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Prevalence of undernourishment: trend and contribution of East African countries to sub-Saharan Africa from 1991 to 2015

Kedir Hussein Abegaz*

Abstract

Background: Sustainable development goal of target 2.1 is about to end hunger and ensure access by all people to safe, nutritious and sufficient food all year round by 2030. But, still malnutrition affects around one in three people on the planet and the vast majority of these hungry people live in lower-middle-income regions including East African countries. Thus, this study aimed to compare the trend of selected East African countries based on prevalence of undernourishment and to identify their contribution to the sub-Saharan Africa prevalence.

Methods: The yearly prevalence of undernourishment data of sub-Saharan Africa and East African countries from 1991 to 2015 was retrieved from World Bank and Knoema report. In the time series analysis, line graph was used to picture and compare the trend, and augmented Dickey–Fuller unit root test was used to check the stationarity of the data. Again, Johansen cointegration tests (trace and max-Eigen statistic) and linear regression were used to ascertain the long-run relationship between the variables and to examine the contribution of East African country to sub-Saharan prevalence, respectively.

Results: The trend confirms that the prevalence of undernourishment was falling from 33.73% in 1991 to 20.15% in 2015 in sub-Saharan Africa, from 74.81% in 1991 to 28.8% in 2015 in Ethiopia, and from 32.4% in 1991 to 19.1% in 2015 in Kenya, respectively. Both trace and max-Eigen statistic show that the test values (14.55 and 12.15) were less than the critical values (15.41 and 14.07), respectively, and the adjusted R^2 in the linear regression was 0.39.

Conclusion: The prevalence of undernourishment of SSA, Ethiopia and Kenya falls gradually from 1991 to 2015, and Kenya's prevalence is lower than the prevalence of the region sub-Saharan Africa, but Ethiopia's prevalence is still higher than the region. More than one-third of prevalence of undernourishment of sub-Saharan Africa was contributed from Ethiopia and Kenya, which had a long-run relationship with sub-Saharan Africa. Finally, this study recommends to the government of Ethiopia and Kenya to continue to tackle the main reasons for the high prevalence of undernourishment: climate change, poverty, and food and agricultural policy.

Keywords: East Africa, Ethiopia, Kenya, PoU, Time series, Undernourishment

*Correspondence: kedir6300@gmail.com
Biostatistics and Health Informatics, Public Health Department, Goba Referral Hospital, Madda Walabu University, Bale Goba, Ethiopia

Background

> *By 2030, end hunger and ensure access by all people, in particular, the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round*
>
> *Sustainable development goal (SDG): Target 2.1*

About 815 million (10.7%) of the 7.6 billion people in the world were suffering from chronic undernourishment in 2016 and malnutrition affects around one in three people on the planet [7, 12]. SDG indicator 2.1.1: prevalence of undernourishment (PoU) is an estimate of the proportion of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life [8, 12]. This indicator is expressed as a percentage and it will measure progress toward SDG Target 2.1.

The vast majority of hungry people live in lower-middle-income regions, which saw a 42% reduction in the prevalence of undernourished people between 1990 and 2014. Despite this progress, in 2016, the global prevalence of undernourishment has been rising [7].

In addition to agenda of 2030 in the world, the 2014 Malabo commitment calls for ending hunger and reducing stunting to below 10% and underweight to below 5% by 2025. This agenda shows, in Africa, food security and nutrition constitute an essential focus of the continent's development [2, 8].

Despite the Malabo agenda, Africa has the highest prevalence of undernourishment. Of which, in sub-Saharan Africa, the prevalence of undernourishment appears to have risen from 20.8 to 22.7% between 2015 and 2016, and the number of people undernourished increased from 200 to 224 million, accounting for 25% of the 815 million people undernourished in the world in 2016 [8]. At the same time, the proportion of the population that has experienced severe food insecurity because of their inability to access food has risen in the region [1, 7, 8].

In the selected East African countries, the prevalence of undernourishment is still significantly higher when compared with the sub-Saharan African countries prevalence of 20.8% except for Djibouti. According to the World Bank report of PoU [15] in 2015 in Ethiopia, Kenya, Rwanda, Uganda and Tanzania, the prevalence was 28.8, 19.1, 41.1, 39 and 32.3%, respectively.

The main reasons for the world countries remaining high in the prevalence of undernourishment are poverty [13], conflict [3, 7], climate change and the degradation of the environment [3–5, 7, 9], political insatiability [9], and food and agricultural policy [6, 7]. More specifically,

1. *Poverty* As of 2013, about 767 million people are living below the international poverty line of less than $1.90 per person per day [13]. All East African countries are in poverty; more specifically Ethiopia has a very large food insecure area due to poverty [11, 12, 14].
2. *Conflict* More than half (489 million) of the 815 million hungry people in the world live in countries affected by conflict and in 2016, the average prevalence of undernourishment in countries undergoing conflict was about four percentage points greater than the prevalence in nonconflict countries [7]. South Sudan and Somalia are among victim countries found in East Africa.
3. *Political instability* In countries facing political instability, the resulting decline of the economy reduces the value of the country's currency, leading to higher food prices and less nutritious food available for purchase [9].
4. *Food and agricultural policy* A lack of adoption of more productive technologies for agriculture in lower-middle-income countries contribute to large differences in the number of crops produced when compared with upper-income countries [6, 8].
5. *Climate change* Throughout the previous 30 years, natural disasters have become increasingly common [8]. Unstable weather patterns can lead to drought—in 2016, El Niño was responsible for conditions of severe food insecurity for 20 million people [9]. Ethiopia and Kenya are among victim countries found in East Africa; this is according to the FAO report [8].

This study had an aim to compare the trend of the selected East African countries based on PoU, to ascertain the long-run relationship between the PoU of SSA and selected countries, and to identify the contribution of these countries to the PoU of sub-Saharan Africa.

Methods

Data source

The data source for this study was the World Bank report on the prevalence of undernourishment [12, 15]. The data contained the prevalence of all countries of the world from 1991 to 2015. For this study, I have selected the SSA, Ethiopia, Kenya, Rwanda, Uganda and Tanzania separately as a variable.

Data analysis

Line graph was used to display and compare the trend of PoU of selected countries with the world's and SSA's PoU in the specified time period. To identify whether there is long-term equilibrium relationship between SSA

and selected countries PoU, the first step was to plot the countries PoU data and examine its stationarity behavior. However, this examination of plots suggests that either the given variables are stationary or not. But, still, it is impossible to say conclusively about the stationary characteristics of these series based on plots. Therefore, I have used statistical method to test the stationary character, called augmented Dickey–Fuller (ADF) unit root test having a model, as follows;

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t;$$

where y_t is variable of interest (countries), t is a time index, Δ is the first difference operator, β is a coefficient, α is a constant, ε is error term, and γ is a hypothesis value of $\gamma = 0$ versus $\gamma < 0$.

The unit root problem was identified at the level, I took the first difference of time series for each variable and test the unit root again, still some of the variables were non stationary, and I took second and third differences finally, when all the variables are stationary, I have checked for long-run relationship using Johansen [10] multivariate cointegration test.

Johansen multivariate cointegration tests

Johansen [10] suggested two tests for H_0: At most k CI vectors: the *trace test* and the *maximal Eigenvalue test*. Both tests are based on the λ's from $|\lambda I - S_{11}^{-1/2} S_{10} S S_{00}^{-1} S_{01} S_{11}^{-1/2}| = 0$. They are LR tests and a multivariate version of Dickey–Fuller unit root distribution so they do not have the usual χ^2 asymptotic distribution under H_0.

The trace statistic $\mathrm{LR}_{\mathrm{trace}}(k) = -2 \ln \Lambda = -T \sum_{i-k+1}^{m} \ln(1 - \hat{\lambda}_i)$ where k is rank of integration of the countries PoU with the SSA PoU and $\hat{\lambda}_i$ denotes the descending order Eigenvalues $\hat{\lambda}_i = \hat{\lambda}_1 > \cdots > \hat{\lambda}_m > 0$ of $|\lambda S_{11} - S_{10} S_{00}^{-1} S_{01}| = 0$.

Note The $\mathrm{LR}_{\mathrm{trace}}$ statistic is expected to be close to zero if there are at most k (linearly independent) cointegrating vectors.

- If $\mathrm{LR}_{\mathrm{trace}}(k) > \mathrm{CV}$(for rank k), then H_0 (CI rank $= k$) is rejected
- If $\mathrm{Rank}(\Pi) = k_0$, then $\hat{\lambda}_{k_0+1}, \ldots, \hat{\lambda}_m$ should all be close to 0. The $\mathrm{LR}_{\mathrm{trace}}(k_0)$ should be small since $\ln(1 - \hat{\lambda}_i) \approx 0$ for $i > k_0$.

An alternative LR statistic, given by: $\mathrm{LR}_{\max}(k) = -2 \ln \Lambda = -T \ln(1 - \hat{\lambda}_{k+1})$. It is called the maximal eigenvalue statistic. It examines the null hypothesis of k cointegrating vectors versus the alternative $k+1$ CI vectors. That is, H_0: CI rank $= k$, versus H_1: CI rank $= k+1$.

Finally, this study empirically examines the contribution of PoU of each country, in the group and separately for the sub-Saharan African PoU using the time series regression with ordinary least square (OLS) estimation approach. For robustness reason, least absolute deviation (LAD), S-estimation methods were employed.

The linear regression model is also given by: $Y_i = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + \varepsilon_i$ where α is constant, β_i s are coefficients and ε_i are error terms. All the data were presented and analyzed using time series analysis approach and STATA-14 was the package.

Results and discussion

The trend of PoU of SSA and the selected countries are displayed in Fig. 1. The PoU of SSA fell gradually from 33.73% in 1991 to 20.15% in 2015 and similarly, PoU of Ethiopia fell significantly from 74.8% in 1991 to 28.8% in 2015. This shows that the PoU of both SSA and Ethiopia had a straight falling from 1991 to 2015. In a different direction, the PoU of Kenya was 32.4% in 1991 then increased slightly to 37.8% in 1994, and then fall gradually to 19.1% in 2015. The same to Kenya's PoU, the PoU of Rwanda was 55.6% in 1991 then increased significantly to 66.4% in 1998, and then decreased gradually to 41.1% in 2015. Similarly, the PoU of Tanzania was 24.2% in 1991 then increased gradually to 37% in 2003, and then fall slightly to 32.3% in 2015. Differently, the PoU of Uganda was 23.2% in 1991, it increased slightly to 30% in 1998, then fell to 24.3% in 2006 and then increased significantly to 39% in 2015.

Table 1 presents the summary statistic of the PoU of the countries and SSA. The summary statistics showed that the average PoU of SSA from 1991 to 2015 was 25.36% with the lowest prevalence of 19.29% in 2011 and the highest prevalence of 33.73% in 1992. Similarly, the average PoU of Ethiopia, Kenya, Rwanda, Uganda and Tanzania from 1991 to 2015 was 48.96, 29.39,

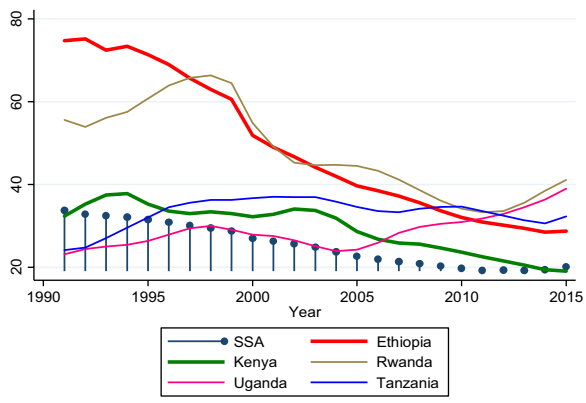

Fig. 1 Trend of PoU of countries from 1991 to 2015

Table 1 Summary statistics of PoU in SSA countries

Countries	Mean (SD)	Minimum PoU	Maximum PoU
SSA	25.36 (5.13)	19.29	33.73
Ethiopia	48.96 (17.1)	28.5	75.2
Kenya	29.39 (5.85)	19.1	37.8
Rwanda	48.14 (10.97)	33.3	66.4
Uganda	28.66 (4.01)	23.2	39
Tanzania	33.18 (3.61)	24.3	37.1

48.14, 2.66 and 33.18%, respectively. This result shows the average PoU of all countries is above the average PoU of their region SSA.

Figure 2 displays the trend of countries separately and their stationarity behavior. The PoU of SSA and all countries were nonstationary at the level, it became stationary after they are smoothened by differencing method, at first difference the PoU of SSA, Ethiopia and Kenya became stationary. The PoU of Tanzania was stationary at the level, and the PoU of Uganda became stationary at the second difference.

The ADF test results are presented in Table 2 to confirm the stationarity of the PoU of the countries and SSA in Fig. 2. The results showed that all the variables were nonstationary (unit root) at the level except Tanzania's PoU, and became stationary (no unit root) at the first difference (SSA, Ethiopia and Kenya), in the second difference (Rwanda), and in the third difference (Uganda). This means that the PoU of SSA, Ethiopia and Kenya has the same order of integration, which is $I(1)$. This result, therefore, suggests that there might be a cointegration relationship among these countries and SSA in the long run. Accordingly, this study has applied Johansen multivariate cointegration tests and the findings of this test are reported in Table 3.

The findings from Johansen tests of both trace and max-Eigen statistic show that the test values (14.55 and 12.15) were less than the critical values (15.41 and 14.07), respectively. This result shows that there was a significant cointegration relationship between the PoU of SSA, Ethiopia and Kenya, meaning that the PoU of Ethiopia and Kenya have a long-run relationship with the PoU of SSA. Based on this finding, this study has applied a time series regression to identify the contribution of Ethiopia's and Kenya's PoU to the SSA's PoU in Table 4. Based on this result, the adjusted R^2 is 0.39, this means that 39% of PoU of SSA has explained by the PoU of Ethiopia and

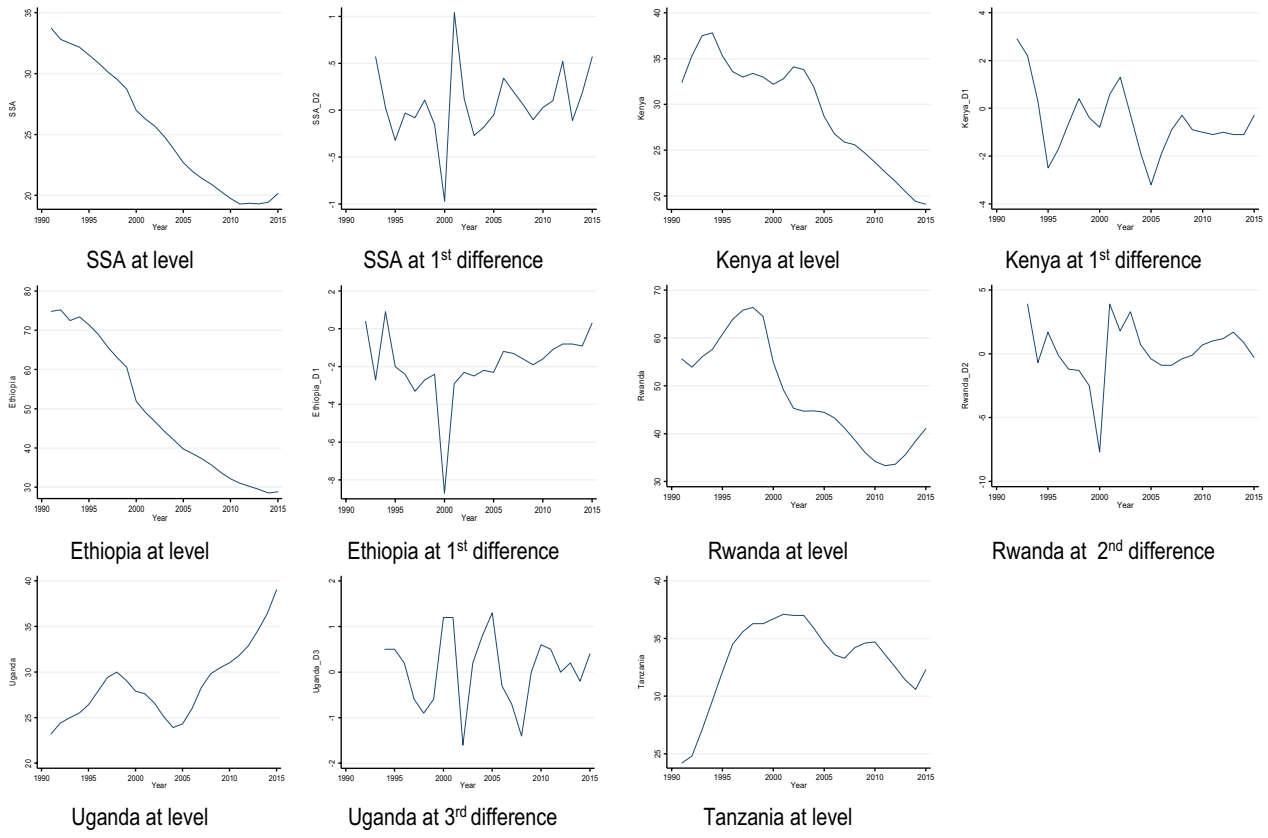

Fig. 2 Trend of PoU of countries and stage of stationarity

Table 2 ADF unit root test results

Countries	Level		First difference		Second difference		Third difference	
	z-stat.	Prob.	*z*-stat.	Prob.	*z*-stat.	Prob.	*z*-stat.	Prob.
SSA	−2.34	0.161	−1.22	0.664	−5.51***	0.000		
Ethiopia	−1.19	0.676	−3.71***	0.004				
Kenya	0.78	0.991	−3.27***	0.016				
Rwanda	−0.67	0.855	−1.79	0.383	−4.33***	0.000		
Uganda	1.33	0.997	−1.15	0.693	−2.75	0.067	−3.77***	0.003
Tanzania	−3.22***	0.019						

***All are significant at a significance level of 0.05

Table 3 Johansen multivariate cointegration test results

Ethiopia and Kenya = *f*(SSA)				
Maximum rank	Trace test		Max-Eigen test	
	Statistic	5% critical value	Statistic	5% critical value
0	39.64	29.6	25.09	20.97
1	14.55***	15.41	12.15***	14.07
2	2.4	3.76	2.4	3.76

***All are significant at a significance level of 0.05

Table 4 The contribution of Ethiopia and Kenya for SSA's PoU

Model	Estimation methods	PoU estimation with 0.51 constant value	
		Coefficient of SSA	Prob.
Ethiopia	OLS	0.124***	0.004
	LAD	0.146***	0.007
	S-Estimator	0.154***	0.000
Kenya	OLS	0.132***	0.025
	LAD	0.148***	0.049
	S-Estimator	0.197***	0.000

***All are significant at a significance level of 0.05

Kenya. This shows that these two countries had a significant contribution to the PoU of SSA. The reason of these countries to contribute more than one-third of the PoU of SSA is that these two countries (Ethiopia and Kenya) were affected by main reasons for the high PoU: climate change, political instability and poverty during the period 1991–2015.

Table 4 also presents to what extent the prevalence of undernourishments of Ethiopia and Kenya has increased when the SSA has increased. When the PoU of Ethiopia is increased by 1, the PoU of SSA is increased by 0.66, and also when the PoU of Kenya is increased by 1, the PoU of SSA is increased by 0.7. This showed that both Ethiopia and Kenya had a 66.6 and 70% of contribution, respectively, for PoU of SSA. This is by assuming the prevalence of Kenya constant, while to see the contribution of Ethiopia and assuming the prevalence of Ethiopia constant, while to see the contribution of Kenya.

Conclusion

The PoU of SSA, Ethiopia and Kenya falls gradually from 1991 to 2015, and Kenya's prevalence is lower than the prevalence of the region SSA, but Ethiopia's PoU is still higher than SSA. The trend of Uganda, Rwanda and Tanzania follows the same path, and it was increased to some point in time and slightly decreased. The PoU of Kenya and Ethiopia has a long-run positive relationship, on top of this; more than one-third of PoU of SSA was contributed by these two countries. Depending on this conclusion, the current study recommends to the governments of Ethiopia and Kenya to continue with a gradual decrement of PoU. Additionally, the Ministry of Health and Ministry of Agriculture of these two governments have to tackle the main reasons for the high PoU: mitigating climate change, poverty reduction, securing political instability, and food and agricultural policy.

Abbreviations

ADF: augmented Dickey–Fuller test; CI: cointegration; FAO: Food and Agriculture Organization; LAD: least absolute deviation; LR: likelihood ratio; OLS: ordinary least square; PoU: prevalence of undernourishment; SDG: sustainable development goal; SSA: sub-Saharan Africa.

Authors' contributions

KHA performed the analysis, wrote, read and approved the final manuscript.

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None.

Competing interests

The author declares that he has no competing interests.

Availability of supporting data

The dataset was found in the World Bank report on the prevalence of undernourishment; available on https://data.worldbank.org/indicator/SN.ITK.DEFC.ZS and Knoema Web site with the title of prevalence of undernourishment, https://knoema.com/ovqznef/prevalence-of-undernourishment.

Consent for publication

Not applicable.

Ethical approval and consent to participate
Ethics approval and participant consent were not necessary as this study involved the use of a previously published and de-identified database by World Bank and Knoema.

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