ISSN: 2771-7763

Research Article

Journal of Economic Research & Reviews

Climate Change and Food Security in Sub-Saharan Africa

Batru Wolde Muleta[1,2]*and Tefera Tezera Negera[3]

[1]College of Business and Economics, Addis Ababa University, Addis Ababa, Ethiopia

[2]Resource Management Office, Ethiopian Insurance Corporation, Addis Ababa, Ethiopia

[3]Dipartiment of Health, Rift Valley University, Addis Ababa, Ethiopia

***Corresponding Author**
Batru Wolde Muleta, College of Business and Economics, Addis Ababa University, Ethiopia.

Submitted: 2023, Feb 18; **Accepted:** 2023, May 20; **Published:** 2023, June 19

Citation: Muleta, B. W., Negera, T. T. (2023). Climate Change and Food Security in Sub-Saharan Africa. *J Eco Res & Rev, 3*(2), 91-97.

1. Abstract
Climate change affects food security directly through temperature levels and water availability in agriculture and indirectly through its impact on disease vectors and pests. This paper investigates the economic impact of climate change on food security in Su-Saharan Africa. Panel data from all Su-Saharan African countries are used to analyze the impact of temperature and precipitation on food security. Their coefficient of variation is used to analyze their impact on food security. The results from the analysis show that the coefficient of variations in both temperature and precipitation affects food security negatively. The climate variables affect food security directly through their impact on food production and indirectly through their impact on other food security indicators. According to the findings, the impact of climate change on food security in the region is damaging. The study recommends ecosystem management and production system improvement. To overcome the impact, the study suggests appropriate land use policy formulation, natural resource conservation, implementing best agronomic practices, and maintaining population growth at an optimum level in the region

Keywords: *Sub-Saharan Africa, Climate change, Food security, panel data*

Abbreviations
FAO: Food and Agricultural Organization

FAOSTAT: Food and Agriculture Organization of United Nations Statistics Division

IAASTD: International Assessment of Agricultural Knowledge, Science, and Technology for Development

IFAD: International Fund for Agricultural Development

IPCC: Intergovernmental Panel on Climate Change

NEPAD: New Partnership for Africa's Development

OLS: Ordinary Least Square

SSA: Sub-Saharan Africa

UNICEF: United Nations International Children's Emergency Fund

WFP: World Food Programme

WHO: World Health Organization

2. Introduction
Climate change can exacerbate land degradation by increasing soil erosion and drought frequency, which further affects food security in multi-dimensions. These occurrences of climate change increase the intensity and number of disasters, threaten food security and human health, reduce freshwater availability, reduce industrial production and damage the physical infrastructure, resulting in declining development. Furthermore, changes in rainfall and river sensitivity to climate variation cause decreased river basin runoff and less water available for agriculture and hydropower generation [23] .

The effect of climate change on the global ecosystem and its impact on agriculture and food security makes it challenging to end hunger and malnutrition. The number of people living under chronically undernourished reaches about 800 million, and stunted children less than five years are estimated at 161 million. Similarly, 500 million people are obese and 2 billion lack the essential micronutrients they need to lead healthy lives [18]. The number of undernourished people reached 239.1 million in the region in 2018 [34]. Hence, to solve the difficulty of undernourishment and to fulfill the food demand, agricultural productivity is likely to increase significantly [1]. However, climate change seriously threatens agricultural productivity and has a significant impact on agricultural yield, food prices, food quality, and poverty in the region [22,36].

Therefore, it is very important to assess the impact of climate change on food security in the region. This research output contributes to filling the unaddressed gaps in empirical evidence and forwarding recommendations, including policy issues. It also helps to understand how to adapt and mitigate climate change as well as coordinate resources to tackle the problem effectively. The main objective of this study is to explore the impact of temperature and precipitation on food security. It also intended to estimate the vulnerability of food security to climate change. The study is conducted to answer the research questions that arise about the impact and vulnerability level of climate change on food security. It also intended to answer the question that arises of how climate is change linked to food security.

3. Literature Review

Food security is a multi-part observable fact resulting from numerous causes [12]. The World Food Summit defines food security as; "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [11]. According to this definition, the four-food security dimensions: availability of food, accessibility, utilization (the way it is used and assimilated by the human body), and stability dimensions are established.

3.1 Availability

it refers to the quantity, quality, and diversity of available food in type. This means a sufficient amount of food that has an appropriate quality with important nutrition content that is supplied through domestic production or import(food aid) [5]. It can be determined by domestic production, storage, distribution, import, and export [18,15]. It is noted that climate change directly or indirectly affects the availability of agricultural products [18]. It affects directly through its impact on crop yield, soil fertility, water holding potential, and crop pests and diseases, and indirectly through its impact on economic growth, agricultural product demand, and income distribution [16,28]. Its impact through ecological change also affects land suitability, potential yield, and varieties currently under production [2].

3.2. Access

refers to the ability of communities, individuals, and countries to purchase food in sufficient quantities and quality. Physical access to food is impacted by climate change through production decline and transportation infrastructures; economic access is represented by domestic food prices, a decline in purchasing power, and an incidence of undernourishment [15]. Food access is not only determined by physical and economic factors but also by social and political factors. Physical availability of food does not guarantee individuals access to food because of poverty, poor infrastructure, high price, high transaction costs, etc [9].

3.3. Utilization

comprises variables that determine the ability to utilize food, particularly access to water and sanitation. The other is the outcome of poor food utilization, like nutritional failures of children less than five years of age, such as wasting, stunting, and being underweight [15]. Climate change negatively affects food utilization through effects on human health and the spread of diseases and pests [16]. It negatively affects food safety and increases the pressure from vectors, water, and food-borne diseases. It affects the ability of individuals to use food effectively [19,31]. Besides food availability and access to food, food utilization is determined by other factors such as food preparation, nutrition content, access to clean drinking water, health care, women, and child care, and women's role [26]. It relates to hygiene, sanitation, proper food processing, and sufficient knowledge about nutrition [5].

3.4. Stability

relates to access to adequate amounts of food at all times by population, household, or individuals. It measures food security risks, such as the cereal dependency ratio, the area under irrigation, and the value of staple food imports as a percentage of total merchandise exports. It is also affected by domestic food price volatility, fluctuations in the domestic food supply, and political instability that are interlinked with variable weather conditions and climate change [15].

Climate change affects all dimensions of food security in complex ways. Harsh climatic conditions such as excessive rainfall, lack of rain, temperature, and humidity cause significant pre-harvest and post-harvest food loss [32]. Infestation by pests and infections by the disease are important causes of food loss and waste that consequently affect food availability negatively [32,24]. Its impact on transportation through infrastructural damage, decrease in purchasing power because of rising food prices, cause water, and foodborne diseases, and a decrease in yield because of extreme events [31].

Sub-Saharan Africa (SSA) is already experiencing significant changes in average temperature, rainfall amount and distribution, and occurrences of extreme weather events such as drought and floods. This climate change decreases production potential and reduces yield significantly and increases the risk of hunger and further affects all food security dimensions [25].

The region experienced severe flood impacts in West Africa; extended and increased droughts in east Africa; depletion of equatorial rain forests in equatorial parts of Africa and ocean acidification problems. These extreme events threaten agricultural production and food security. The impacts also affect health, water access, and infrastructure damage and increase potential consequences for political instability and conflicts [4,33].

According to predictions made by [30] due to climate change, the prices of rice, wheat, and maize are predicted to rise by 48, 36, and 34 percent globally from 2000 to 2050, and similarly by 7, 15 and 4 percent in Africa. Because of climate change, cereal yield is projected to decline by a net 3.2% in 2050 in SSA. This decline in yield results in an increase in food prices by up to 20% that is projected to reduce nutrition consumption of the family by 1.3% or 37 kilocalories per capita per day resulting in 0.6 million more malnourished children in the region [30]. High food prices have a long-term human capital effect. Studies revealed that due to undernourishment, people in early childhood have more than 10 percent lower lifetime earnings due to physical and mental impairment [5].

Sub-Saharan Africa shows a low level of progress in improving food security in all types of indicators. This is indicated by the high anthropometric prevalence of stunted and underweight children less than five years of age [14]. The region faces low improvement in access to drinking water, sanitation facilities, dietary quality, and diversity of the poor. Of the four dimensions, the food stability dimension shows the least progress, mainly due to political instability, war, and civil strife [14,15].

Climate change impacts the four dimensions of food security; availability, access, utilization, and stability, directly and indirectly [18]. Evidence since 1990 showed that the impact of climate change on food security dimensions, availability, access, utilization, and stability is represented by 70 percent, 11.9 percent, 13.9 percent, and 4.2 percent, respectively.

As asserted by different literature, still about 700 million people live in extreme poverty, and about 815 million suffer from chronic hunger [13]. FAO revealed that, by 2030, over 650 million people would suffer from undernourishment. This is due to the depletion of land, water, and biodiversity with climate change threatening agricultural production needs to meet the food demand [13]. Although progress has been made against hunger globally, it tends to be concentrated among the landless and farmers with small plots in the SSA region because of the slow growth of agricultural outputs and expanding population [21]. In the region, the number of undernourished was about 33% and 31% of people between 1990-92 and 2001-2003 respectively [20]. Among food-insecure people on the African continent, 97% live in SSA where 34% are categorized as undernourished [27].

It is projected that climate change will increase the number of malnourished children by 11 percent by 2050 in low-income developing countries, compared to no climate change or perfect mitigation scenario. The number of malnourished children worsened because of climate change in the SSA and is projected to be 1 million more in 2030 and 600,000 more in 2050 relative to no climate change scenario [30,5].

Africa is highly vulnerable to climate change impacts that threaten its efforts at food security and economic development [10]. However, Africa contributes less than 7% of greenhouse gas emissions, which is very low in global emissions history. It is estimated that developing countries and SSA need between US$75 - 100 billion and US$14-17 billion per year respectively, to adapt to a temperature change that reaches 20C by 2050.

In addition, its stress increases the manifestation and the incidence of pests and diseases [30]. The spread of malaria has increased during the past four decades in the regions where the phenomenon was not common and the climate was cooler 50 years ago [4]. In Sub-Saharan Africa, malaria and other vector-borne diseases can have a large effect on labor productivity, which could make many countries trapped in a vicious cycle of disease, low productivity, poverty, and deficient health care [17].

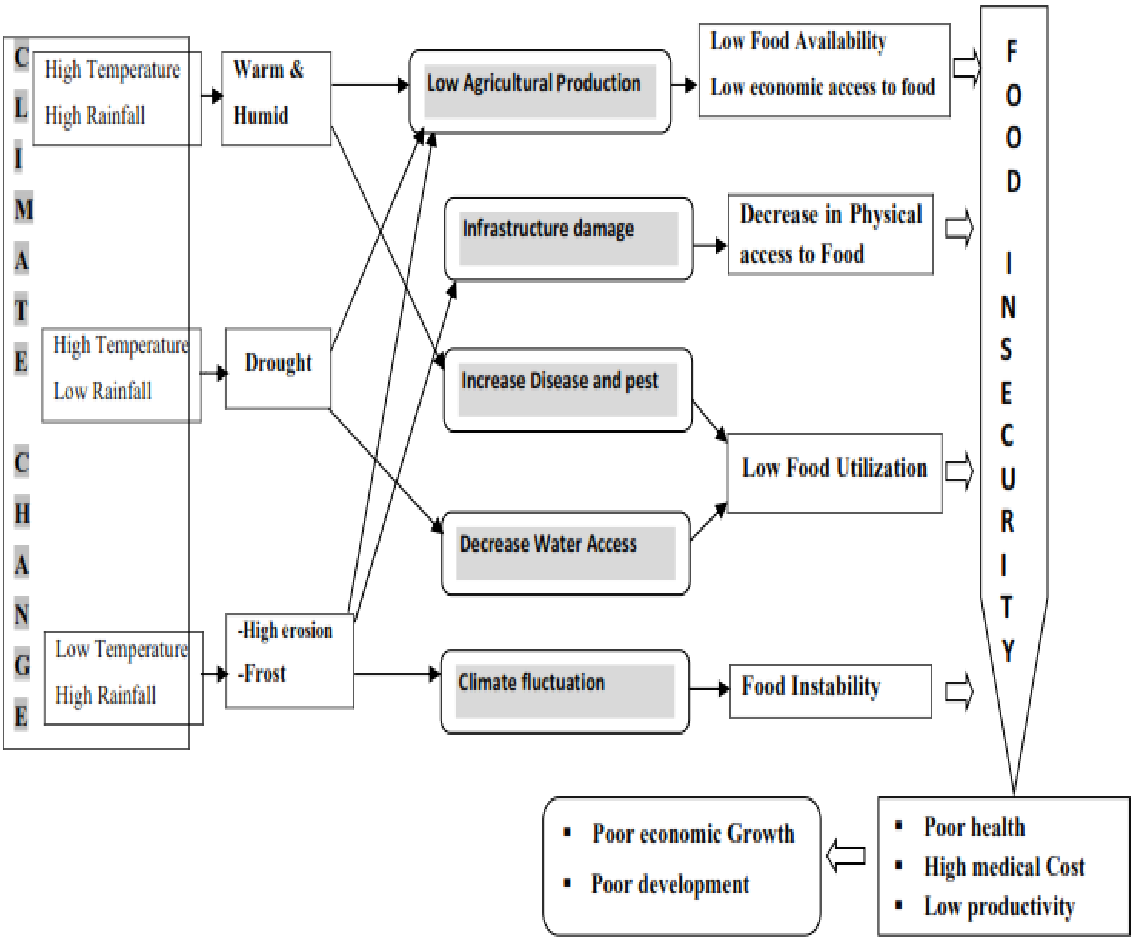

Figure 1: Climate change impact on Food Security
Source: Author Construction.

4. Methodology

The study used panel data research design and fully depends on secondary data from all Sub-Saharan African countries. The secondary data used includes climate variables, economic variables, and food security indicators data from a 30-year period from 1989 to 2018.

5. Data Sources and Nature

For statistical data analysis, unbalanced panel data is used in the paper. The empirical analysis is based on the panel data of SSA countries. Regarding data source, temperature and precipitation data are collected from the World Bank climate change Portal website. The two-year moving average is used for 2017 and 2018 years using stata for climate variables due to the unavailability of the data for the two years.

Food security indicator variables like people's access to clean water, food supply variability, GDP per capita, food production index, and percentage of irrigated land data are collected from the Food and Agriculture Organization of United Nations Statistics Division (FAOSTAT), World Development Indicator of the World Bank and Our World in data database.

Descriptive data analysis methods mean and standard deviations are used to compare the effect of variables. In addition, the relationships between dependent and independent variables are tested using regression analysis. The outputs are presented using text, tables, and graphs. Stata and eviews are used to analyze quantitative data.

6. Model Specification

The study used Ordinary Least Square (OLS) regression analysis in order to analyze the impact of climate change on food security in SSA countries.

$$UN_{it} = \delta_0 + \delta_1 P_{it} + \delta_2 T_{it} + \delta_3 F_{it} + \delta_4 GDPP_{it} + \delta_5 W_{it} + \delta_6 FS_{it} + \delta_7 I_{it} + \varepsilon_{it} \quad (1)$$

Where; UN_{it} represents the prevalence of undernourishment as a food insecurity indicator. Pit represents the coefficient of variation of annual precipitation from its long-term average; T_{it} represents the coefficient of variation of annual temperature from its long-term average. The long-term average is calculated over the period 1901-1950, which is considered a pre-climate change era. F_{it} represents a food production index that captures the availability of food; $GDPP_{it}$ is GDP per capita represents economic access to food equivalent to purchasing power; W_{it} represents the percentage of the population accessing improved drinking water to appraise food utilization; FS_{it} represents food supply variability, measuring the stability to food and I_{it} represents the percentage of agricultural land equipped for irrigation measuring stability dimension of food and "ε" stands for the error term.

7. Results

7.1. Descriptive Results

Table 1 below provides a summary of descriptive statistics for the variables utilized in the model. It summarizes the mean, standard deviation, maximum value, and minimum values for each variable used in the analysis.

Variable	Observation	Mean	Std.Dev	Min	Max
PUN	1,141	26.14365	14.58057	0.5	76.8
FP	1,141	97.14958	27.72531	37.03	206.96
GDPpct	1,290	4389.41	5476.556	436.7203	41249.44
ACWS	1,220	64.88574	18.51493	13.2	99.9
PFSV	875	41.67886	26.76632	3	184
IRGL	737	9.339891	20.32669	0.1	100
TCV	1,470	3.135065	2.78805	-3.17978	17.15362
PCV	1,470	-1.93470	16.55088	-72.1652	110.4732

Table 1: Summary of food security indicators and climate variables

Source: Own computation using stata software

Statistical tests are carried out to determine the model's robustness, the characteristics of the error terms, and the long-term relationship between the variables, as well as to choose the best model for the regression analysis. The Driscoll-Kraay estimator is employed in the regression to produce consistent standard errors; since the results of the statistical test indicate the presence of autocorrelation, heteroskedasticity, and cross-sectional dependency. The regression analysis employs a random effect model based on the Hausman test.

7.2 Emperical results

Table 2 summarizes the random effect panel data analysis for climate change's impact on food security in the SSA. The model analyzed the data given in equation (1). The result from the regression analysis shows that the temperature coefficient of variation is statistically significant ($P<0.01$) and that of the precipitation coefficient of variation is statistically significant at the ($P<0.1$). The food production index, which measures the food production in the region, has a significant result at ($P<0.001$), and GDP per capita, which is equivalent to the purchasing power of the people, measures economic access to food is significantly at ($P<0.1$). Access to clean water sources that measures the food utilization indicator of food security is statistically significant ($P<0.1$). The results of food supply variability which measures the stability of food in the region as well as the percentage of irrigated land in the region are not significant (P>0.1).

Dependent Variable: Prevalence of undernourishment				
Regressors	**Coefficient**	**Standard error**	**T-Ratio**	**Prob.**
Food Production index	-.1287948	.0134169	-9.60	0.000
GDP per-capita	-.0006263	.0003095	-2.02	0.071
Access to Clean Water	-.1889945	.0334522	-5.65	0.000
Per capita food SS Variability	-.0014452	.0072669	-0.20	0.846
Irrigated Land	-.1192689	.1176792	-1.01	0.335
Temp. CV	.2734217	.0674253	4.06	0.002
Precipitation CV	.0346592	.0156746	2.21	0.051
constant	52.86369	1.581244	33.43	0.000
Overall R^2	0.30			
N	418			

Table 2: Empirical results for the impact of climate change on food security
Source: Own Computation using stata software

8. Discussion

Different imperial findings show that the impact of climate variations on food security in the region is a negative correlation. The present study result revealed that the impact of climate variables temperature and precipitation negatively correlated with food security indicators. Climate variables, temperature coefficient of variation, and precipitation coefficient of variation positively affect food insecurity. The temperature coefficient of variation is statistically significant and keeping all factors unchanged, a 1% increase in the temperature coefficient of variation causes a 0.27% rise in food insecurity. The previous study confirms that the level of rainfall affects food security through its impact on crop production and children's health mostly diarrhea in Africa [3]. Based on the finding from this study keeping other factors unchanged, a 10% increase in precipitation variation unpredictability causes a 0.34% increase in food insecurity. Food production has a positive correlation with food security in terms of per capita food supply, food self-reliance, and undernourishment [7]. The food production index has a negative impact on the prevalence of undernourishment, implying that food insecurity decreases with an increase in food production. A unit increase in food production leads to a 0.12 percentage point decrease in the level of food insecurity, keeping other variables constant.

Under the climate change scenario a reduction in GDP per capita by up to 50% cause reducing overall agricultural production which consequently reduces purchasing power and causes to fall in daily calorie consumption consequently increasing the number of undernourished people to 9.3 million by 2020 [8]. This implies that an increase in income by 1 dollar leads to a decrease in food insecurity by 0.06 percentage points, keeping other variables constant.

A previous study revealed that access to safe drinking water in the region is only 30% in 2020 with low progress trend [35]. The result from this research also shows access to clean water sources negatively affects food insecurity in the region. Keeping other factors constant a 1% increase in access to clean water sources decreases food insecurity by about 0.2%.

Surprisingly, the percentage of land equipped for irrigation and the prevalence of food supply variability is insignificant. This may be due to irrigation usage and data obtained in the region is not remarkable. Only 4% of agricultural land is cultivated by irrigation which is low compared to other regions [6].

9. Conclusion and policy implications

This paper analyzes the impact of climate change on food security using panel data of SSA countries from 1989 to 2018. The research investigates the impact of climate variables and food security indicators on the prevalence of undernourishment within the region. The result shows that the temperature coefficient of variation and precipitation coefficient of variation negatively affect food security. Both temperature and precipitation variability affect food security negatively and significantly. Food security indicators; food production index, GDP per capita, and people's access to clean water are positively associated with food security and play a significant role in improving food security within the region.

Climate change negatively affects food security directly through its impact on food production, with its link to agricultural production, and indirectly through its impact on food security indicators. To reduce its direct impact irrigation water should be used efficiently to adapt to water scarcity and drought. Similarly, in order to maintain ecological equilibrium, there should be afforestation and reforestation by multipurpose Agro-forest trees on the bare land that is not utilized for farming and grazing. It is also crucial to fund agricultural research and development to release varieties that easily adapt to the local climate conditions and require low water to mature. Moreover, controlling crop pests and diseases to prevent agricultural yield loss both in the field and storage should be practiced all the time. The focus should be placed on developing and enacting workable regulations with steadfast enforcement regarding land use, greenhouse gas emissions reduction, and optimal population growth.

References

1. Adedoyin, F. F., Alola, A. A., & Bekun, F. V. (2020). The nexus of environmental sustainability and agro-economic performance of Sub-Saharan African countries. Heliyon, 6(9), e04878.
2. Alagidede, P., Adu, G., & Frimpong, P. B. (2016). The effect of climate change on economic growth: evidence from Sub-Saharan Africa. Environmental Economics and Policy Studies, 18, 417-436.
3. Bandyopadhyay, S., Kanji, S., & Wang, L. (2012). The impact of rainfall and temperature variation on diarrheal prevalence in Sub-Saharan Africa. Applied Geography, 33, 63-72.
4. Besada, H., Lisk, F., Sewankambo, N., Kabasa, J. D., Sage, I., Willms, D., ... & Shaw, E. (2009). Climate change in Africa: Adaptation, mitigation and governance challenges.
5. Chijioke, O. B., Haile, M., & Waschkeit, C. (2011). Implication of climate change on crop yield and food accessibility in Sub-Saharan Africa. Centre for Development Research. Bonn: University of Bonn.
6. Ching, L., Edwards, S., & El-Hage, S. (2011). Climate change and food systems resilience in sub-saharan Africa. Food and Agriculture Organization of the United Nations (FAO).
7. Demeke, M., Di Marcantonio, F., & Morales-Opazo, C. (2013). Understanding the performance of food production in sub-Saharan Africa and its implications for food security. Development and Agricultural Economics, 5(11), 425-443.
8. Ehui, S. (2002). Food security in sub-Saharan Africa to 2020 (Vol. 49). ILRI (aka ILCA and ILRAD).
9. Ericksen, P. J., Thornton, P. K., Notenbaert, A. M. O., Cramer, L., Jones, P. G., & Herrero, M. T. (2011). Mapping hotspots of climate change and food insecurity in the global tropics. CCAFS report.
10. Fankhauser, S., & Ward, J. (2010). Regional implications of the AGF recommendations: Africa.
11. FAO, (1996). Rome Declaration on World Food Security and World Food Summit Plan of Action: World Food Summit 13-17 November 1996, Rome, Italy, FAO.
12. Yearbook, F. S. (2013). World food and agriculture. Food and Agriculture Organization of the United Nations, Rome, 15.
13. FAO, (2017). The State of Food and Agriculture: Leveraging Food Systems for Inclusive Rural Transformation. 2017, Food and Agriculture Organization of the United Nations.
14. FAO, (2018). The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome.
15. FAO, I. (2014). Strengthening the enabling environment for food security and nutrition. The State of Food Insecurity in the World, 1-57.
16. Fonta, W., Edame, G., Anam, B. E., & Duru, E. J. C. (2011). Climate Change, Food Security and Agricultural Productivity in Africa: Issues and policy directions.
17. Gallup, J. L., Sachs, J. D., & Mellinger, A. D. (1999). Geography and economic development. International regional science review, 22(2), 179-232.
18. Gitz, V., Meybeck, A., Lipper, L., Young, C. D., & Braatz, S. (2016). Climate change and food security: risks and responses. Food and Agriculture Organization of the United Nations (FAO) Report, 110, 2-4.
19. Hossain, M. S., Setu, N. N., & Rahman, R. (2014). Climate change and its impact on food security in south Asian countries. In An international conference on Logistics and Supply Chain Management in Food Industry At: BUET.
20. IAASTD, (2009). Agriculture at a crossroads: Sub-Saharan Africa (SSA) report. International assessment of agricultural knowledge, science and technology for development, v.
21. IAC, (2004). Realizing the promise and potential of African agriculture. Science and technology strategies for improving agricultural productivity and food security in Africa. IAC (Inter Academy Council) Amsterdam.
22. Ibe, G. O., & Amikuzuno, J. (2019). Climate change in Sub-Saharan Africa: A menace to agricultural productivity and ecological protection. Journal of Applied Sciences and Environmental Management, 23(2), 329-335.
23. Change, I. C. (2019). Land: An IPCC Special Report on Climate Change. In Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems (Vol. 41).
24. John, A. (2014). Rodent outbreaks and rice pre-harvest losses in Southeast Asia. Food Security, 6, 249-260.
25. Kotir, J. H. (2011). Climate change and variability in Sub-Saharan Africa: a review of current and future trends and impacts on agriculture and food security. Environment, Development and Sustainability, 13, 587-605.
26. Negin, J., Remans, R., Karuti, S., & Fanzo, J. C. (2009). Integrating a broader notion of food security and gender empowerment into the African Green Revolution. Food Security, 1, 351-360.
27. Union, A. (2003). Comprehensive Africa agriculture development programme. Midrand, South Africa: NEPAD.
28. PEDERCINI, M., KANAMARU, H. & DERWISCH, S. (2012). Potential impacts of climate change on food security in Mali. Natural Resources Management and Environment Department, FAO, Rome, 7-19.
29. Ringler, C., Bryan, E., Hassan, H., Alemu, T., & Hillesland, M. (2011). How can African agriculture adapt to climate change: insights from Ethiopia and South Africa.
30. Ringler, C., Zhu, T., Cai, X., Koo, J., & Wang, D. (2010). Climate change impacts on food security in Sub-Saharan Africa: Insights from comprehensive climate change scenarios (No. 1042). International Food Policy Research Institute (IFPRI).
31. Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. Proceedings of the National Academy of Sciences, 104(50), 19703-19708.
32. SCHUSTER, M., DELGADO, L. & TORERO, M. (2018). The Reality of Food Losses: A New Measurement Methodology.
33. TADESSE, D. (2017). The impact of climate change in Africa. ISS paper 220.
34. World Health Organization. (2019). The state of food security and nutrition in the world 2019: safeguarding against

economic slowdowns and downturns (Vol. 2019). Food & Agriculture Org.
35. World Health Organization. (2021). Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs.
36. Zougmoré, R. B., Partey, S. T., Ouédraogo, M., Torquebiau, E., & Campbell, B. M. (2018). Facing climate variability in sub-Saharan Africa: analysis of climate-smart agriculture opportunities to manage climate-related risks. Cahiers Agricultures (TSI), 27(3), 1-9.