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Article

Trends of Hunger and Food Insecurity over IGAD Region of Eastern Africa

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Abstract: Food security is interdisciplinary; therefore, multiple socioeconomic, climatic, and other environmental indicators must be considered in assessing hunger and food insecurity trends. We employed the Food and Agriculture Organization of the United Nations (FAO), which is a publicly accessible database known as FAOSTAT. Descriptive and analytical statistics were used to assess the trends in extreme events. Food security components, hunger, and food insecurity are the main objectives of this paper. The trends of protein supply, supply of protein of animal origin, and dietary energy supply adequacy show direct effects of drought that are driven by changes in rainfall onset, cessation, wet/dry days, and spells on food availability. Ethiopia, Kenya, Djibouti, and Uganda showed improvements in GDP as indicators of food access. Food utilization indicators showed improved water and sanitation services, an increase in obesity in adults, a decrease in the percentage of children overweight, and anemia among women. The number of people undernourished and the percentage of undernourishment, the number of moderately and severely food insecure people, and the percentage of people insecure increased in recent years, especially during the 2021–2022 drought. Although the percentage of undernourishment in Somalia fell from 60% in 2013 to 47% in 2022, the country is still recording the highest percentage in the IGAD region. The percentage of undernourishment

never came down below 20% over Kenya and Uganda, while Sudan recorded the lowest percentage of undernourishment(below 11%) since 2013. The findings of this study offer specific insights on the observed status of hunger and food insecurity; therefore, countries are required to invest heavily in food production, verities of income, food system infrastructure, and consumption.

Keywords: Food security, hunger, food insecurity, temporal patterns, IGAD region, East Africa

1. Introduction

The eight countries under intergovernmental Authority on Development (IGAD) of eastern Africa considered as one of countries in Africa continent vulnerable to climate change and Extreme events(IPCC, 2018). Change and variability in extreme rainfall and temperature is projected to adversely affect rain-fed food crops production in developing countries especially East Africa (Thornton,*et al,* 2010), because food production mostly depend on seasonal rainfall patterns, distribution and amount for a good harvest (Kahsay & Hansen, 2016), GDP, food sources and employment (Ochieng *et al*., 2016), protect the livelihoods of the poor (Tittonell *et al*., 2010) and to ensure food accessibility for most rural communities (Inder *et al.*, 2017). The key factors affecting food security are divided into climatic and non-climatic factors (Epule and Buyinza, 2018).

The climatic factors include extreme rainfall events (flash floods/drought) , cyclones, cold events, lightning, wind storms/dust storms and hailstorms/thunderstorms(Shikuku *et al.*, 2017). Non-climatic such as market prices, rising demand for food, crop production inputs, area under harvest, yields variability, increasing competition over land, input prices not affordable, soil degradation among others (Wossen *et al*., 2018), human disease such as HIV and AIDs that lower labor availability for food production, social unrests and conflicts, loss of transfers, deaths of household producer, high population density in a place, which increase demand for food, livelihoods of people identify the type of food needed, increase in urban population increase prices and competition on houses and services, slums compromise basic service and development in infrastructure, malfunctioning food markets, trade policies, regulations governing and high food prices, poverty and very weak institutional capacity to handle issues of food deficit , low access to basic services increased risk of sicknesses, food crop diseases and pests that negatively influence on food production and access to high quality of food consumed (Harris-Fry *et al.*, 2015).

Extreme rainfall has the potential to accelerate and intensify the levels of risks and number of people at risk of shortage of food and hunger especially small income families in sub-Saharan Africa (Krishnamurthy *et al.*, 2014). Extreme rainfall enhances land degradation through persistent droughts that affect vegetation growth or through frequent floods that wash away exposed soils through erosion leaving the land less productive, then food security is compromised (IPCC, 2017). Land degradation through persistent droughts lowers the productive capacity of the land to produce high quantities of food, reduced outputs in term of food crop yields or livestock yields (El Bilali *et al*., 2020). The concern over land degradation in the IGAD region is driven by the fact that most economies highly depend on agricultural production (both livestock and crop) for food security (Abera *et al*., 2018). This has led to degradation problem being experienced in rural areas due to poor agricultural practices and land-use systems (Abera *et al.*, 2018). It reflects the results of over-exploitation of land resources or inappropriate farming systems, which include continuous cultivation without adding supplements, agricultural intensification, overgrazing the land, poor seasonal land and soil management practices, continuous soil nutrient depletion through poor management, lack of soil and deforestation, and desertification (Abera *et al*., 2018). All these factors are negative on production and non-production components of food systems.

Food security is exposed to extremes in climate events, particularly changes in future daily rainfall characteristics could drive the recurrent of drought or floods in IGAD region (Mwangi *et al*., 2014). The 2011 East Africa drought caused horrible situations across several countries in the region and led to a widespread, scarcity of food and costly famine in the East Africa (Gebremeskel *et al*., 2019). The rainfall pattern is highly variable and unpredictable and this makes the region to be prone to recurrent severe dry or droughts which hinder crop and livestock production panning and activities (Kimaro & Chibinga, 2013) then effect on rain-fed food production systems and activities (Thornton *et al.*, 2010).

Designing sustainable food security interventions for the present and the future necessitates acquiring a tailored understanding of the trends in the three components of food security, hunger and food insecurity at the regional and national levels. The information is also helpful in creating place-based approaches that match the unique possibilities and difficulties of a specific part of the world. The development of long-term territorial-based agriculture and food security measures could benefit from a deeper understanding of the temporal component of hunger and food insecurity. This might lead to an improvement in the productivity of small-scale farming and, consequently, food security.

To the best of our knowledge, there are gaps in the literature covering regional comparisons of hunger and food insecurity trends. The majority of accessible research on food security, hunger, and food insecurity are at the national or sub-national level. These studies employed questionnaires to

measure household livelihood and coping mechanisms. As a result, the primary goal of this research is to add to the body of knowledge and fill the gaps mentioned above. The rest of the paper is structured as follows: Section 2 explains the materials and methods, Section 3 describes the results and discussions, and Section 4 concludes.

2. Data and Methods

2.1. Data

This study used a suite of Food Security Indicators (FSI) from Food and Agriculture Organization of the United Nations (FAO): FAOSTAT web portal (FAOSTAT) for datasets at countries levels. The FSI used to evaluate the status of food security and hunger and food insecurity, and how past and present change and variability in extreme Rainfall events contributed to food insecurity in East Africa. The indicators selected based on four food security components (food availability indicators, food accessibility indicators, food stability indicators, and food utilization indicators) at national and sub-national levels. The food security indicators filtered and most relevant indicators based on availability of data national level selected. The food Availability indicators are average protein supply, average supply of protein of animal origin and average dietary energy supply adequacy. The indictors selected for food access is Gross Domestic Product(GDP) per capita. The selected indicators for food utilization are Percentage of population using at least basic drinking water services and sanitation services, Percentage of child malnutrition represented as Percentage of children under 5 years of age who are stunted and overweight, Prevalence of anemia among women of reproductive age and prevalence of obesity in the adult population. The indicators selected for Hunger and food insecurity are number of people undernourished, prevalence of moderate or severe food insecurity in the total population, male adult and female adult population, number of people undernourished, prevalence of moderate or severe food insecurity in the total population, male adult and female adult population.

In addition, the High-resolution Satellite Rainfall Estimates (SRE) products selected for this study are Climate Hazards Group (CHG) Infrared Precipitation with in-situ station (CHIRPS) datasets from the University of California at Santa Barbara (UCSB) are used to calculate extremes rainfall events. The detailed information of this dataset, algorithm, major input datasets and processes found in Funk et al., (2015) used to calculate the extreme rainfall indicators, which play significant role in food security. The extremes rainfall indicators used are Precipitation Index(SPI) as meteorology drought indicator, early/late Rainfall Onset Dates(RODs), Rainfall cessation Dates(RCDs), Length of Rainy

Season(LRS), wet/dry days and spells computed at each eight countries in the IGAD region (Figure 1).

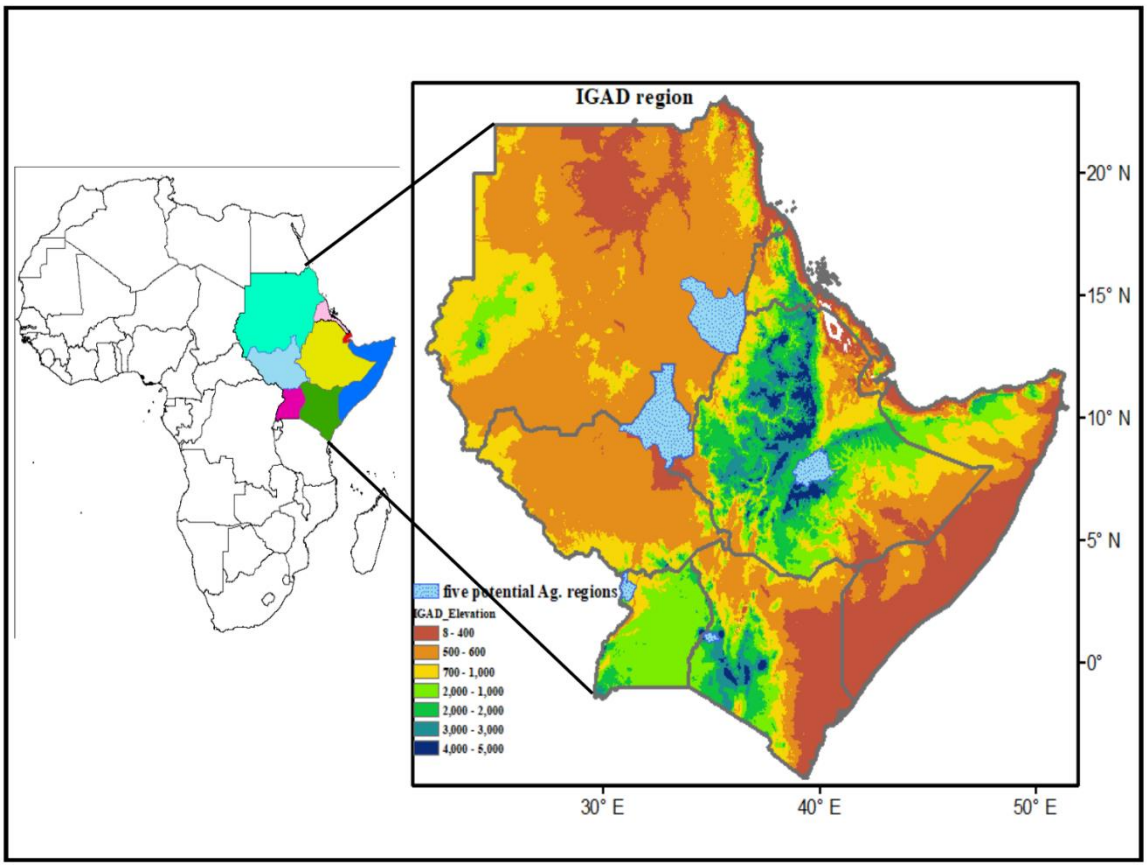

Figure 1: Eight IGAD countries member states, position in Africa continent, and five sub-regions (shaded in sky blue) are potential areas for agriculture and food security

2.2. Methods

2.2.1. Extremes rainfall events

We used the criteria and thresholds to compute the extreme rainfall events related to food security, hunger and food insecurity. These extremes are Drought Precipitation Index (SPI), early/late Rainfall Onset Dates(RODs), Rainfall cessation Dates(RCDs), Length of Rainy Season(LRS), wet/dry days and spells computed at each eight countries in the IGAD region. The full details and descriptions of criteria and thresholds used in calculating the RODs, RCDs and LRS found in study by Omay et al., (2022), while thresholds used in calculating the wet/dry days and spells found in study by Omay et al., (2023). Since some of food security indicators are the average of three years, the extreme rainfall anomalies of three years computed to facilitate the graphical presentation, relationship and comparison of the patterns of extreme rainfall events and food security indicators of eight IGAD countries. The

early/late onset dates, early/late Cessation dates, prolonged/shortened season length, more/fewer wet days/dry days, prolonged/shortened wet/dry spells, more/less rainfall intensity, increase/decrease in rainfall total, frequency and intensity of drought/floods are the extremes rainfall events examined if they are responsible for hunger and food insecurity over IGAD region.

2.2.2. The graphical statistical methods

The descriptive and analytical statistics were employed to compare the temporal patterns of food security components, hunger, and food insecurity. The descriptive statistical methods used to understand the trends, while analytical statistics employed to analyze the reason behind the changes in trends of food security components (availability, accessibility, utilization), hunger and food insecurity under current trend of extreme rainfall events. The histograms, box and scatter plots, pie, line and area bar chart are graphical statistical methods used to display trends and patterns of non-climatic factors linked to food security systems. The main purpose for displaying the trend graphically is to support a stated hypothesis of years with extra-ordinarily extreme wet or dry conditions if is linked to selected food availability, accessibility, utilizations and stability indictors.

3. Results and Discussion

3.1. Observed Extreme Rainfall Events Indicators over Eastern Africa

The standardized anomaly of rainfall intensity, onset dates, cessation dates, length of rainy season, wet/dry days, wet/dry spells, total rainfall and drought/flood signals analyzed at all 8 IGAD countries. The results for Sudan, Ethiopia and South Sudan, Somalia, Kenya, Uganda presented in Figure 2. It can be seen clearly, the drought events and years observed coincided with less rainfall intensity, delayed onset dates, early cessation, shortened season length, more dry days and prolonged dry spells. The floods events or years occurred as a result of more intense daily rainfall events, early onset dates, late or delayed cessation, long season length, more wet days, and prolonged wet spells. For example, the severe and devastated drought in 1983-1985, failed consecutive five rainy seasons of 2021, 2022 coincided with severe late onset, early cessation, less wet days, wet spells. The extra-ordinary floods in 1988 in Sudan, 1997, 2018,2019 and 2020 coincide with early onset, late cessation, more wet days and prolonged wet spells over most parts of countries especially Lake Victoria.

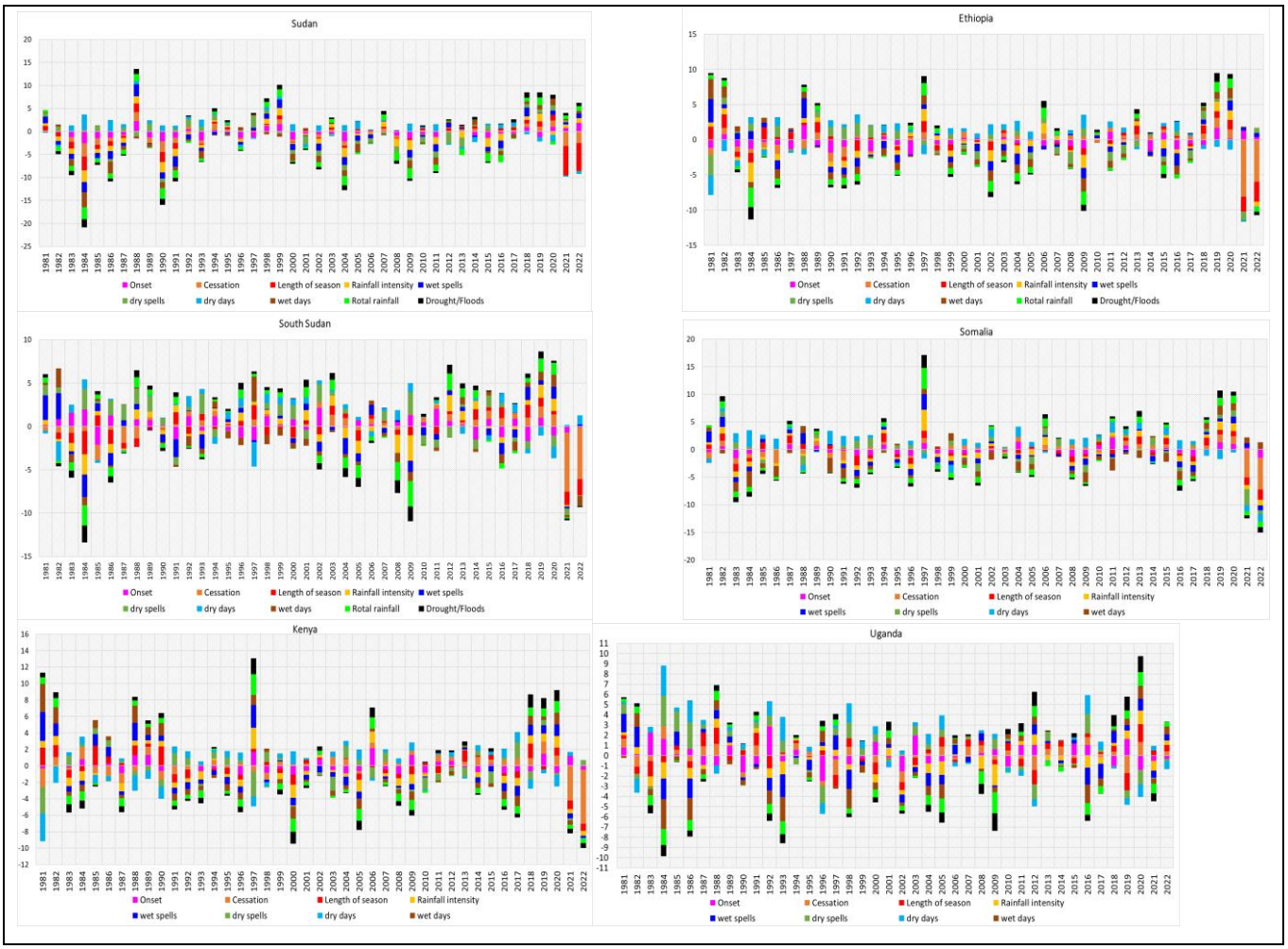

Figure 2: Temporal patterns of early/late onset dates, early/late Cessation dates, prolonged/shortened season length, more/fewer wet days/dry days, prolonged/shortened wet/dry spells, more/less rainfall intensity, increase/decrease in rainfall total, frequency and intensity of drought/floods over IGAD region

3.2. Temporal Patterns of Three Components of Food Security

The three components of food security examined in this sub-section are food availability, food accessibility and food utilization. The indicators selected to assess the temporal patterns of food availability presented in Figure 3, while Figure 4 and 5 show the patterns of food utilization respectively. Food Accessibility is one of the most important food security components; it is achieved mainly through production. In Figure 3a,b,c, we present the average protein supply. Supply of protein of animal origin, dietary energy supply adequacy and value of food production as one of the four indicators to assess level of food availability in the IGAD region. In general, all countries recorded significant improvement in protein supply in recent years. The results show the impacts of drought and Floods on protein supply are not a direct relationship. Although the severe drought signal in 2021-2022, the protein supply trend kept increasing as evidence of role played by other non-climatic factors

(Figure 3a). Starting from 2014, Sudan, Ethiopia, Uganda and Kenya recorded increase in protein supply as positive aspects of food availability polices. Djibouti, where food availability relies on food imported didn't recorded any improvement in protein supply. The supply of protein of animal origin in Uganda and Kenya were very low between 2000-2005, increased between 2006 and 2010, then declined again due to 2011. Ethiopia and Djibouti recorded low supply of protein of animal origin in recent years. The trend of supply of protein of animal origin shows the impacts of drought on livestock in the region. For example, 2021-2022 drought, Kenya, Ethiopia and Somalia lost big number of livestock's, this reflected in decline in protein of animal origin in 2021-2022(Figure 3b). The supply of protein of animal and non-animal origin very important indicator of food availability in any country. A study in Kenya show adoption of stress-tolerant different types of a variety of crops enhanced household dietary diversity rating by 40% and minimized food deficiency by 75%, enhanced and resilient breeds of cattle and sheep improved families dietary diversity by 38% and lowered food deficiency by 90%, according to a study conducted by (Radeny et al., 2022). Since 2000, the average of dietary signal for Kenya from 2013, with a yearly average of per person per day over Somalia and Ethiopia and Kenya are below average, however the trend kept improving yearly, with positive signal from 2013 for Kenya, yearly average of 2020-2022 for Somalia. Uganda kept positive signal of dietary energy supply over all the years. Although, impacts of drought in 2021-2022, the dietary energy supply improved over Sudan, Djibouti, Somalia and Ethiopia (Figure 3c). This mean number of calories from foods available has improved over time. This could be as result of better balance between commodities being produced locally, imported from and exported to other nation.

Food access is the second pillar of food security in any country that may be influenced by food shortages and sustainable infrastructures. Figure 4 illustrates the Gross Domestic Product (GDP) per capita as an indicator of food accessibility. GDP per capita calculated on the basis of purchasing power parity (PPP). Gross domestic product adjusted to international dollars using purchasing power parity rates is referred to as PPP GDP. The results demonstrate the importance of economic and political stability, effective leadership, and the absence of violence and natural disasters in GDP growth. Sudan recorded decrease in GDP since 2018 to present days due to political instability. Kenya, Ethiopia, Uganda and Djibouti recorded improvement in GDP year by year. It is obvious that COVID-19 in 2020 in Kenya compare to other countries exacerbated and pushed down the GDP, limit food accessibility through the market, and have an influence on daily individual income, and cause various changes in country priorities. It is obvious that GDP stability might enhance the density of rail lines and transportation networks, which play an important role in delivering food from regions and producing areas throughout the country with less effort and expense, which would reflect on food costs. The GDP trend among countries since 2019 demonstrates that the East Africa has tremendous

chances to expand GDP and advance the development agenda. This may be accomplished by investing in accessible resources such as human resources in rural and urban areas, arable and agricultural lands, crop yields, balanced commodity consumption policies, and food supply through local markets.

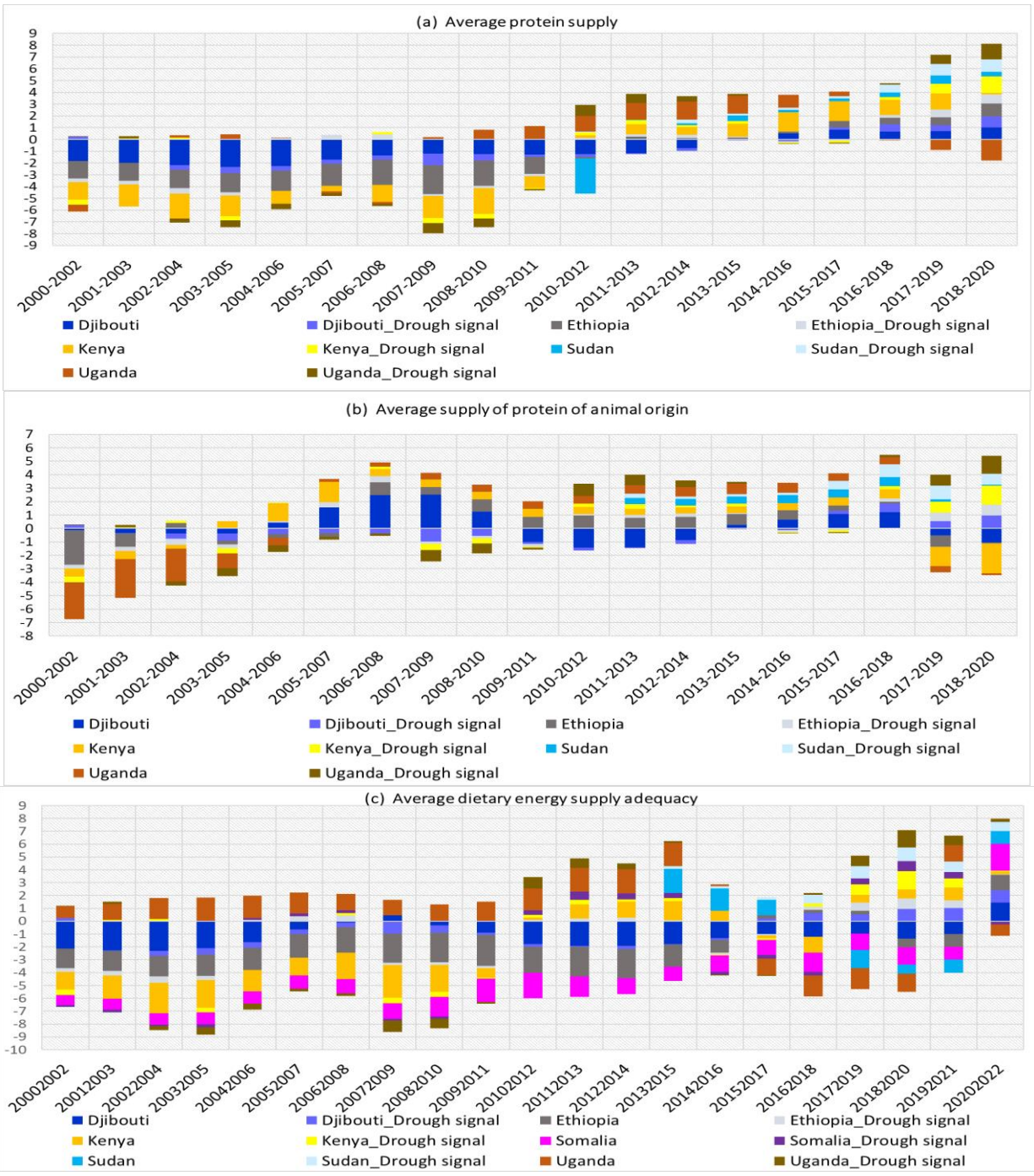

Figure 3: Line chart showing the average protein supply, average supply of protein of animal origin and average dietary energy supply adequacy. Data sources: Author Processed row data from FAOSTAT database

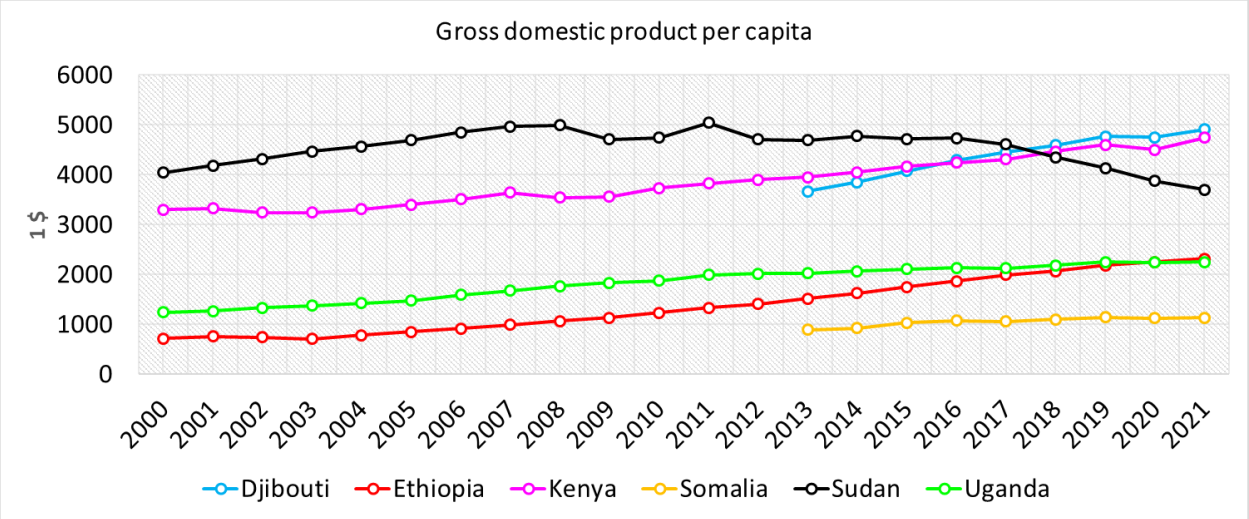

Figure 4: Gross domestic product per capita, based on purchasing power parity (PPP) and (Data are in constant 2011 international dollars). Data sources: Author Processed row data from FAOSTAT database

The Percentage of population using at least basic drinking water services and sanitation services, Percentage of child malnutrition, Prevalence of anemia among women of reproductive age and Prevalence of obesity in the adult population are indicator used to assess the food utilization. Figure 5 presents the population utilizing at least basic drinking water services and sanitation services. The results show, except South Sudan, other countries recorded improvement in basic drinking water services utilization. Djibouti and South Sudan was the two nations in the region that did not perform well in terms of basic drinking water services (Figure 5a). Ethiopia recorded lowest in sanitation services, this may be driven by large number of rural populations compared to those in urban (Figure 5b).

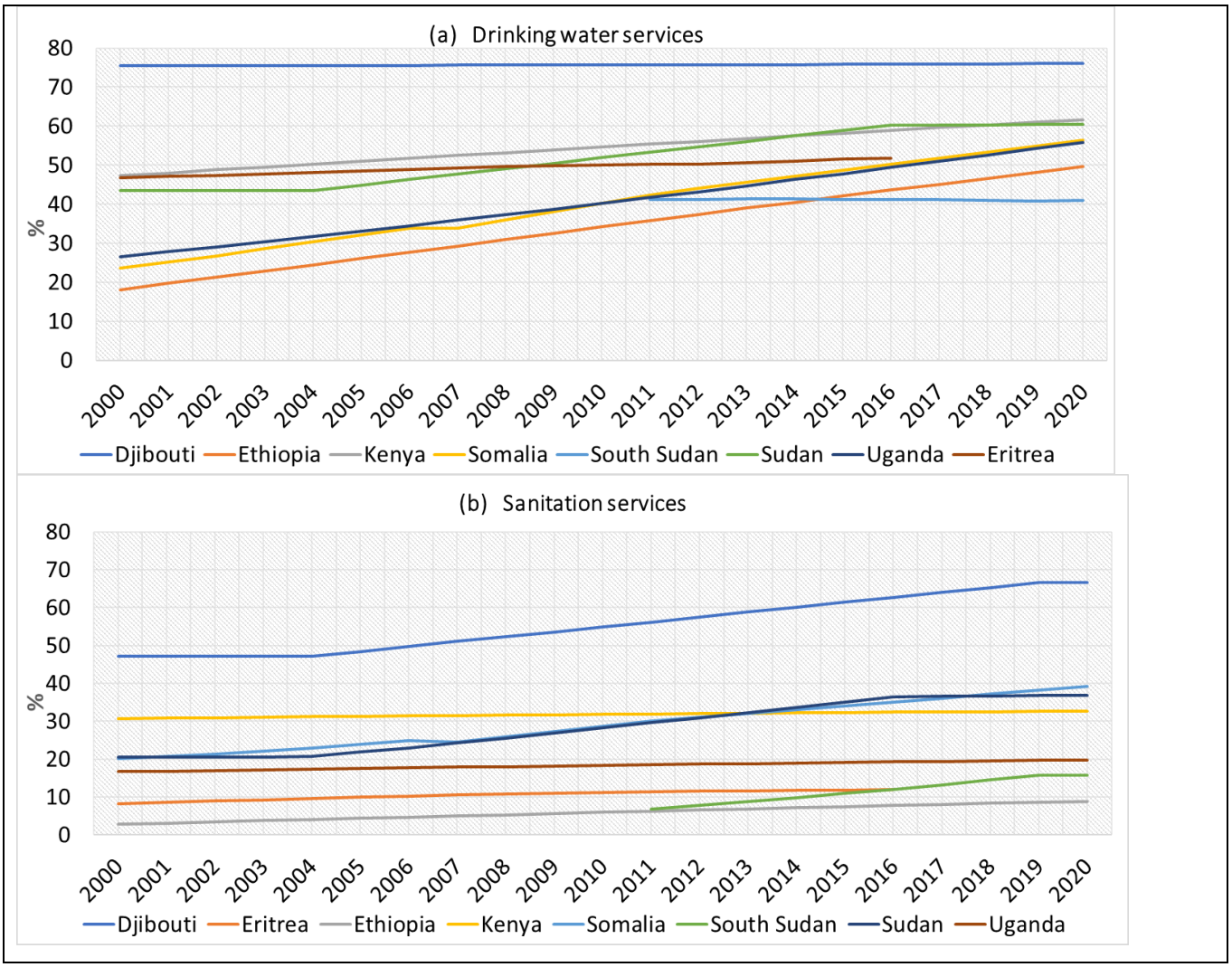

Figure 5: Percentage of population using at least basic drinking water services and sanitation services. (Data sources: Author Processed row data from FAOSTAT database)

The proportion of child malnutrition is the second indicator used to assess food utilization. This was demonstrated in terms of stunted and overweight children under the age of five. As is customary, children are more vulnerable to both climatic and non-climatic disturbances. However, our findings in Figure 6 demonstrate a drop in the percentage of stunted children (Figure 6a) and a decrease in the percentage of overweight children. This might be linked to improvement in other services such as primary health care and routine children vaccinations. This conclusion shows that climate has no direct influence on malnutrition. Even during the 2021-2022 drought and failed five consecutive rainy seasons in the Horn of Africa, the percentage of stunted children still on decrease (Figure 6b). In a study conducted in Uganda, Amondo et al., (2023) found that both boys and girls proportions of stunting were associated with nutrient deficiencies, and that various coping and strategies for adaptation greatly influenced rural family's capacity to protect children's health and well-being from the effects of extreme weather.

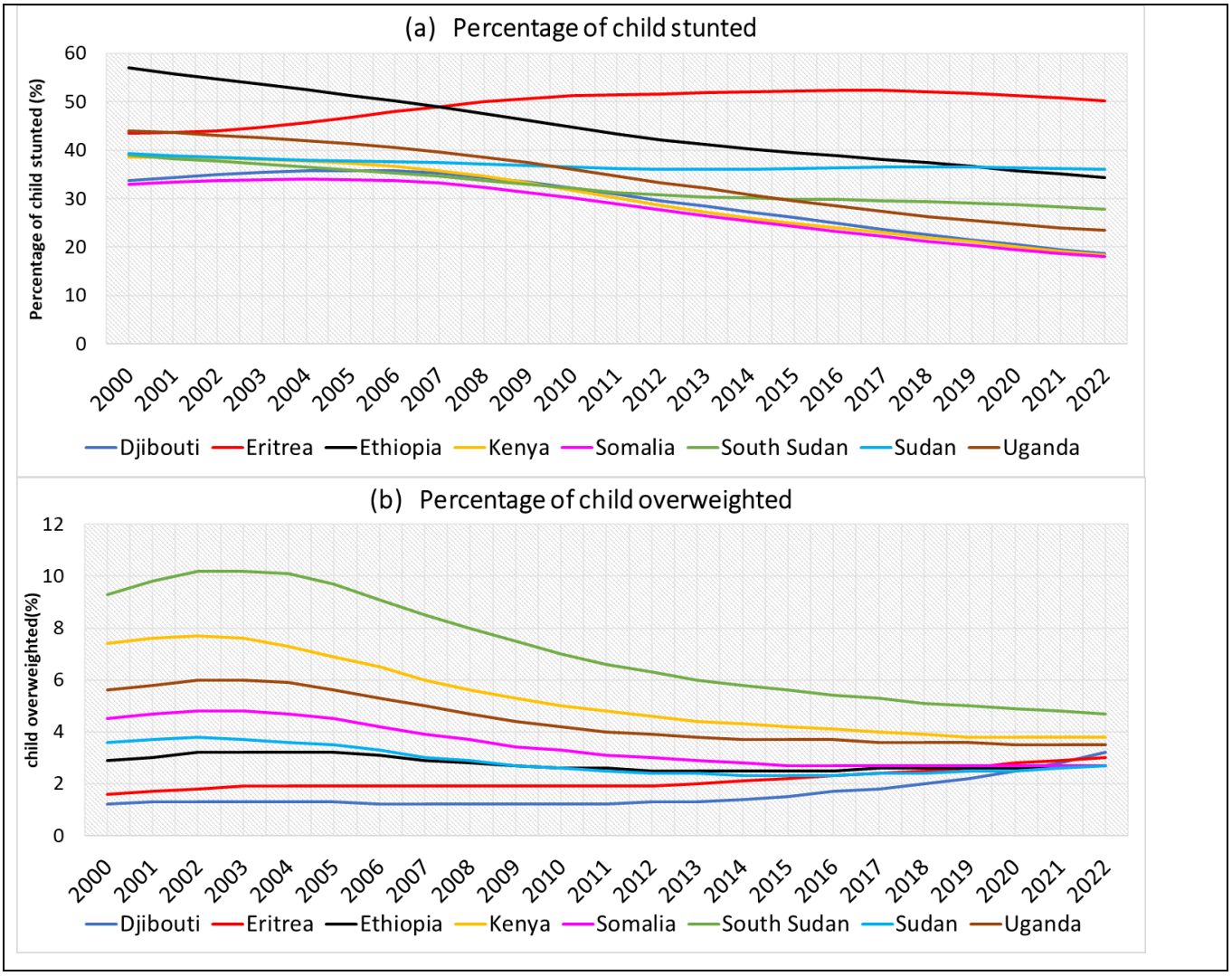

Figure 6: Percentage of child malnutrition represented as Percentage of children under 5 years of age who are stunted and overweight. (Data sources: Author Processed row data from FAOSTAT database)

Figure 7 illustrates the percentage of cases of anemia among reproductive-age women and the prevalence of obesity in the adult population. Anemia among women of reproductive age is reduced in the majority of the region (Figure 7a). Ethiopia had the lowest anemia rate, while Somalia had the highest among women of reproductive age (15-49). All countries had an increase in adult obesity, with Ethiopia having the lowest proportion and Djibouti having the highest (Figure 7b). Again, extreme rainfall events had no direct influence on the frequency of anemia in women of reproductive age or obesity in the adult population. It appears that GDP growth recoded by majority of countries improved livelihood, life style and general services reflected positively on food utilization.

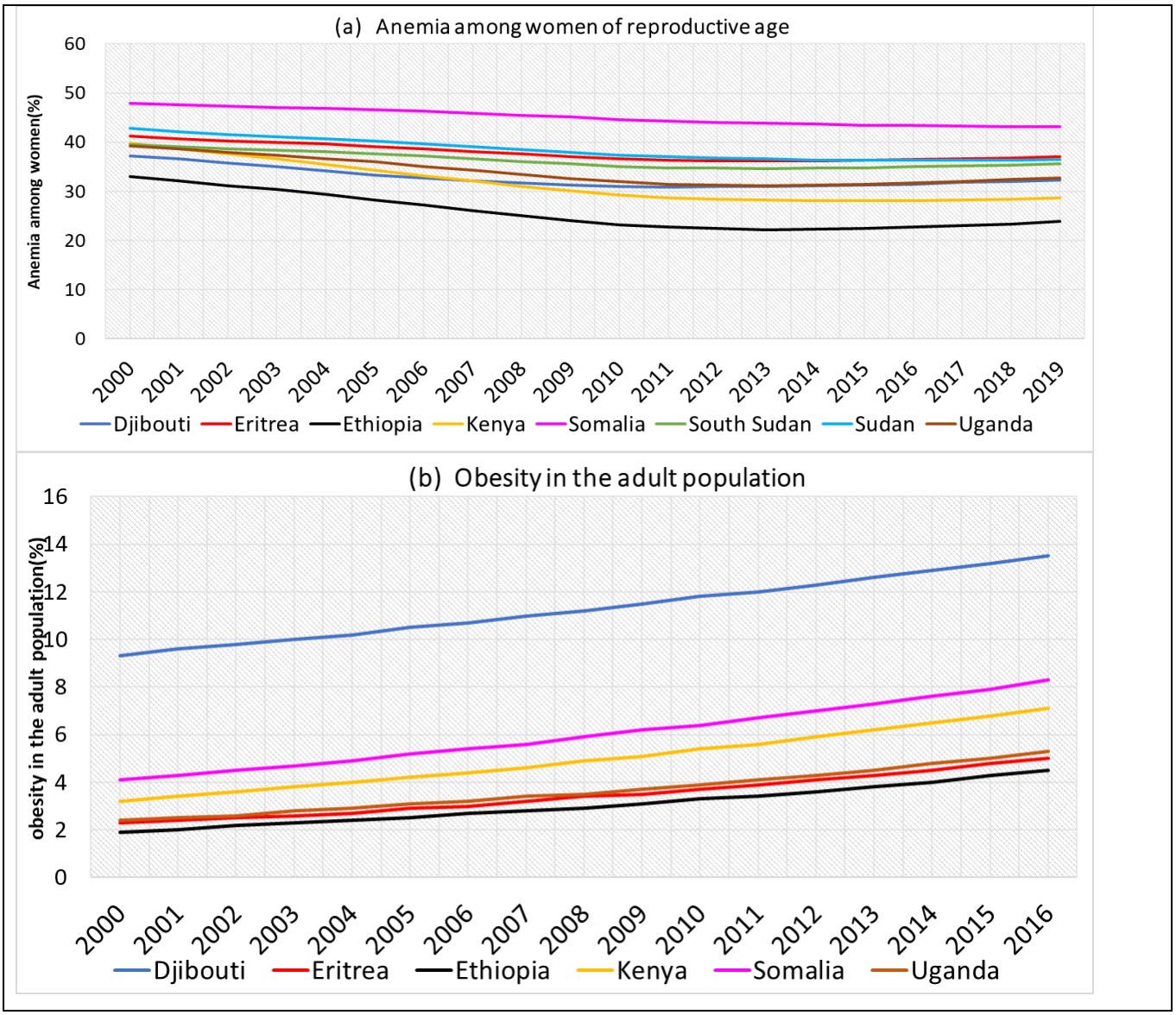

Figure 7: Prevalence of anemia among women of reproductive age and prevalence of obesity in the adult population. (Data sources: Author Processed row data from FAOSTAT database)

3.3. Temporal Patterns of Hunger and Food Insecurity

The patterns of hunger and food insecurity in the IGAD region have been shown in Figures 8 and 9. The indicators used are number of people undernourished, prevalence of moderate or severe food insecurity in the total population, male adult and female adult population. Also, Prevalence of undernourishment and number of moderately or severely food insecure people. According to the results, extreme rainfall events, particularly drought and floods, have a substantial effect in an increase or decrease in the number of persons experiencing acute hunger and food insecurity. It is obvious that the number of undernourished persons increased/decreased in years with unusually high rainfall (Figure 8a). Furthermore, it is clearly evident that hunger and food insecurity are caused by climatic

and non-climatic factors. For example, while rainfall was above average in 2018-2020, the impact of COVID-19 restrictions and other measures increased the number of individuals who were undernourished. Drought has pushed up the number of undernourished persons in all IGAD nations from October 2020 to 2022. The trends of undernutrition in Sudan from 2002 to 2014 explained the impact of economic and political stability in reducing undernutrition. In contrast, the number has risen from 2012 to the present owing to the effects of oil revenue after South Sudan's independence from Sudan. Somalia has the greatest percentage (%) of undernourishment prevalence in the region (Figure 8b). This condition arose as a result of fewer agricultural area, lower yield, insecurity, and the type of imbalanced commodities produced, imported, and exported. Although there is no data for South Sudan or Djibouti, the frequency of undernourishment in the region ranked at countries level from higher to lower in Uganda, Kenya, Ethiopia, Sudan and Djibouti as lower. The number in Uganda and Kenya has increased during 2016 compared to previous years. During the drought, climatic signals and COVID-19 metrics increased the prevalence of malnutrition in Kenya during period of 2020-2022.

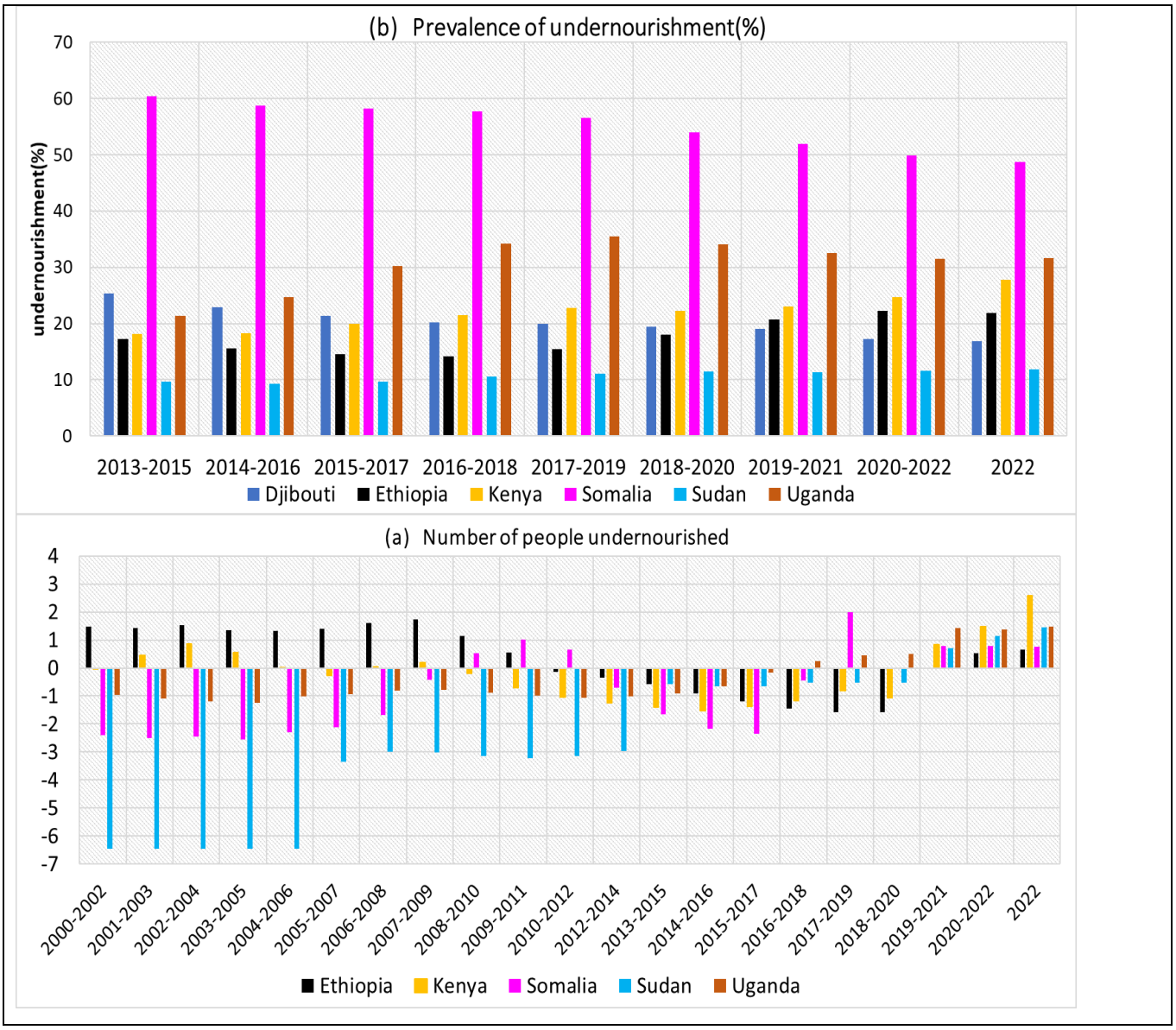

Figure 8: Showing number of people undernourished, prevalence of moderate or severe food insecurity in the total population, male adult and female adult population. (Data sources: Author Processed row data from FAOSTAT database)

Figure 9 demonstrates the total number of persons (male and female) who are moderately or severely food insecure. The years of extreme drought (2021-2022) and flood signals (2018-2020) saw the highest percentage of male and female moderately or severely food insecure people. The number of persons that are food insecure varies by nation and is determined by the entire population of the country. Ethiopia has a larger proportion of food insecure individuals than other nations in the area. Ethiopia, Kenya, Uganda, Sudan, and South Sudan have never had populations below 16, 6, 7, 9, and 2.7 million in the previous 10 years (Figure 9a). In Kenya, females outnumber males in terms of food insecurity. Food insecurity has lately grown across all nations. In comparison to the average from 2014 to 2022, the number of male and female food insecure in the majority of countries in the region has

never decreased since 2018. Whether there is good rainfall or not, the trend has been upward, owing to the effects of non-climatic variables such as economic and political stability. The total number of people (male and female) moderately or severely food insecure presented in Figure 9b. The years of server drought (2021-2022) and floods signals (2018-2020) recorded highest number of male and female moderately or severely food insecure. The variation in number of people food insecure people among countries depend on total population of country. The Ethiopia as country with highest population in the region, the number of food insecure people higher compare to other countries. In last ten years, Ethiopia, Kenya, Uganda, Sudan and South Sudan never came below 16, 6,7,9 and 2.7 million respectively. Number of females facing food insecurity are high than male in Kenya. The number of food insecure has increased recently across all countries. Compare to average of 2014-2022, the number of male and female since 2018 for most countries in the region never witness decrease in number of food insecure.

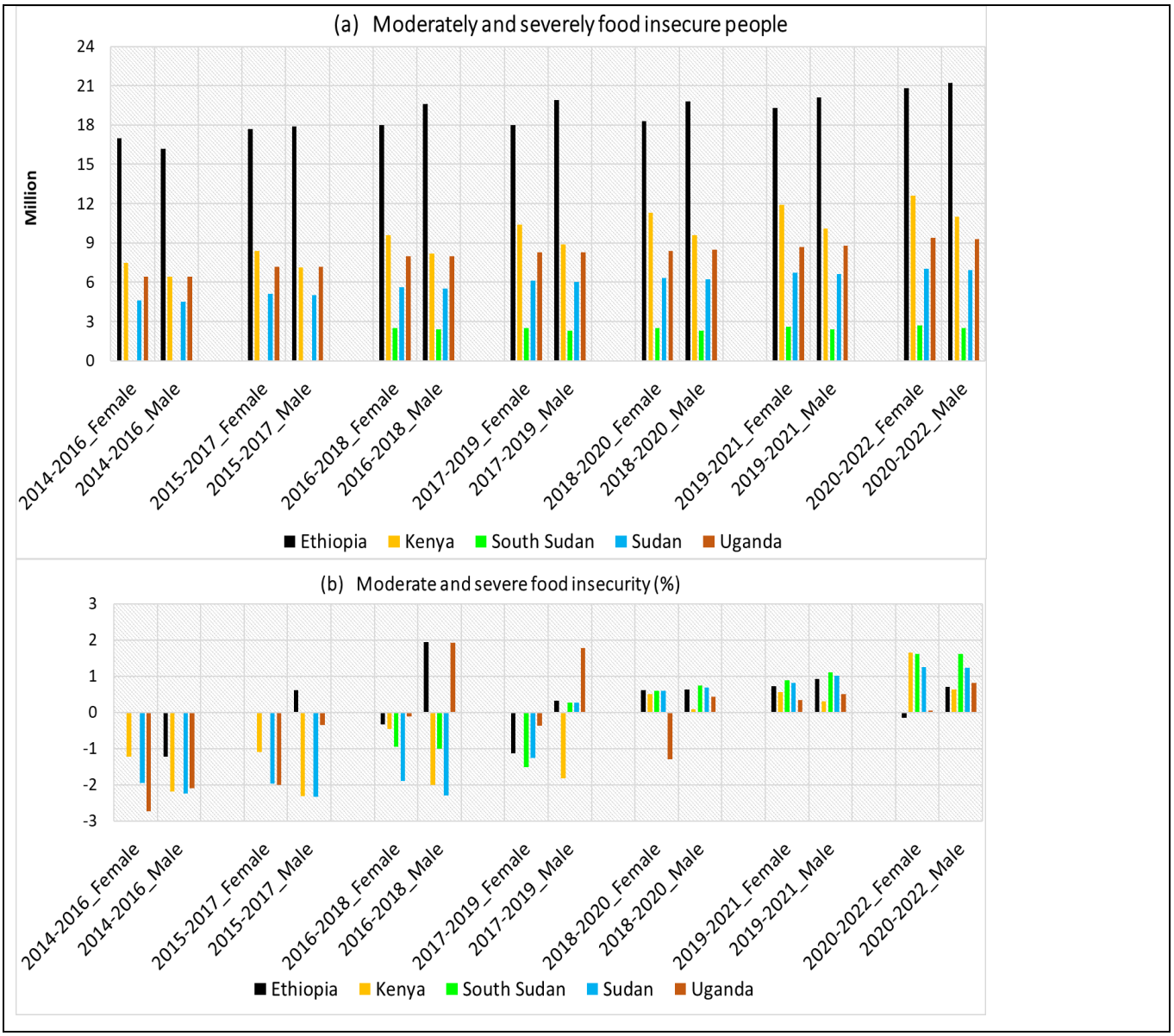

Figure 9: Showing number of people undernourished, prevalence of moderate or severe food insecurity in the total population, male adult and female adult population and number of moderately or severely food insecure people. (Data sources: Author Processed row data from FAOSTAT database)

4. Conclusions

In the IGAD region of eastern Africa, the years with late onset, early cessation were shortened length of the rainy season, more dry days and prolonged consecutive dry spells coincided with hunger and food insecurity. The early onset, late cessation, prolonged length of the rainy season, wet days and wet spells coincided with improved food production and food security indicators. The reduction of protein supply, supply of protein of animal origin, and dietary energy supply adequacy in 2021–2022 over Ethiopia, Somalia, Uganda, and Kenya showed a negative impact of drought on food production.

The improvement in GDP over Ethiopia, Kenya, and Djibouti contributed to improvements in food accessibility. The food utilization indicators analyzed showed over time improved drinking water and sanitation services, a reduction in the percentage of child malnutrition and anemia among women of reproductive age, and an increased number of obesities in the adult population. The increase (reduction) in the number of people undernourished and the percentage of undernourishment, the number of moderately and severely food insecure people, and the percentage of people insecure increased in recent years coincided with a recurrent drought (floods). The late onset dates and early cessation of rain, the short rainy season, increased dry days, dry spells, and less rainfall intensity in 2021–2022 are the main drivers of the increase in the percentage of people experiencing undernourishment, hunger, and food insecurity. The findings of this study showed that if countries invest heavily in food production inputs and sources of income, the GDP trend will keep rising, hunger and food insecurity will be issues of the past, and a zero hunger and sustainable development agenda of 2030 will be achieved.

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Declarations: I declare that this paper is my original work and has not been submitted elsewhere for publication. Where other people's work, or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.

Conflict of interest: All authors declare no competing interests

Consent to participate: All authors consent to participate

Consent for publication: All authors consent to publish this work

Data Availability: The secondary datasets generated during analysis are available via request. The primary data are open access from FAOSTAT

Code availability: We used Climate Data Operators (CDO), R-Packages and Climate Data Tool (CDT) codes

Author contribution: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Paulino Omoj. Omay. The first draft of the manuscript was written by Paulino Omoj Omay supervised by Nzioka J. Muthama, Christopher Oludhe and Josiah M. Kinama. The Final manuscript version was reviewed by Guleid Artan and Zachary Atheru. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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