Environmental Change, Conflicts and Internal Displacement as Destabilizing Factors to Food Security in Sudan: Econometric Analysis

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Abstract

This study investigates the relationships between food security measured by the depth of food deficit, environmental change measured by forests land, rainfall, and conflicts represented by internal displacement and arms imports in Sudan, together with income per capita, cereal yield, food imports and food prices. The study uses autoregressive distributed lag bounds test cointegration approach with annual time series data over the period of 1983-2016. The bounds test confirms existence of a long-run equilibrium relationship between food security, environmental change and the number of internally displaced persons (IDPs). In the short run, food security is found to be harmed by fluctuations of rainfall and arms imports, while income per capita and food imports contribute to enhance food security in Sudan. In the long run, food security is found to be negatively affected by fluctuating rainfall and the number of IDPs, while only income per capita contributes to reduce food insecurity. These results indicate that the positive effect of economic growth on food security has been more than outweighed by the negative effects of declining forest land, highly erratic rainfall, prolonged conflicts and high number of IDPs. The research findings imply that the benefits of economic growth should be distributed equitably with inclusion of IDPs so that food security can be enhanced. Forests should be managed sustainably, together with expansion of water harvest projects in Sudan to cope with fluctuations of rainfall. The study provided policy relevance measures to the Sudan's government and humanitarian organizations concerned with promoting food security in situations internal displacement and environmental changes.

Keywords

Environmental changes, conflicts, IDPs, economic growth, food security, co-integration, Sudan

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Introduction

The study of the combination of environmental changes, conflicts, internal displacement, and food security is complex both theoretically and empirically. However, addressing such complex relationship is of utmost with particular regard to ending hunger, achieving food security and promoting sustainable agriculture by 2030 as set in the sustainable development goals, Committee of World Food security, CFS (2016), Perez-Escamilla (2017) and Banik (2019). According to the Food and Agriculture Organization (FAO, 2012) approximately 870 million people were undernourished by in 2012, and the vast majority of these, i.e., 852 million live in developing countries, of who more than 70 million are internally displaced persons (IDPs). Food crisis has been particularly severe in sub-Saharan Africa, most notably in situations of conflict, environmental disasters in terms of droughts and floods, compounded by economic disruptions. Major causes of food insecurity are conflicts and environmental changes including natural disasters, which are common causes of internal displacement (Internal Displacement Monitoring Center, IDMC, 2019). Unfavorable environmental changes have negative impacts on conflicts, displacement, and food security in low income counties with limited statehood such as Sudan (Liese, 2018). Furthermore, in situations of deteriorating environmental conditions and conflicts, economic growth is not enough to end hunger and achieve food security.

A report by the IDMC (2009) states that about 4.9 million people live as IDPs as a result of the Sudan's numerous conflicts, making it as the country with the largest number of IDPs in the world. In 2010 there were 4.8 million IDPs, declined 3.4 million in 2016. According to a report by Global Crisis Overview (GCO, 2015) of 3.1 million IDPs in Sudan, 2.5 million were in Darfur and 378 000 were in Blue Nile and South Kordofan. Out of these 3.1 million IDPs, 1.28 million were under critical and emergency forms of food insecurity. In Darfur, the proportion of food insecure households among IDPs increased from 43 in May 2016 to 58 percent in May 2017 (World Food Programme, WFP, 2017). Another WFP report shows that the prevalence of food security among IDPs in Eastern and Southern Sudan was 30 percent and larger than 40 percent in Blue Nile state and in South Kordofan. In the Eastern Sudan – a poor region in which armed conflict started since 1995, there were up to 420 000 IDPs by the end of 2008 (IDMC, 2009). Total food-insecure population in Sudan in 2016 was estimated as 16.5 million representing 45% of the total number of population of 36.8 million (Food Security Information Network, 2017). Thomas A.-C. et al. (2017) report that Sudan score in the global food security index in 2016 was 34.7 (out of 100 points) and ranked as number 98 out of 113 countries assessed.

As a result of continues conflicts and deteriorating environmental conditions, Sudan has been on the top of the list of countries with IDPs since 2003, and only Syria, Iraq, and Colombia have higher stocks of IDPs than Sudan as of 2015 (Pape, et al. 2017), but with 144 000 newly IDPs due to conflict alone (IDMC, 2016). Peter O. F., et al. (2016) document that the main reasons for displacement in Sudan are armed conflicts. Abigail L. (2015) shows that one of the major causes for food insecurity in Sudan is displacement due to conflicts. Conflicts cause mass internal displacements, economic recessions, and employment disruption and erode finances for social protection, and thus cause food insecurity through these channels. However, worsening food security conditions have also been observed in more peaceful settings. This is because economic slowdown exhausts foreign exchange and fiscal revenues, affecting both food availability through reduced imports and food access through reduced fiscal space to protect poor households against rising domestic food prices. Furthermore, even if there is a decline in international food prices, depreciation of national

countries, reduces the purchasing power of poor people and drive up local food prices and thus hurt food security.

A second source of internal displacement in Sudan and hence food insecurity is natural disasters including drought, desertification and flooding. For example, below-average rainfall and reduced planting in Darfur region of Sudan during the 2015 rainy season has led to a 30-50% crop loss (GCO, 2015), directly affecting food security of more than 6 million people of whom there were at least 2 million living in IDPs camps in the region.

The third cause of displacement and hence food insecurity is government-sponsored development schemes, where displacement takes the form of organized resettlements. The Aswan High Dam construction resulted in 100 000 displaced persons (Cernea, 1997). In Sudan, the construction and operation of Merowe dam by 2008, forced more than 700 000 to evict their habitual places to resettle in camps without proper agreement on compensations with the government. Another example, was when the government of Sudan, took hold on of 80 000 square kilometers in Nuba mountains for large-scale mechanized agriculture, and it has been found that out of a population of 1.13 million, about 170 000 people were displaced to live in camps under the control of the government, while tens of thousands had fled into the mountains (Robinson, 2003). However, the victims of development-induced displacement receive little attention compared with those displaced by conflicts while the consequences may be comparably dire (Robinson, 2003). Dam-induced displacement has first received investigations from anthropological and sociological perspectives and later seen some economic investigations. A survey of literature on dam-induced displacement can be found in Hay, et al. (2019).

Continual massive population displacement in Sudan has been a source of major environmental damage in many parts of the country. Halting displacement will require concurrent action to halt environmental degradation (UNEP, 2009). Internal displacement is identified as a cause of severe deforestation around the larger camps in many parts of the country. With civil wars, the country has been a recipient of much humanitarian aid, but many IDPs never provided by a source of energy and thus IPDs have been left with limited livelihood strategies such as collection of wood for household energy needs and to fuel brick kilns which became major source of deforestation in settlements in Darfur (Suliman, 2011). With lack of controls and solutions camps became spots for human rights abuses, conflicts over resources and food insecurity (Suliman, 2011). In much of northern and central Sudan, the effects of environmental and climatic changes are more damaging in relatively dry regions with low woodland density and tree cover particularly Northern Darfur and northern Kassala, where large numbers of IDPs are located. In eastern Sudan, camp-related deforestation has been occurring for at least twenty years, with little or no measures to prevent people from cutting down trees for fuel as long as their ongoing energy needs were not addressed (Suliman, 2011). The UNEP (2007) report states that deserts spread by an average of 100km in the last four decades, and overgrazing of fragile soil, and the conflict in turn, owing to the displaced people in Darfur, is further exasperating the spread of deserts and deforestation. In sum, IDPs can cause deforestation, which in turns worsen the state of food security among IDPs.

Suhrke (1993) highlights tensions in Sudan due to the expansion of the desert where people are forced to seek alternative sources of livelihood. According to the author, nomadic pastoralists found themselves increasingly restricted in their search for pasture and water and thus increase the incidents of armed violence between pastoralists and farming groups. The spreading desert linked to climate change had eradicated all the pasture and water corridors that served as buffers during the dry seasons, Suhrke (1993). Salomé (2011) argues that given the complexity of climate-conflict linkages and human security in Sudan, there is a need for interdisciplinary research approaches, policy development and practical interventions. As

noted by the author, the Sahelian areas of Sudan have already experienced climatic changes, historical environmental stresses such as desertification, and competition between farmers and pastoralists over water and arable land for grazing and farming.

Under unfavorable climate changes in terms of increased temperature, erratic rainfall, and deforestation in conflict-ridden countries, internal displacement and food insecurity reinforce each other in complex and dynamic ways. For example, in 2011, 26.4 million persons were displaced due to weather-related hazards, human rights violation and religious or communal conflicts and displacement increased to 38 million in 2014 and to 40.8 million at the end of 2015 (IDMC, 2016). FAO (2018) states climate variability and extremes were among the key drivers behind the increase in global hunger and one of the leading causes of severe food crises. Kahsay & Hansen (2016) find a substantial negative effect of within growing season variance of precipitation in East Africa, and with simulated prediction of climate change for the region they find a resulting output reduction of between 1.2% and 4.5%. High temperature, fluctuating rainfall, droughts and floods were cited as main causes of insecurity in the Horn of African (HOA) (Van de Giessen (2011). In 2015, disasters triggered by rapid-onset natural hazards forced 1.1 million people from their homes in 33 countries and flooding was the most significant cause of flight, accounting for more than 90 percent of displacement associated with disasters every year since 2009 (IDMC, 2016).

Sudan is not only a conflict-ridden country of armed conflicts, but also facing major environmental degradations. Food insecurity has been a chronic problem particularly among IDPs. Prevalence of malnutrition among IDPs in Sudan in terms of Global Acute Malnutrition (GAM) which measures acute malnutrition in refugee children aged between 6 and 59 months was 16.3 per cent and Severe Acute Malnutrition (SAM) was above 2 per cent which were above the emergency threshold of 15 per cent and 2 per cent respectively (USAID, 2016). However, in an analysis of 169 surveys for the period 1 January 2004 to 31 December 2008, Nielsen (2009) concludes no difference in GAM and SAM between IDPs and residents in Darfur, but with slight increase in SAM among IDPs. Although Sudan is a country with the largest number of IDPs in Africa, but surprisingly is not a signatory member of the Kampala Convention for the Protection and Assistance of IDPs, which was agreed by the African countries in 2009 and entered into force in 2017. Instead, Sudan has enacted national laws to regulate internal displacement.

Food security exists as when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FOA, 2010). The four dimensions of food are food availability, economic and physical access to food, food utilization and stability. One measure of food security is the depth of food deficit (DFD), defined as the calories needed to lift the undernourished from their status. DFD is supposed to be associated with high IDPs. Table 1 presents numbers of IDPs and table 2 shows food insecurity in terms of DFD in Sudan compared with some countries of the HOA.

Table 1: IDPs Sudan and some HOA Countries

Country	2009	2010	2012	2014	2016	Average	Rank
	IDPs	IDPs	IDPs	IDPs	IDPs	IDPs	
Kenya	341686	303786	397626	310568	178746	306482.4	2
Sudan	4980000	4820000	3084000	3287000	3422738	3918748	1
Rwanda	5460	5920	3225	1513	9731	5169.8	5
Ethiopia	310000	350000	370118	446653	604719	416298	4
Uganda	435000	166000	30216	79906	55494	153323.2	3

Source: Author's calculations based on the World Bank, WDIs, 2018.

Table 2: Food Deficit in Sudan and some HOA Countries

Country	2009 DFD	2010 DFD	2012 DFD	2014 DFD	2016 DFD	Average DFD	Rank
Kenya	166	165	151	140	135	151.4	5
Sudan	169	168	176	173	178	172.8	3
Rwanda	324	301	260	247	232	272.8	1
Ethiopia	304	291	264	250	236	269	2
Uganda	164	168	165	167	172	167.2	4

Source: Author's calculations based on the World Bank, WDIs, 2018.

Table 1 and table 2, read together, show that while Sudan ranks as number 1 in terms of IDPs, it ranks as number 3 in terms of food deficit. Rwanda ranks as number 5 in terms of IDPs, but it ranks as number 1 in terms of food deficit. The point is that higher numbers of IDPs are not necessarily associated to high food insecurity. This gives rise to the role of socio-economic factors in determining food security among IDPs. It worth mentioning that during the period 2000-2008, Sudan, Kenya, Somalia, and Rwanda had the biggest share of twelve armed conflicts and 378 social conflict events per year in Africa, which resulted in significant number of IDPs and fatalities (Hendrix and Salehyan 2008). Figure 1 depicts the time trend of IDPs in Sudan which shows no significant decline over the period 1983-2016.

Figure 1: Time Trend of (IDPs)

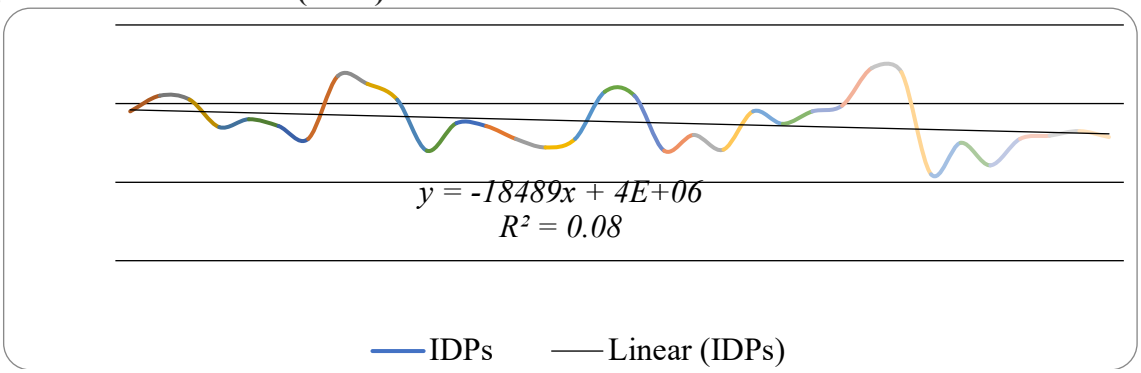
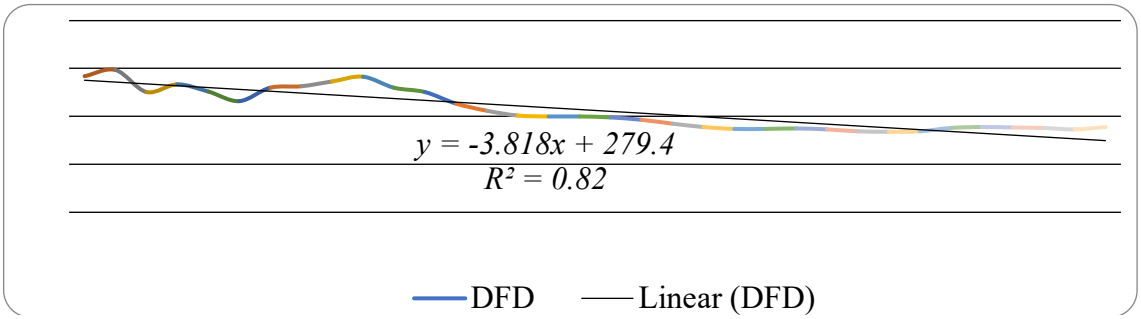


Figure 2 depicts time trend of food security which shows significant decline over the period 1983-2016. Read together, figure 1 and figure 2 tell that internal displacement per se can't be blamed as the sole factor behind food insecurity in Sudan.

Figure: Time Trend of DFD



Recently, Sudan has experienced three serious famines. The first one was in the late 1970s, the second in the mid 1980s, and the last in early 1990s (El-Dukheri et al. 2006). With continual conflicts and displacement, Sudan has experienced unfavorable climate conditions, mainly drought but also floods over these periods which concurrently resulted in food

insecurity, Conway & Schipper (2011) and Ghebrezgabher et al. (2014). Declined rainfall quantity and quality led to serious drought with all its negative consequences on cereals production in the country from mechanized and traditional rainfed farming systems as they both depend on the rainfall pattern (El-Dukheri et al. 2006). Leory & Fana (2011) document reduced rainfall in Darfur since 1970s has turned marginal grazing land into desert, placing significant stress on the livelihood systems of local groups. In eastern Sudan, the average reduction of rainfall during the 10 most severe droughts of the 20th century has reached almost 100% (Carlo B. 2010). Northern Sudan is totally a desert region. Reduced rainfall with deteriorating water collection means has hampered the traditional migration patterns of pastoralists and different population groups and livestock concentrate around the remaining water sources, leading to localised environmental degradation and conflict. In a comparative study, Jürgen et al. (2014) conclude that while interpastoral conflicts in north-western Kenya result in limited numbers of casualties, the Darfur conflict in Sudan has been shaped by the civil war causing significant loss of lives and destruction, but the impact of climate change is less direct in Sudan than in Kenya. To avoid violence, in both cases the authors suggest that it is essential to reduce socio-economic marginalisation and restrain access to arms for a sustainable and peaceful intervention in order to contain the adverse impacts of climate change. Put collectively, Sudan is highly vulnerable with respect to Climate Security Vulnerability Model (CSVM) as summarized in table 3.

Table 3: Sudan Vulnerability to Climate and Security

Climate and Security Vulnerability	Status of Sudan
Climate Related Hazard Exposure (C)	Medium
Population density P (people per sq km): lowest 1-10; highest 50.001-99.055	Within the category of 51-500 except some unpopulated areas in Northern Sudan
Household and Community Resilience (H); Education, Health, Daily Necessities, Access to Healthcare (Each bears 25%)	Very bad
Governance: (G) Government Response Capacity [Government Effectiveness (20%)]; Government Responsiveness [Voice and Accountability (20%)]; Political Stability [Polity Variance (10%) - Number of Stable Years (as of 2011) (10%)]; Openness To External Assistance [Globalization Index (20%)] Assistance; History of Violence [Subnational conflict events (20%)]	Near worst
$CSVM_{additive}$ = [C+P+H+G]/4: zero maximal vulnerability; 1 no vulnerability	Almost extensively vulnerable
Number of Climate Related Disasters (1997-2011- 2016)	2-3 – 4-6

Note: Based on Joshua, Todd & Nisha (2015).

Sudan wars have placed significant burden on the economy of Sudan, indicated by military expenditure and arms imports over the period 1963-1985, Mohammed (1998). In 1983, civil war remerged in South Sudan and only ended in 2005 with the signing of the Comprehensive Peace Agreement (CPA), but already the Darfur crisis started since 2003. By all measures, the continued wars in Sudan, definitely contributed to worsening economic condition and food security with increasing numbers of IDPs. Gross Domestic Product (GDP) of Sudan is comprised of agriculture accounting more than 40%, industry accounting less than 20% and services accounting more than 42.6% on average for the period 1980 - 2016. The continued civil war had a crippling effect on the economy, with huge loss of lives and

environmental destruction that undermined domestic and foreign investment and consequently limited employment and skewed income distribution (El-Dukheri et al. 2006). Poverty is widely spread in Sudan, for example, in 1998 there were 94% of Sudan's population living under the poverty line, declined to 46.5% in 2009 (Central Bureau of Statistics, 2009), and according to a recent speech of the Minister of Finance and Economic Planning in May 2020, more than 80% of Sudan population are living under poverty line.

The country's total outstanding debt amounted to US$ 23.7 billion in 1999, increased to more than US$ 63 billion in 2016, and major shares of which are bilateral ranging from 65-70%. Production and exportation of oil since late 1999, spurred government revenues and contributed to reduce the budget deficit, and overall led to improvement of economic growth to an annual average of 6% over the period 1999-2011. Inflation, measured by the Consumer Price Index (CPI), reached more than 160% in 1996, and declined to one digit on oil booming sector over the period 2000-2011. But with the secession of South Sudan from the North in July 2011, economic growth in Sudan dropped to negative record by the end of 2012, with dwindling government revenues, soaring price levels, and deteriorating quality of basic services and life. These conditions have led to uprisings and major demonstrations against the government in December 2018, and finally led to ousting of president Omer Al-Bashir, who ruled the country since 1989, in April 2018. The objective of this study is to investigate how environmental changes, conflicts, internal displacement and economic factors affect food security in Sudan.

Literature Review

One of the most debated analyses of relationships between environmental changes, conflicts and people movements is that of Homer-Dixon (1994, 1996). Homer-Dixon framework focuses on environmental scarcity, described as (i) degradation and depletion of renewable resources, (ii) increased consumption of those resources, (iii) and/or uneven distribution of these resources. Homer-Dixon (1996) proposed three hypotheses linking environmental changes with violent conflict. First, decreasing supplies of physically controllable environmental resources, such as water and good agricultural land provoke interstate conflicts or resource wars. Second, large population movements caused by environmental stress induce group-identity conflicts. And third, severe environmental scarcity increases economic deprivation and disrupt social institutions, which in turn would cause deprivation conflicts. In general, in Homer-Dixon theoretical scheme environmental disruption leads to four social effects including decreased agricultural production, population displacement, decreased economic productivity, and disruption of institutions.

Hartmann (1998) criticized Homer-Dixon scheme, claiming that Homer-Dixon arguments are built upon weak definitional foundation and the increased consumption of resources is mainly linked to population growth. Environmental degradation is also confused with renewable resource scarcity although there is no necessary link between the two. By adding the social distribution of resources into the definition of environmental scarcity, Homer-Dixon de facto creates a link to conflict, since political conflict often revolves around issues of resource control which the main tool force very disparate conflictual situations. Hartmann argues that the greatest deforestation occurred under colonialism and, today, most tropical wood and beef production, for example, is destined for foreign markets, and Homer-Dixon's approach fails to link the consumption patterns in the world's wealthiest countries and of Southern élites to local land uses.

Gleditsch (1998) provides several critiques to Homer-Dixon literature claiming that it neglects political and economic factors, which have a strong influence on conflict and mediate the influence of resources and environmental factor. Gleditsch (1998) argues that economic development has a restraining influence on violent behaviour in environmental conflict, since wealth is negatively associated with armed conflict. In Sudan, historical armed

conflicts caused large damage to the environment and enforced mass number of people to live as internally displaced. Sudan is war-torn country, since its independence in 1956. The country ended up in a vicious cycle of poverty, poor governance, environmental degradation, and a relapse into violence and that these issues and violent conflict are influenced by other political, economic and social factors already in play (Gleditsch 2007). Daniel M. et al., (2000) counter-argument is that Gleditsch's proposal is a methodological straight-jacket which severely constrains research in the field. Daniel et al., (2000) contend that the case-study method has qualities that complement quasi-experimental methods. Furthermore, Homer-Dixon (2001) and Schwartz and Randall (2003) argued that there is a direct link between environmental conditions and violent conflict. However, Hagmann (2005) argues that the concept of environmentally induced conflict is itself fundamentally flawed and that the literature reveals the shakiness of the concept's core assumption. He argues that research on the ecologic sources of conflict has been characterised by a one-sided fixation on causality and that environmental conflict literature amalgamates eco-centric and anthropocentric conceptions of agency that are incompatible (Hagmann, 2005). He pointed out that the field has failed to take into account how social actors contribute to and cope with environmental change and degradation. Buhaug, Gleditsch & Theisen (2008) find that prevailing research shows no evidence of a direct link between the environment and conflict, but that this could be due to the limitations inherent in existing research.

Hendrix (2008) argues that the effect of climate change on armed conflict is contingent on a number of political and social variables, which, if ignored by analysts, can lead to poor predictions about when and where conflict is likely. This strand of literature suggest that environment-conflicts problems lay on resource abundance rather than resource scarcity as a major cause of poor economic and social institutions, conflicts and insecurity (Hendrix & Salehyan 2008). If resource abundance with deficient institutions leads to resource curse and aggravate conflicts, then it is plausible to expect internal displacement and food insecurity as outcomes. Displacement of people, their vulnerability particularly to food insecurity can be attributed to multi-factors, including environmental scarcity, climate change and can be aggravated by social and armed conflicts (Hendrix & Salehyan 2008). For example, when drought reduces the availability of water and pasture and the productivity of agricultural land, competition for resources between pastoralists and farmers may increase the risk of conflict and violence, and therefore displacement and food insecurity. On the other hand, conflict and violence also increase the vulnerability of communities whose livelihoods and survival depend on timely and adequate rainfall. For example, Hendrix and Salehyan conclude that rainfall has a surprising influence on the prevalence of social conflict and conflict events have been more common in extremely wet and dry years than in years of normal rainfall. In general, not only will mean levels of rainfall change, but their variance also will and extreme rainfall events may become much more common.

With reference to Social Conflict Analysis Database (SCAD), Hendrix & Salehyan (2008) argue that unlike other environmental variables, such as soil erosion and water quality, rainfall is not directly affected by human behavior and this enhances the validity of causal arguments about climate change, social conflict and food insecurity. Hendrix & Salehyan (2008) state that war in Sudan started in May, 1983, and ended January 2005, there were 7909 days of various types of conflicts and civil unrests. In addition to the continued crisis in Darfur after 2008, and in other parts of Sudan, there should be additional 2920 days of various types of social conflicts civil unrests events in Sudan. Hendrix & Salehyan (2012) using a new SCAD database of over 6 000 instances of social conflict in Africa over 20 years find that rainfall variability has a significant effect on instances of political conflict, and that rainfall correlates with civil war and insurgency, although wetter years are more likely to

suffer from violent events. Extreme deviations in rainfall are associated positively with all types of political conflict, though the relationship is strongest with respect to violent events.

Laura (2017) argues that even if rainfall remains constant, with increasing temperatures, existing water stress will be amplified, putting more pressure on agricultural systems in Africa. High temperatures and changes in rainfall patterns are likely to reduce cereal crop productivity, in Sudan and their effects are magnified because much of Sudan agriculture's vulnerability to climate change lies in the fact that its agricultural systems remain largely rain-fed and underdeveloped on one hand. On other hand, many Sudanese depend on food, fiber, and income on agriculture and fisheries which are inherently climate-sensitive sectors. Stagnant agricultural yields with relatively high population growth definitely lead to fall in per capita food availability, which has been the case since the 1970s (Niang et al. 2014).

Within the unsettled debate of the relationship between environmental changes, internal displacement and food security, food insecurity itself can also be viewed to cause environmental degradation, conflicts over resources, physical and mental distress to those who are food insecure, particularly IDPs. Peter, et al. (2016) state that living with pain is one of the distressing effects of food insecurity among IDPs. The authors state that vulnerability of IDPs to emotional pain, metabolic imbalance, chronic illnesses and non-communicable diseases are associated with stressed livelihood and restricted access to balanced diets in their camps.

Empirical quantitative studies on the effects of environmental, conflicts, displacement, socio-economic factors on food security are rare worldwide, coupled with debated theoretical propositions in the field. Some studies focused on food security determinants in groups of countries as Lofgren & Richards (2003) and Clemens B. et al. (2010) for the Middle East and North African (MENA), Ahmet et al., (2017) for MENA and Turkey, Abdul Manapa, et al. (2017) for a panel of 57 countries. None of these studies focus on the role conflict factors including internal displacement on food security and in a case of a single country. This is what our study tries to address in the case of Sudan and thus adding to the scanty empirical literature, but also highlights the theoretical debate on the role of environmental factors and conflicts on displacement and food security.

Lofgren & Richards (2003) state that in MENA household food insecurity is related to poverty and undernourishment and most severe in rural areas and concentrated within Iraq, Sudan, and Yemen. They argue that the key to increased national and household-level food security is pro-poor growth, driven by export-oriented, labor-intensive sectors and agricultural sector policies subordinate to the pro-poor growth. Without inclusion of conflicts and displacement as determinants of foods security, Lofgren and Richards (2003), suggest that their pro-poor strategy requires conflict resolution; macroeconomic stability; physical and human capital accumulation; reliance on markets and the private sector, and diffusion of ecologically friendly farming practices. Clemens et al. (2010) for MENA including Sudan, suggest that achieving food security requires economic growth and diversification that generates jobs, breaking the strong vulnerability to international oil and food price volatility, effective management of depleting water resources and climate change adaptation.

Ahmet et al. (2017) analyse the determinants of food insecurity using an overall food insecurity index. They apply panel-data methods on 18 MENA countries and Turkey for the period of 1990-2014. They find that price increases, poor water management and waste of irrigation have harmful effect on food security, while education and freshwater withdrawals have good effects on food security. Abdul Manapa, et al. (2017) use three dependent variables to measure food insecurity, namely prevalence of food inadequacy (PFI), prevalence of undernourishment (POU) and the depth of food deficit (DFD) applying panel datasets from 57 developing countries for the period 1990 to 2007. They find that food import

index, food production index, purchasing power parity, water improvement and arable land as the most important factors reducing the DFD while food aid and paved roads are found to be insignificant, and sanitation services and GDP have adverse effect on DFD.

Based on a survey data covering 500 households in Niger, Seydou et al. (2014) identify drought, food prices, poverty, soil infertility and diseases as the main causes of food insecurity. They show that female headed households are more vulnerable to food insecurity. Laibuni et al. (2015) note that policy interventions for food security in East Africa countries have been characterized by abrupt changes, do not achieve much, because they are costly and unsustainable thus the region continues to suffer from food insecurity. They argue for paradigm shift in the policy direction to focus more on improved food production and productivity and regional trade. Sabbil et al. (2016) in a sample of 140 households in Aboshouk IDPs camp in North Darfur State find that 47.8 of the IDP households are food insecure, and that food security status is determined by food relief received, the household ownership of domestic animals, and the number of household members earning money.

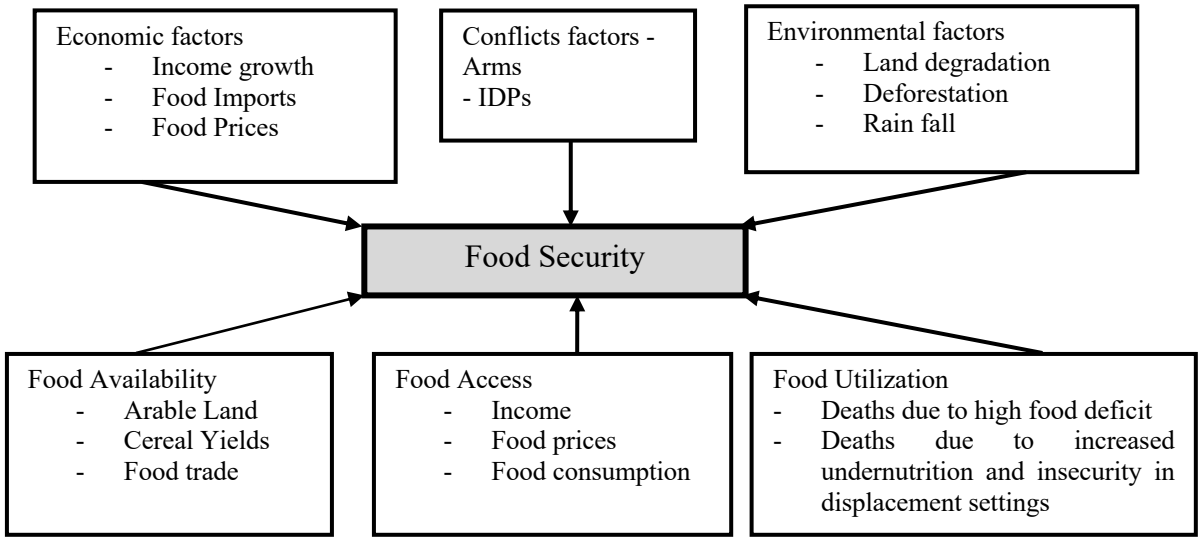
Conceptual and Analytical Framework

This study is empirical and quantitative in that it uses econometric methods. Studies on environmental change, conflicts, displacement and food security need to be based on clear theoretical framework, rigorous methodology and reliable data. Yet, empirical quantitative studies using dynamic econometric methods on these relationships are rare, although such methods are usually more rigorous (Mitchell & Bernauer 1998).

Environmental changes, conflicts and economic factors selected to explain food security in this study is conditioned by the availability of reliable data and the possibility of establishing meaningful comparisons across time periods. This study uses indicators which focus on conditions that generate food insecurity, such as poverty; food availability, access, affordability and utilization and instability. The study incorporates three dimensions of food security – availability, access and utilization operating within socio-economic, environmental and conflict context. The availability dimension is related to agricultural production reflected by cereals yield, which is also affected by environmental and climate change factors, but increase in agricultural production is likely to reduce forest lands, Hilderink et al. (2012). The access dimension includes food prices and income. The utilisation dimension concerns impacts from inadequate use of food, represented by the depth of food deficit DFD and its interaction with internal displacement. For estimations, food security is measured by the DFD for reasons as this measure is an outcome and embodies other measures of food security.

Environmental change factors are represented by forest land area (FL) which also reflects deforestation, annual rainfall (ARF) which affects and affected by IDPs. Economic factors are represented by real GNI per capita (GNIP), real food price index (FPI), and food imports (FMM), which affect access to food. The supply and demand interactions through prices at the national and international level affect food security in a dynamic and complicated way. Local food prices are determined by local production and distribution of food as well as food imports. For example, globally, the real prices of wheat and maize continue to fall, but the FAO food price index for East Africa has more than doubled. Conflict is represented by two interrelated proxies, arms imports (ARM) and the number of IDPs and also reflecting political stability and absence of violence. The selection of these factors comes within the context of food security as part of human security which is affected by conflicts, environmental and climate change, poverty, migration and weak states as discussed by Ahmed (2011). The analytical model adopted in this study is set as a context of food security within environmental, conflicts and socio-economic model as sketched in figure 3.

Figure 3: Food Security within Environmental, Conflicts and Socio-economic-context



Definition of the study variables

DFD: Depth of the food deficit, defined as the calories needed to lift the undernourished from their status. The importance DFD is that it reflects the actual food consumption and food deprivation of the undernourished. The average intensity of food deprivation of the undernourished is the difference between the average dietary energy requirement and the average dietary energy consumption of the undernourished population. This is then multiplied by the number of undernourished to provide an estimate of the total food deficit in the country. Normalizing the total food deficit by the total population gives the per capita DFD. In this sense, declining DFD at the individual and national level means increasing food security.

FL: Forest land area as percentage of total land area.

ARF: Annual average rainfall defined as average precipitation in depth (mm per year) over space and time in the country.

CEY: Cereal yield (kg per hectare), harvested land, which includes wheat, millet and sorghum.

GNIP: GNI is gross national income which is the sum of the value added by all resident producers plus any product taxes (less subsidies) plus net receipts of primary income from abroad, divided by midyear population evaluated at constant 2010 US$ to give the real GNIP.

FPI: Real food price index (international).

FMM: Food import as percentage of merchandize imports.

ARM: Arms imports defied as arms transfers covering the supply of military weapons through sales, aid, gifts, and those made through manufacturing licenses. As defined in the World Bank (2018), data cover conventional weapons such as aircraft, armored vehicles, artillery, radar systems, missiles, and ships designed for military use, using Stockholm International Peace Research Institute definition.

IDPs: Number of internally displaced persons. Combining conflict-induced and development-induced displacement provided a definition of IDPs articulated by Francis M. Deng – Representative on IDPs appointed by the UN Secretary-General, "as persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights, or natural or human-made disasters and who have not crossed an internationally recognized State border" (Robinson, 2003).

Data on all variables is processed from the WDIs, 2018, except for the real food price index, which is sourced from FOA, (2017).

Econometric Methods and Data

This study adopts empirical-quantitative research design. Without setting hypotheses about the relationships between food security, environmental, conflicts and economic factors, the study designed the analytical framework outlined in figure 3 which takes into account results of previous research. In this study, the dependent variable is food security measured by the depth of food deficit scaled to national average, while the scales and measurements of independent variables are as defined above. This enables the selection of the statistical, empirical-quantitative method for analyzing the co-variation of the study variables, namely the autoregressive distributed lag (ARDL) model. Although, the main dependent variable is food security, but since we are using the ARDL bounds test approach all variables become dependents and dynamically interacting with one another. This also justifies our decision of not to set hypotheses and presumption of direction of causal relationships. Furthermore, the derived results from the case of Sudan can be validated and placed within the previous decisions and can be generalized to other cases with similar conditions, particularly to the countries of the HOA. The study uses annual time series secondary data on its selected variables covering the period 1983-2016.

Descriptive statistical analysis

Table 4 presents the descriptive statistics and correlations of the study variables. From the Jarque-Bera (J-B) and the associated probability values, all variables look normally distributed expect arms imports and average rainfall. The highest kurtosis is associated with arms imports followed by food imports and forest lands. As for average rainfall, it has been reported that summer monthly precipitation over the Sahel of which Sudan, is not normally distributed. This is not particularly surprising since monthly mean rainfall rarely shows a perfectly normal distribution. What is more interesting is that in the case of the Sahel including Sudan, the largest deviation occurs on the dry tail. This means that precipitation can be significantly less than would be expected in a normally distributed process, Carlo B. (2010).

Table 4: Summary of descriptive and correlation Statistics

	DFD	FL	ARF	CEY	GNIP	FPI	FMM	ARM	IDPs
Mean	214.74	12.11	1132.86	545.76	1039.20	115.20	15.81	769.643	3542733
Median	200.00	12.27	1712.00	563.80	931.39	106.80	15.64	650.000	3426700
Maximum	297.00	16.73	1712.00	729.50	1757.59	165.99	25.87	2930.000	4900000
Minimum	168.00	8.05	250.00	290.40	680.91	87.57	5.26	300.000	2200000
Std. Dev.	43.41	2.19	680.49	102.82	330.50	22.28	4.12	658.260	661809
Skewness	0.51	-0.34	-0.31	-0.41	0.88	0.87	0.05	1.22	0.25
Kurtosis	1.69	3.00	1.12	2.66	2.56	2.44	3.90	4.65	2.47
J-B	3.99	0.67	5.71	1.16	4.79	4.91	1.19	12.68	0.78
Prob.	0.136	0.714	0.058	0.561	0.091	0.086	0.553	0.002	0.676
Obs.	35	35	35	35	35	35	35	35	35
Correlations									
DFD	1.00								
FL	0.74	1.00							
ARF	-0.39	-0.02	1.00						
CEY	-0.40	-0.38	0.09	1.00					
GNIP	-0.77	-0.86	-0.05	0.37	1.00				
FPI	-0.53	-0.67	-0.11	0.24	0.82	1.00			
FMM	0.32	0.28	0.12	-0.10	-0.34	-0.17	1.00		
ARM	-0.53	-0.33	0.13	0.16	0.38	0.33	-0.34	1.00	
IDPs	0.28	0.36	-0.03	0.01	-0.27	-0.19	0.26	-0.16	1.00

From the correlation matrix in table 4, food security (DFD) is found to be negatively correlated with arms imports and food prices but unexpectedly DFD is also negatively correlated with economic growth. DFD is found to be positively correlated with forests land and to a lesser extent with the number of IDPs. Among the independent variables, forests land is highly negatively correlated with economic growth while economic growth is positively correlated with food prices.

Econometric Analysis

General Econometric Model

A general log linear model to capture the complexity of environmental changes, conflicts, internal displacement, economic growth and food insecurity in Sudan is written as:

$$L(DFD) = \alpha + \beta_1 L(FL) + \beta_2 L(ARF) + \beta_3 L(CEY) + \beta_4 L(GNIP) + \beta_5 L(FPI) + \beta_6 L(FMM) + \beta_7 L(ARM) + \beta_8 L(IDPs) + \mu \ldots\ldots\ldots\ldots\ldots\ldots 1$$

ARDL Model specification

An autoregressive distributed lag model of Pesaran and Shin (1999) is used to investigate the short-run dynamics and long run equilibrium of food insecurity as the dependent variable and its explanatory variables. An ARDL model for DFD as the dependent variable on the basis of equation 1 is specified as follows:

$$\begin{aligned}\Delta L(DFD)_t &= \alpha + \sum_{i=1}^{p} \beta_{1i} L(DFD)_{t-1} \\ &+ \sum_{i=0}^{p} \Delta\beta_{2i} L(FL)_{t-1} + \sum_{i=0}^{p} \beta_{3i} \Delta L(ARF)_{t-1} \\ &+ \sum_{i=0}^{p} \beta_{4i} \Delta L(CEY)_{t-i} + \sum_{i=0}^{p} \beta_5 \Delta L(GNIP)_{t-i} \\ &+ \sum_{i=0}^{p} \beta_6 \Delta L(FPI)_{t-i} + \sum_{i=0}^{p} \beta_7 \Delta L(FMM)_{t-i} \\ &+ \sum_{i=0}^{p} \beta_8 \Delta L(ARM)_{t-i} + \sum_{i=0}^{p} \beta_9 \Delta L(IDPs) \\ &+ \beta_{10} L(DFD)_{t-1} + \beta_{11} L(FL)_{t-1} + \beta_{12} L(ARF)_{t-1} \\ &+ \beta_{13} L(CEY)_{t-1} + \beta_{14} L(GNIP)_{t-1} + \beta_{15} L(FPI)_{t-1} \\ &+ \beta_{16} L(FMM)_{t-1} + \beta_{17} L(ARM)_{t-1} + \beta_{18} L(IDPs)_{t-1} + \mu_t \ldots\ldots 2\end{aligned}$$

The parameter p is the lag length and Δ is the difference operator. Equation 2 can be estimated through the ordinary least squares (OLS) method to explore the long run relationship of the model variables by performing an F-test for the joint significance of the lagged-level variables. The null hypothesis of no cointegration (i.e., no long run equilibrium relationship) of equation 2 is:

$H_0 : \beta_{10} = \beta_{12} = \beta_{12} = \beta_{13} = \beta_{14} = \beta_{15} = \beta_{16} = \beta_{17} + \beta_{18} = 0$, against the alternative hypothesis of existence of cointegration that: $H_1 : \beta_{10} \neq \beta_{11} \neq \beta_{12} \neq \beta_{13} \neq \beta_{14} \neq \beta_{15} \neq \beta_{16} \neq \beta_{17} \neq \beta_{18} \neq 0$

The decision rule for existence of cointegration in the bounds testing approach according to Pesaran & Shin (1999) is two sets of critical values for the F-statistic: the lower bound where all variables are cointegrated of the order I(0) and the upper bound where all variables are cointegrated of the order I(1). If the F-statistic lies below the lower bound value, the conclusion is no cointegration and if the F-statistic is found to be above the upper bound value, then cointegration exists, whereas if the F-statistic falls between the upper bound and the lower bound, then the test is inconclusive. Equation 1 is first estimated using the OLS method and the results are summarized in table 5.

Table 5: Summary Results of OLS Model

	Dependent Variable L(DFD)	Coefficient	t-Statistic	Prob.
Explanatory Variable	C	8.57	6.431	0.000*
	L(FL)	0.20	1.383	0.178
	L(ARF)	-0.08	-5.129	0.000*
	L(CEY)	-0.08	-1.137	0.266
	L(GNIP)	-0.44	-3.589	0.001*
	L(FPI)	0.18	1.470	0.154
	L(FMM)	0.04	0.830	0.414
	L(ARM)	-0.04	-2.947	0.007*
	L(IDPs)	0.003	0.045	0.964

R^2= 0.90; Adjusted R^2 = 0.86; F-Stat. = 28.03 (P. 0.000); DW = 1.46; SER = 0.072; SSR = 0.136; AIC = -2.20; SC = -1.80; HQ = -2.06

OLS Diagnosis

Test	Stat.	Prob.	DW
Normality (J-B)	1.22	0.542	1.46
Serial Correlation LM: (F)	1.64	0.215	2.03
Heteroskedasticity: (F)	2.90	0.019	2.13
Stability Ramsey RESET (F)	0.86	0.362	1.44

* indicates significance at 1% level

The OLS model results show that food insecurity is mostly affected by economic growth, rainfall and arm imports. Implicitly, if these variables have effect on internal displacement, then the number of IDPs has effect on food insecurity. This finding is what motivates the need for dynamic econometric analysis to address the interrelationships between environmental, conflicts, internal displacement and economic factors and food insecurity.

Stationary and cointegration

A first step in dynamic econometric analysis is to investigate the characteristic of time series data. For reliable econometric estimation, it is a requirement that time series data should be stationary. Stationary of time series included in this study is tested through the conventional Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests. Cereal yield, food imports, arms imports and internally displaced persons are found to be stationary at level I(0) and first difference I(1) while the first differencing makes all variables stationary as presented in table 6.

Table 6: Unit Root Test Results

Variable	ADF I(0)	PP I(0)	ADF I(1)	PP I(1)	Order of Integration
L(DFD)	-0.913	-1.382	-2.165	-6.338	I(1)
L(FL)	-0.366	-0.214	-6.413	-6.466	I(1)
L(ARF)	-1.239	-1.335	-5.575	-5.575	I(1)
L(CEY)	-5.727	-5.774	-10.759	-19.120	I(0) & I(1)
L(GNIP)	1.049	0.827	-5.562	-8.139	I(1)
L(FPI)	-1.034	-1.097	-5.031	-5.031	I(1)
L(FMM)	-3.756	-2.736	-5.362	-7.693	I(0) & I(1)
L(ARM)	-3.198	-3.175	-8.032	-11.772	I(0) & I(1)
L(IDPs)	-4.237	-4.049	-7.790	-20.603	I(0) & I(1)

Since the study variables are found to stationary at both level and first difference, it is appropriate to use the ARDL model. The ARDL bounds test is performed on equation 2, where each variable is treated as the dependent while all other variables are the independents. The results show that there are eight cointegrated forms as summarized in table 7. Thus, the results of the bounds test confirm existence of a long run equilibrium relationship between food insecurity in relation to the set of covariates included.

Table 7: ARDL Bounds Test Summary Results

Dependent variable	F. Stat.
FL(DFD)|L(FL), L(ARF), L(CEY), L(GNIP), L(FPI), L(FMM) L((ARM), L(IDPs)	3.80*
FL(FL)|L(DFD), L(ARF), L(CEY), L(GNIP), L(FPI), L(FMM), L(ARM), L(IDPs)	5.00*
FL(ARF)|L(DFD), L(FL), L(CEY), L(GNIP), L(FPI), L(FMM), L(ARM), L(IDPs)	5.71*
FL(CEY)|L(DFD), L(FL), L(ARF), L(GNIP), L(FPI), L(FMM), L(ARM), L(IDPs)	5.61*
FL(GNIP)|L(DFD), L(FL), L(ARF), L(CEY), L(FPI), L(FMM), L(ARM), L(IDPs)	7.49*
FL(FPI)|L(DFD), L(FL), L(ARF), L(CEY), L(GNIP), L(FMM), L(ARM), L(IDPs)	3.52*
FL(FMM)|L(DFD), L(FL), L(ARF), L(CEY), L(GNIP), L(FPI), L(ARM), L(IDPs)	1.67
FL(ARM)|L(DFD), L(FL), L(ARF), L(CEY), L(GNIP), L(FPI), L(FMM), L(IDPs)	4.05*
FL(IDPs)|L(DFD), L(FL), L(ARF), L(CEY), L(GNIP), L(FPI), L(FMM), L(ARM)	3.69*

Asymptotic critical value bounds are obtained from Table F in appendix C, Case II: intercept and no trend for K = 8;
* denotes rejection of the null hypothesis at 5% level

F-Statistic	Critical Value	
	I(0)	I(1)
3.80	2.11	3.15

The ARDL is then used to investigate the short run dynamics and long run equilibrium relationships between environmental changes, conflicts, internal displacement and economic factors and food security. The estimated model is ARDL (2, 2, 2, 2, 0, 0, 0, 2, 2) selected according to LR, FPE, AIC, SC and HQ criteria presented in table 8.

Table 8: VAR Lag Order Selection Criteria

Lag	LL	LR	FPE	AIC	SC	HQ
0	40.707	NA	1.11e-12	-1.982	-1.569	-1.845
1	199.327	218.102	1.06e-14	-6.833	-2.711*	-5.466
2	335.703	110.805*	1.37e-15*	-10.294*	-2.461	-7.698*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The ARDL short run dynamics and long run equilibrium results are summarized in table 9.

Table 9: ARDL Short and Long Run Estimations

ARDL short run dynamics				ARDL cointegration long run			
Variable	Coefficient	t-Stat.	Prob.	Variable	Coefficient	t-Stat.	Prob.
$DL(DFD)_{t-1}$	-0.50	-3.700	0.004***	L(FL)	-0.38	-1.694	0.118
DL(FL)	-0.43	-5.262	0.000***	L(ARF)	-0.06	-3.553	0.005***
$DL(FL)_{t-1}$	-0.81	-4.758	0.001***	L(CEY)	-0.21	-1.385	0.193
DL(ARF)	0.07	3.563	0.005***	L(GNIP)	-0.58	-4.468	0.001***
$DL(ARF)_{t-1}$	0.06	4.150	0.002***	L(FPI)	0.01	0.167	0.870
DL(CEY)	-0.04	-2.095	0.060*	L(FMM)	0.12	1.254	0.236
$DL(CEY)_{t-1}$	0.08	3.933	0.002***	L(ARM)	-0.02	-0.941	0.367
DL(ARM)	-0.02	-5.969	0.000***	L(IDPs)	0.29	2.030	0.067*
$DL(ARM)_{t-1}$	-0.02	-3.580	0.004***	C	7.40	5.310	0.000***
DL(IDPs)	0.08	3.287	0.007***				
$DL(IDPs)_{t-1}$	-0.08	-2.779	0.018**				
ECT_{t-1}	-0.79	-8.310	0.000***				

ARDL cointegration: R-squared = 0.99; Adjusted R-squared = 0.97; SER = 0.032;
SSR = 0.011; LL = 82.13; F. stat. = 48.09 P(0.000); AIC = -3.82; SC = -2.86;
HQ = -3.50; DW = 2.30
EC = L(DFD) - 0.38L(FL) -0.06L(ARF) -0.21L(CEY) -0.58L(GNIP) + 0.01L(FMM) + 0.12L(FPI) -0.02L(ARM) + 0.29L(IDPS) + 7.40)
ECM: R-squared = 0.87; Adjusted R-squared = 0.80; SER = 0.023;
SSR = 0.011; LL = 82.13; AIC = -4.38; SC = -3.83; HQ = -4.20; DW =2.30

ARDL Diagnosis

Test	Test Stat.	Prob.	DW
Normality: J-B	(0.66)	(0.718)	2.30
Autocorrelation: F	(2.54)	(0.133)	2.12
Heteroskedasticity: F	(1.86)	(0.144)	2.70

The ARDL model shows that in the short run, decrease in forests land is associated with decrease in food deficit with a coefficient of -0.62 while decreased rainfall is associated with increase in food deficit with a coefficient of 0.07. Economic growth measured by real gross national income per capita GNIP has no effect on food security. While the number of IDPs is associated with food deficit with a coefficient of zero, arm imports associates with food deficit with a coefficient of -2. Increases in food imports contribute to reduced food deficit with a coefficient of 0.04, while food prices have no effect on food security. In the long run, fluctuations of rainfall and cereal yields have no bad effect on depth food deficit and reduced cereal yield. Increases in real GNIP contribute to reduce food deficit by a coefficient of -.58. Food prices, food imports and arm imports have significant effects on food security. IDPs have negative and significant effect on food security. The coefficient of the error correction term (ECT) of -0.79 is highly significant confirming conitegration of the study variables and shows high speed of adjustment to equilibrium of food security in the long run in response to the short run shocks of the model variables. Results of the diagnostic tests show that the estimated ARDL suffer none of the econometric problems associated with time series data. Thus, the estimated model is stable, reliable, and robust and significantly captures the behavior of food security and its associated explanatory variables. As evident from plots of cumulative sum (CUSUM) in figure 4, and plots of the cumulative sum of squares (CUSUMSQ) in figure 5, that all statistics of the recursive residuals lay within the critical bounds, implying that the coefficients in the error-correction model of the ARDL are stable.

Figure 4: ARDL Stability: CUSUM

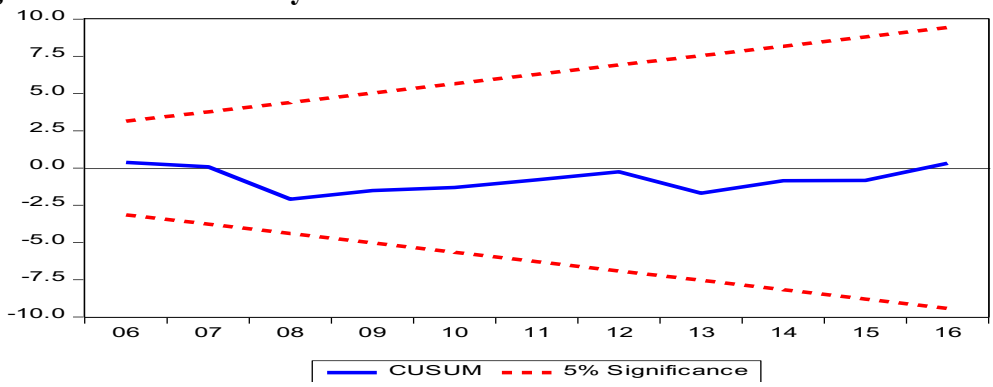
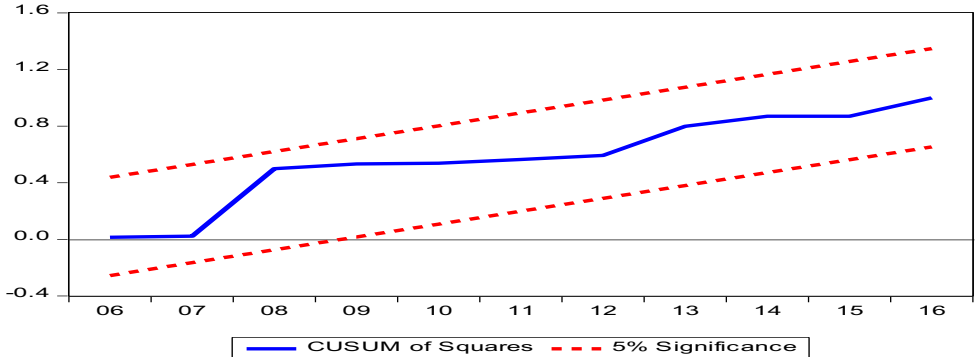


Figure 5: ARDL Stability: CUSUM squares



Johansen cointegration test

In addition to the ARDL bounds test approach, Johansen cointegration method is also employed at lag length of 2 to test the co-movement between food security and its covariates. Johansen cointegration test shows that there at least five cointegrating equations shown in

table 10, confirming existence of a long run equilibrium relationship amongst the variables of the study.

Table 10: Summary of Johansen Cointegration Test Results

H_0	H_1	Intercept		Intercept and Trend	
		Trace Stat.	Max-Eigen Stat.	Trace Stat.	Max-Eigen Stat.
r = 0	r = 0	314.472*	90.348*	400.544*	127.244*
r ≤ 1	r < = 1	224.124*	62.668*	273.300*	66.587*
r ≤ 2	r < = 2	161.456*	51.386*	206.713*	60.034*
r ≤ 3	r < = 3	110.070*	41.282*	146.679*	48.984*
r ≤ 4	r < = 4	68.787	29.714	97.695*	40.204*
r ≤ 5	r < = 5	39.073	20.761	57.491	23.871
r ≤ 6	r < = 6	18.312	11.951	33.619	20.373
r ≤ 7	r < = 7	6.361	5.7605	13.247	9.035
r ≤ 8	r < = 8	0.601	0.601	4.212	4.212

Intercept: Trace and Max-Eigen value test indicate 4 cointegrating equations
Intercept and Trend: Trace and Max-Eigen value test indicate 5 cointegrating equations
* denotes rejection of the hypothesis at the 0.05 level

Johansen cointegration results confirm the findings of the ARDL bounds test. Consistency of the results of the two cointegration methods means that the findings are robust and reliable. This means that unfavorable environmental changes (declining forest land and erratic rainfall), unstable cereal yield, conflicts (arms imports and IDPs), and unstable food imports have been destabilizing the state of food security even economic growth has been positive over the study period in Sudan.

Discussions

This study contributes threefold to determinants of food security. First, the study is a synthesis of arguments on environmental change, conflicts, internal displacement, economic growth and food insecurity unified in analytical framework. Second, based on the analytical framework, it used dynamic quantitative approach for empirical tests in a context of a single country case – Sudan. Selection of Sudan is at least based on two facts: (i) the country has long history of violent conflicts, with the largest number of IDPs in the World for many years, and facing major environmental changes (ii) availability of data from the WDIs, FAO and Sudan sources. Third, the study is an econometric investigation using two of the most reliable and widely used methods – the autoregressive distributed lag ARDL bounds test and Johansen method to Cointegration.

The econometric models of the ARDL bounds and Johansen cointegration test results show existence a long run equilibrium relationship between food security, environmental change, conflicts, and internal displacement in Sudan. In the long run, food security found to be negatively and significantly affected average rainfall, real income per capita, cereal yield and arms imports. Interestingly, IPDs have significant effect on food security in the short run only with no effect in the long run. This suggests that the longer the IDPs stay they become more food insecure, mostly due to lack of private self-adaptation and with insufficient supports from national and international organizations. On the other hand, arms imports have negative effect on food security only in the short run. It also amounts to arguing that the negative effect of arm imports on food security is immediate and direct, while the effect of internal displacement takes longer time to operate. Effects of conflicts mostly mediated through their effects on forest land and cereal production, particularly where rainfall is disturbed. For economic growth to affect food security positively there must be increases in real per capita income but more importantly there should be reduction of income inequality in the long run. The estimated ARDL model is statistically valid, empirically reliable and significantly captures the behavior of food insecurity and its associated explanatory variables,

chief among them being internal displacement. The study acknowledges the complexity of dealing with food security at the national level in presence internal displacement as a chronic problem in Sudan and that displacement in Sudan ostensibly caused by conflict has been traced back to root causes such as drought and forests deterioration, and a food crisis that became a full famine where the government neglects and in some cases changing regional demographics. Keen and Lee (2007) argued that dysfunctional and violent processes of development must be reversed where the damages cannot be compensated for-but may be legitimized-by attempts to use food aid as a 'safety net', and that those who benefited from war may have incentives to derail the peace.

Conclusion

The results of the ARDL bounds and Johansen cointegration models consistently show that deteriorating forest land and fluctuations of rainfall have been negatively impacting food security in Sudan, while only economic growth contributes significantly to reduce food insecurity. IDPs have a long term negative effect on food security. The policy relevance from the findings of this study to Sudan's government is that there are urgent needs to manage the remaining forest lands in sustainable manners. There also a need to integrate IDPs in the economic cycle as they are almost permanently resettled in urban peripheries, particularly around Khartoum where halve of IDPs exist. This in terms requires a new vision for urban planning that provide shelters and above all livelihood opportunities for IDPs. Ending hunger and achieving food security at the national level in Sudan can't be envisioned without ending the causes of internal displacement, namely conflicts and environmental degradation. Climate change conditions are beyond the control of the government, but there are needs to provide coping mechanisms to famers and pastoralists including insurance against harvest failure during unfavorable climatic changes, which often lead to production loss and food insecurity.

The findings are also of practical policy relevance to international humanitarian organizations concerned with food security in situations of prolonged conflicts and internal displacement. Such organizations need to secure sufficient fund for mass numbers of IDPs and other households who have been protracted to be critically food insecure. They also need to cooperate and coordinate well with central and local governments in accessing food insecure in conflict-ridden areas. The study adds to empirical-quantitative research in the field of environment, conflicts and internal displacement and overall security, where reliable results are derived with well known econometric methods and thus its findings can be generalized to other countries of similar condition, namely in the Horn of Africa where conflicts are persistent and climate changes have evident negative impacts on agriculture and food production. Food security among IDPs at the individual and household level needs special anthropometric-economic study, taking into account its variations to regional environmental and climate factors and conflicts differences.

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