable group mostly the poor have started feeling the negative impacts of climate change. Shortage of rainfall in climate change induced drought areas of Africa has caused unusual low crop yields and/or widespread crops flops resulting in rising food prices.

Despite this, current climate change policies in Africa have not strongly integrated 1.5^0 C at its core. Current policies for climate warming adaptation seem week (Vogel & van Zyl, 2016). Climate warming risks at 1.5^0 C must be integrated in academic curricular and government climate policies should include nationally generated 1.5^0 C emergency funds rather than wait for international funds – this should call for a new genre of budget code dedicated to 1.5^0 C fund.

4. Method and Results

Secondary data were collected on the annual average temperature from NASA (2017) and on maize production from Indexmundi (2017) in a sample of five Southern African countries for six years (2011 – 2016). The sample of countries used comprises South Africa, Zimbabwe, Namibia, Swaziland and Madagascar. Data were arranged according to the cross-sectional panel data approach, which constituted five cross sectional units for six time series giving a total observation of thirty. Thereafter the analysis was conducted using the OLS fixed effect regression.

The regression model:

$\gamma = \beta_0 + \beta_1\chi_1 + \varepsilon$

Where:

γ = maize production (representing grain production);

β_0 = constant

β_1 = regression coefficient

χ_1 = temperature

ε = error term (representing unaccounted independent variables)

Results

Temperature and maize production in 5 Southern African countries for six years (2011 – 2016). South Africa; Zimbabwe; Namibia; Swaziland; Madagascar

Table 1. Regression Result on the Relationship between Rising Temperature and Maize Production in Southern Africa

Model 1. Fixed-effects, using 30 observations

Included 5 cross-sectional units

Time-series length = 6

Dependent variable: Maize Production

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	3.69578e+06	1.03094e+06	3.5849	0.00149	***
Temperature	-2.0182e+06	1.35681e+06	-1.4875	0.14992	

Mean dependent var	2188861	S.D. dependent var	4561610
Sum squared resid	2.63e+13	S.E. of regression	1046300
R-squared	0.956460	Adjusted R-squared	0.947389
F(5, 24)	105.4433	P-value(F)	1.58e-15
Log-likelihood	-455.0441	Akaike criterion	922.0882
Schwarz criterion	930.4954	Hannan-Quinn	924.7778
rho	0.204925	Durbin-Watson	1.282508

Results from Table 1 show that indeed there is a negative relationship between temperature and maize production within the five sample of countries in Southern Africa. This is indicated by regression coefficient of -2.0182, which shows that a percent increase in temperature would result in a 2.01 reduction in maize production. The regression output above also show that the R-squared or coefficient of determination is 95.64%, which is very high. Since the R-squared show the closeness of the data to the regression line, it can be reasonably concluded that a 95.64% linear fit is very close to the regression line.

Drawing from the above high regression result between temperature and maize production, it becomes apparently plausible to conjecture likely economic implication on both the consumers and producers of maize. This concomitant economic implication is most important given that Southern African staple food rely heavily on maize (Department of Health SA, 2017). The economic implications stem from implicit low production of maize (one of the field crops) caused by high temperature. Figures 3 - 7 present aspects of economic implication, which includes inter alia, the plummeting of maize production in South Africa since the 2014 high temperature and accompanying drought, increase in agricultural debt, which arose mainly from financial costs of managing drought periods by grain farmers, increase in price of maize, increase in consumer expenditure on maize consumption. The correlations between these variables appear in Table 2.

Figure 8 presents the financial implication framework for further studies. The crux of the framework is high temperature, which is pivotal to increasing high cost of production for grain farmers and the attendant increase in grain price to recover the cost of production. Financing the climate change-induced temperature has also meant that farmers would borrow from financial institutions to sustain their production amidst high temperature and drought. Additional price of maize in the retail outlets has led to additional expenditure burden on consumers but the greatest burden of increasing maize price falls on poor consumers – with the implication that high temperature might widen food poverty.

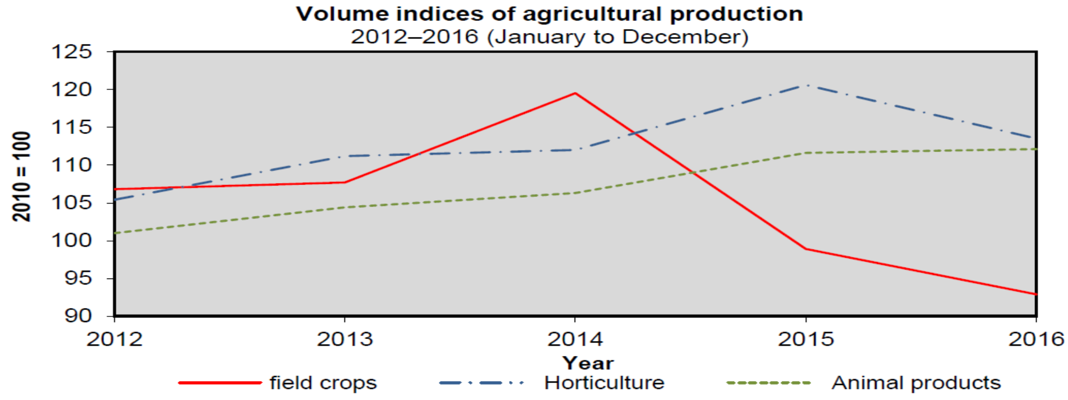

Figure 3. Decline in Agricultural Production in South Africa 2014 - 2016

Source: Department of Agriculture, Forestry and Fisheries, Directorate of Statistics and Economic Analysis South Africa (2017, p. 2)

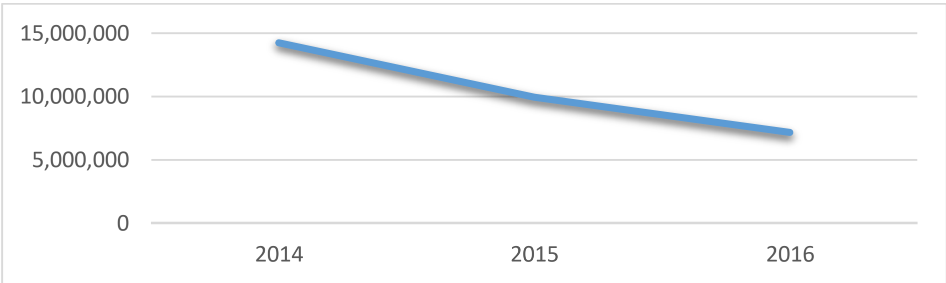

Figure 4. Decline in Maize Production in South Africa 2014 - 2016

Source: Author with data from Indexmundi (2017)

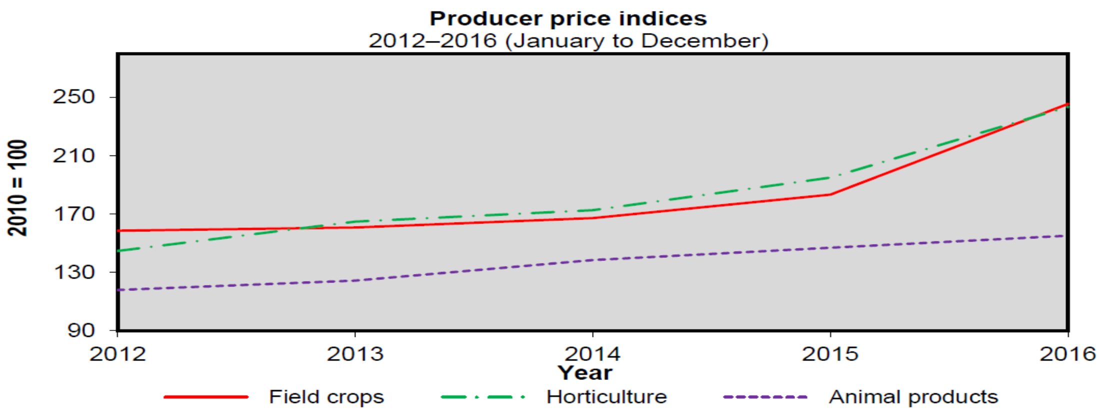

Figure 5. Rising Price of Maize in South Africa 2014 - 2016

Source: Department of Agriculture, Forestry and Fisheries, Directorate of Statistics and Economic Analysis South Africa (2017, p. 2)

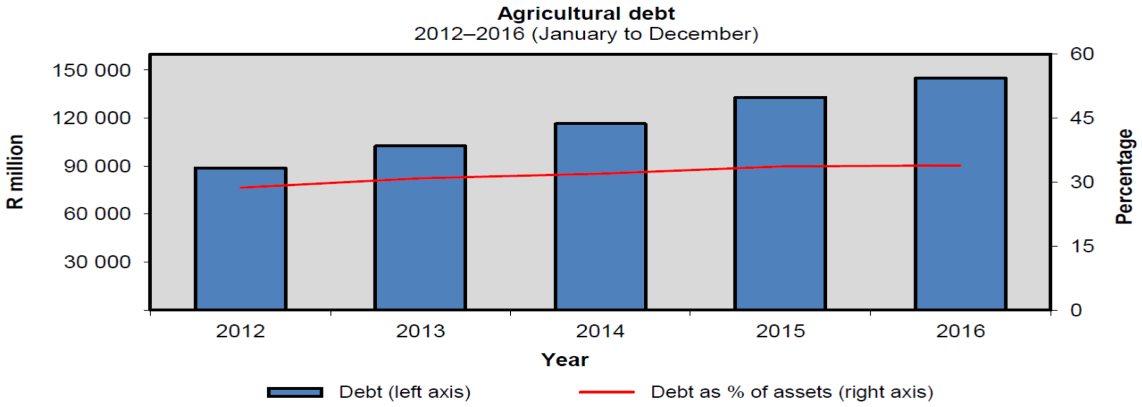

Figure 6. Rising Agricultural Debt in South Africa 2014 - 2016

Source: Department of Agriculture, Forestry and Fisheries, Directorate of Statistics and Economic Analysis South Africa (2017, p. 9)

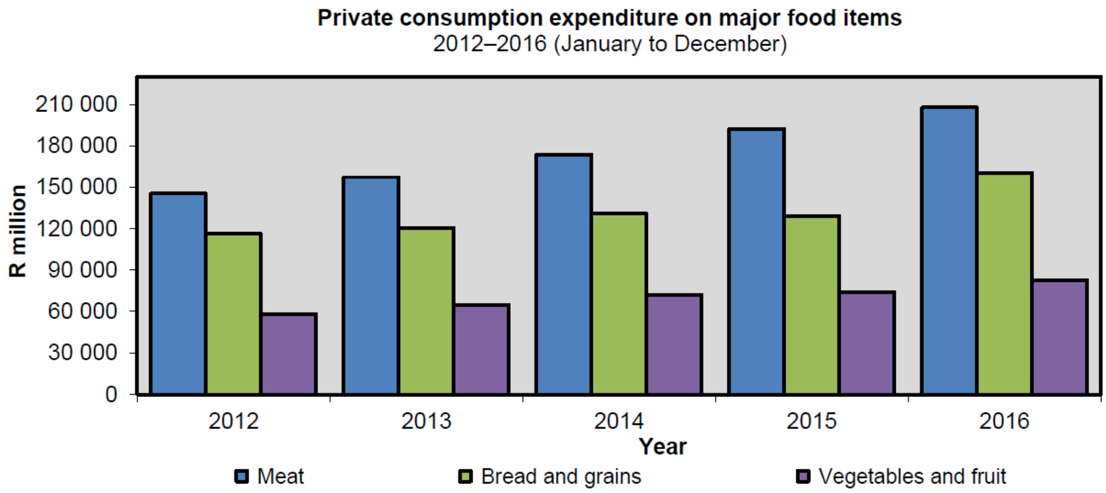

Figure 7. Increase in Consumer Expenditure on Maize

Source: Department of Agriculture, Forestry and Fisheries, Directorate of Statistics and Economic Analysis South Africa (2017, p. 9)

Correlation of the Variables in Figures 3 – 7.

This section considered the correlation between the variables in Figures 3 – 7. The correlation amongst these variables was conducted using the Statistical Package for Social Sciences (SPSS) at an alpha of 0.05. The correlation result is presented in Table 2. Overall results from the correlation of the variables indicate that the variables have significant correlation. These variables were applied in the formulation of the framework in Figure 8. The structuring of the framework also reflects the correlation of the variables.

Table 2. Correlations

Correlations

		AgricPrdn	MaizPrdn	MaizePrice	Agricdebt	ConsuExp
AgricPrdn	Pearson Correlation	1	.990*	-.749	-.945	-.817
	Sig. (1-tailed)		.046	.231	.106	.196
	N	3	3	3	3	3
MaizPrdn	Pearson Correlation	.990*	1	-.836	-.982	-.891
	Sig. (1-tailed)	.046		.185	.061	.150
	N	3	3	3	3	3
MaizePrice	Pearson Correlation	-.749	-.836	1	.924	.994*
	Sig. (1-tailed)	.231	.185		.125	.035
	N	3	3	3	3	3
Agricdebt	Pearson Correlation	-.945	-.982	.924	1	.961
	Sig. (1-tailed)	.106	.061	.125		.089
	N	3	3	3	3	3
ConsuExp	Pearson Correlation	-.817	-.891	.994*	.961	1
	Sig. (1-tailed)	.196	.150	.035	.089	
	N	3	3	3	3	3

*. Correlation is significant at the 0.05 level (1-tailed).

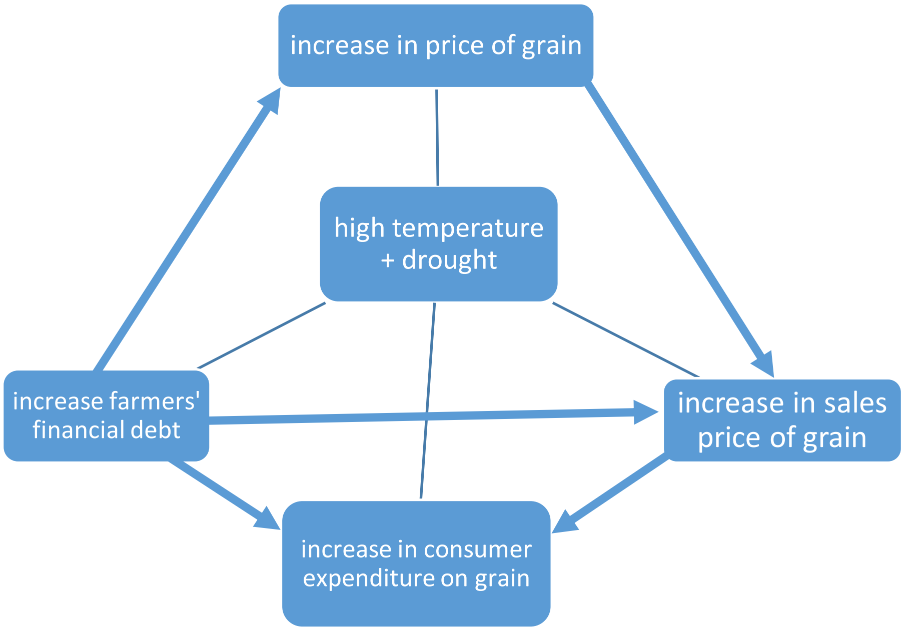

Figure 8. Financial Implication Framework of Rising Temperature on Grain Producers and Consumers

Source: Author's Framework

5. Conclusion

This paper analysed the relationship between climate change induce-temperature and grain production in Southern Africa. The paper became essential given the temperature-accompanying drought in Southern Africa between 2014 and 2016. The paper used the data on maize production as a proxy for grain production. Data collection was from archival data on maize production on a sample of five Southern African countries, where high temperature and drought has disrupted grain farming within the recent years.

Data were arranged according to the cross-sectional panel data method and the fixed effect OLS regression was applied in the analysis of data. Results from the regression analysis showed a high correlation between temperature and low maize productivity in the sample of five Southern African countries. Furthermore, it was found that temperature and drought has resulted in higher cost of production on farmers as farmers has had to borrow more money toward cushioning drought and high temperature. Additional cost of maize production has led to increasing price of grain and overall increase in consumer expenditure on maize. The final part of the paper presents a framework of financial implication on farmers and consumers. The climax of the framework is the likely implication of high temperature and increase in grain price on widening food poverty. The paper recommends further study, which should expand on the sample size to conduct future research using more countries. It is also recommended that further research on the effect of climate change induced-temperature on food poverty gap in Southern Africa should be conducted, as this has not been widely examined. This further research would be important since eradication of food poverty is an essential aspect of the 2030 Sustainable Development Goals agenda.

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