Cereal food commodities in Eastern Africa: consumption - production gap trends and projections for 2020

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Consumption – Production Gap Trends and Projections for 2020

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Abstract

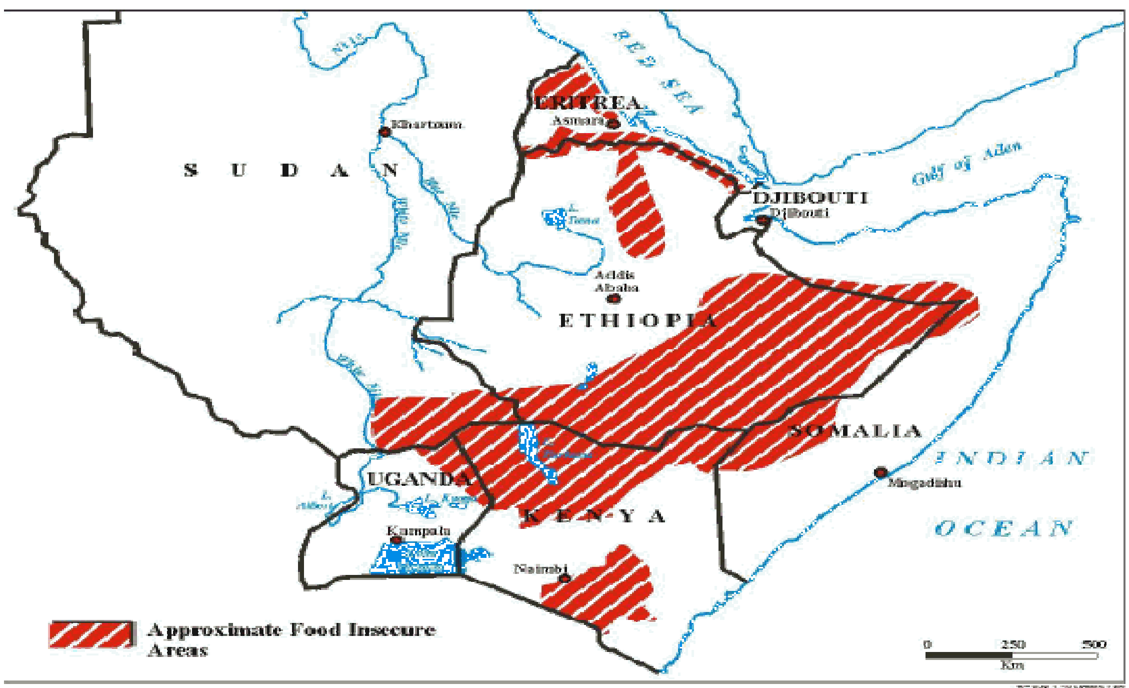
The present paper presents the supply and demand trends of maize, rice and wheat. It provides the supply and demand projections for 2015 and 2020. These projections have been based on change in productivity levels, changes in price, growth of population and income growth. The future supply-demand gap that has been mapped and projected for 2015 and 2020, has been discussed in the light of policy requirements. It is concluded as postulated by Dyson (2009) that an increase in total cereal demand is mainly due to growth in population. A diversification in consumption basket significantly away from maize towards more wheat and rice has been observed. On the supply side, production is constrained by low yield growths. This is more severe for maize. Since population growth is going to be the main element behind the expansion of the regional food demand over the short even to long terms time horizon, then yield growth will be the key to the future expansion of the region's sustainable food supply. While in the short term imports are covering for the food gap, they may not be feasible in the medium to long term. Volatility of food and fuel prices on the global market makes reliance on distant sources for the bulky staple food commodities fiscally unsustainable, regardless of who is paying for it.

Key words: *cereal food balance, trends and projections, Eastern Africa*

1. Introduction

The Eastern Africa is one of the most food-insecure sub-regions of the world. In the seven countries of the region that are members of the Intergovernmental Authority on Development (IGAD), out of a total population of almost 160 million, some 70 million people (around 45 percent) live in areas that have been subject to extreme food shortages and the risk of famine at least once every decade over the past 30 years (UNOCHA, 2012). At the height of the 2011 food crisis including the officially declared famine in two regions of southern Somalia, an estimated 12.4 million people needed relief assistance in especially Somalia, Ethiopia, Kenya and Djibouti that the UN estimated to cost $2.5 billion in aid for the humanitarian response (UN OCHA, 2011).

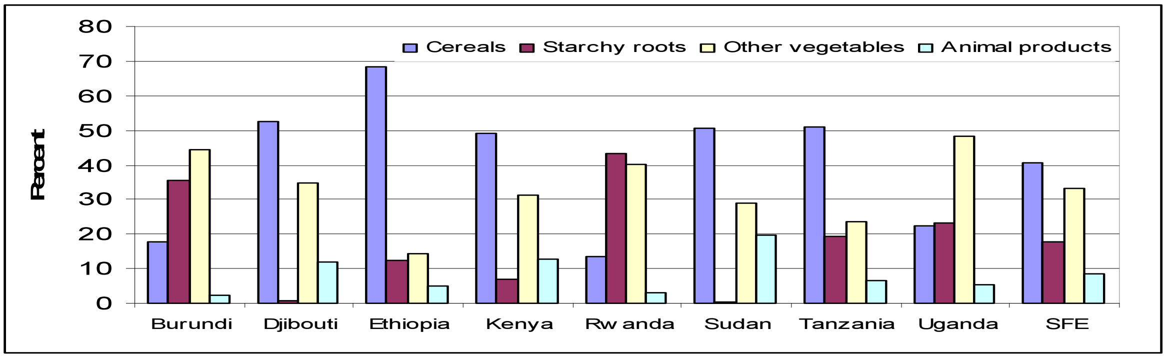
Map 1: Areas with chronically food-insecure population in Eastern Africa



Source: UNOCHA (2012)

Eastern Africa sub-region has a great diversity of foods owing to its diverse biodiversity and ecologies. Having said that, however, the human diets are dominated by cereals that contribute on average over 40 per cent of total direct human dietary calorie intake with Ethiopia (68 per cent) the highest and Rwanda (12 per cent) the lowest. The second major source of dietary energy is a group of starchy roots (yams, cassava, sweet potato, potato, etc), followed by plantains and bananas. These are consumed across the sub-region but mostly in Burundi, Rwanda and Uganda (Figure1).

Figure 1: Dietary energy sources for the countries in Eastern Africa; 2003



Source of data: FAOSTAT

In this document we seek to map out the current food gap, its trends and projections for 2015 and 2020 so as to inform policy action to addressing the chronic food deficits of the sub-region. The focus is on three main cereals: maize, rice and wheat. Apart from being the major cereals in the sub-region, the focus on the three cereals was considered also due to data limitations (from the principal source FAOSTAT) on the other equally important cereals such as Teff in Ethiopia [2007 annual production of 12.06 million MT] and Sorghum/millet in Sudan [2007 annual production of 12.1 million MT] (Okoboi, 2010).

The countries included in this analysis are Burundi, Djibouti, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. In this analysis, data on area harvested, yield, production and consumption of cereal commodities has been drawn from *FAOSTAT*. While data on income per capita and cereal prices is from the *IMF World Economic Outlook*, and population estimates from the *US Census Bureau.*

2. Past trends in cereal food consumption

The data provided by the FAOSTAT indicate an increasing trend in the annual per capita consumption of food cereals. Table 1 illustrates the average annual rate of growth of per capita consumption during the last five decades. Consumption of cereals per capita increased from 49.9 kg per annum in the 1960s to 72 kg per annum in the period 2000-2003.

Table 1: Trends in annual cereal per capita consumption by cereal type in Eastern Africa, 1961-2003

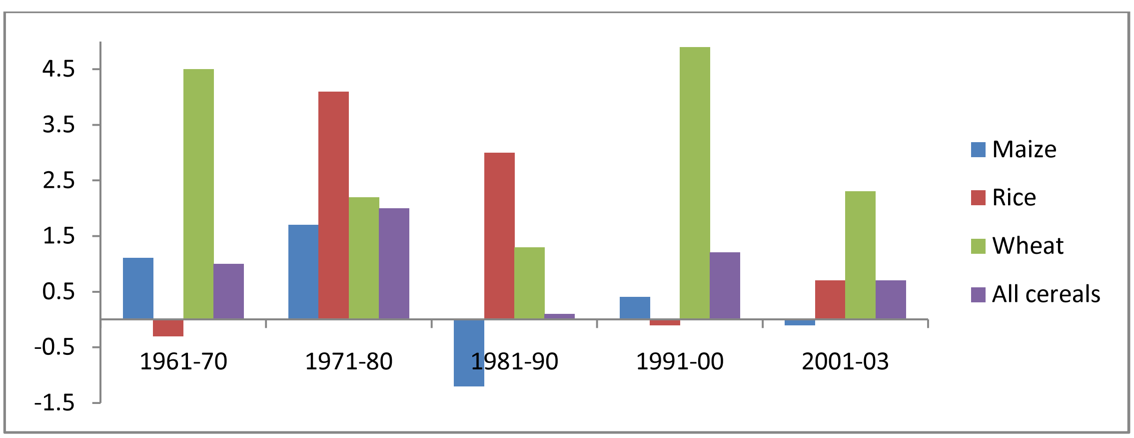
Food Items	Annual per capita consumption (kg per person per year)				
	1961-70	1971-80	1981-90	1991-00	2001-03
Maize	31.1	35.5	34.4	33.5	32.7
Rice	8.3	9.8	13.6	12.2	12.5
Wheat	10.4	13.3	14.6	21.0	26.8
All cereals	49.9	58.6	62.6	66.6	72.0

Source of data: FAOSTAT

While per capita consumption of maize changed marginally between 1960s and 2000s, the per capita consumption of wheat more than doubled. Rice consumption also increased significantly from 8.3kg per annum in 1960s to 12.5kg in 2000s.

Figure 2 below illustrates that average annual rate of growth of per capita consumption was variable across last five decades and among the commodities. Per capita wheat consumption growth was the highest followed by rice, with a negative growth for maize in the same period.

Figure 2: Average annual growth rates (%) for per capita consumption



Source of data: FAOSTAT

Across the countries, the annual average per capita cereal consumption and growth have also been variable (Table 2). Kenya's per capita cereal consumption was the highest at an average consumption of 123 kg per person per year, followed by Djibouti's (112 kg), and Tanzania's (91 kg). On the other hand, the lowest consumers of cereals1 in the region during the same period were Rwanda (16.2 kg), Uganda (28.1 kg) and Sudan (28.4 kg). Some possible reasons for these regional variations in per capita cereal consumption could be that some countries are more dependent on staples other than maize, rice and wheat. For, example, sorghum and millet for Sudan (Abdelrahman, 1998), plantains and roots and tubers for Uganda, parts of Rwanda and parts of Tanzania (McIntyre, et al., 2001).

Table 2: Trends in annual cereal per capita consumption by country in Eastern Africa; 1961-2003.

Country	Annual per capita consumption (kg per person per year)					Annual growth rate (%)				
	1961-70	1971-80	1981-90	1991-00	2001-03	1961-70	1971-80	1981-90	1991-00	2001-03
Burundi	33.2	36.1	35.2	31.7	29.7	2.9	0.4	-0.1	-1.7	3.7
Djibouti	85.5	91.6	104.8	132.1	147.3	0.3	1.8	1.4	3.3	-1.5
Ethiopia	40.7	42.2	51.3	60.7	76.7	1.1	0.4	2.4	3.0	3.8
Kenya	123.8	134.3	122.7	114.3	121.3	1.1	0.7	-2.5	1.8	0.6
Rwanda	10.5	14.8	17.7	21.3	16.7	7.9	2.9	1.6	-0.2	4.6
Sudan	14.1	21.1	31.5	36.8	38.3	11.6	0.1	5.8	-1.9	6.9
Tanzania	60.7	86.4	105.2	98.4	105.0	-1.5	7.8	0.4	-0.2	0.0
Uganda	21.7	25.9	19.2	33.2	40.3	2.9	2.2	1.6	5.7	2.0

Source of data: FAOSTAT

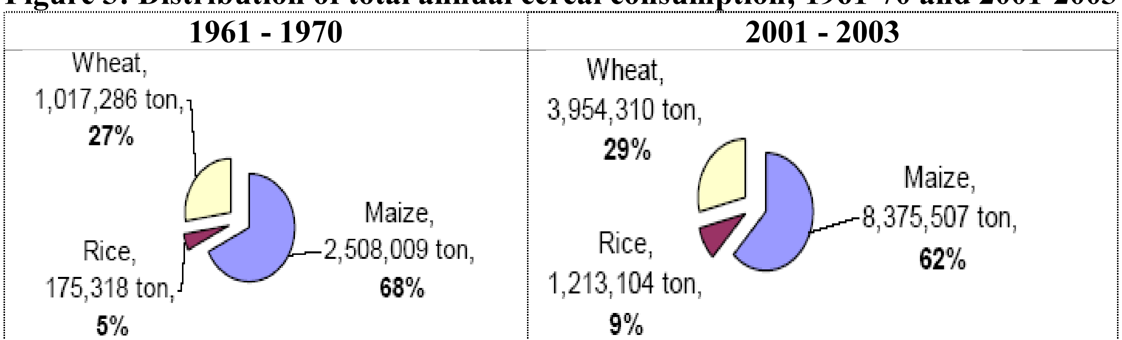
In terms of annual growth in per capita consumption of cereals, Sudan (6.9 per cent), Rwanda (4.6 per cent) and Ethiopia (3.8 per cent) experienced the highest growth in the period 2001-2003, while Djibouti experienced a decline (-1.5 per cent) and no change for Tanzania in the same period.

[1] Maize, rice and wheat.

3. Shifts in the selected cereal food consumption

Figure 3 shows consumption distribution by commodities in the periods 1960s and 2000s. In the 1960s, out of the region's average annual cereal consumption of 3.7 million tonnes, maize constituted 2.5 million tonnes, representing 68 per cent of the total cereals in tonnes consumed in the region, and the remainder was contributed by wheat (27 per cent) and rice (5 per cent). However, in the 2000s, the proportion of maize consumption declined to 62 per cent, while that of wheat increased significantly from 1 million tonnes in the 1960s to almost four million tonnes in the 2000s. Rice consumption increased from 0.18 million tonnes in the 1960s to 1.2 million tonnes in the 2000s.

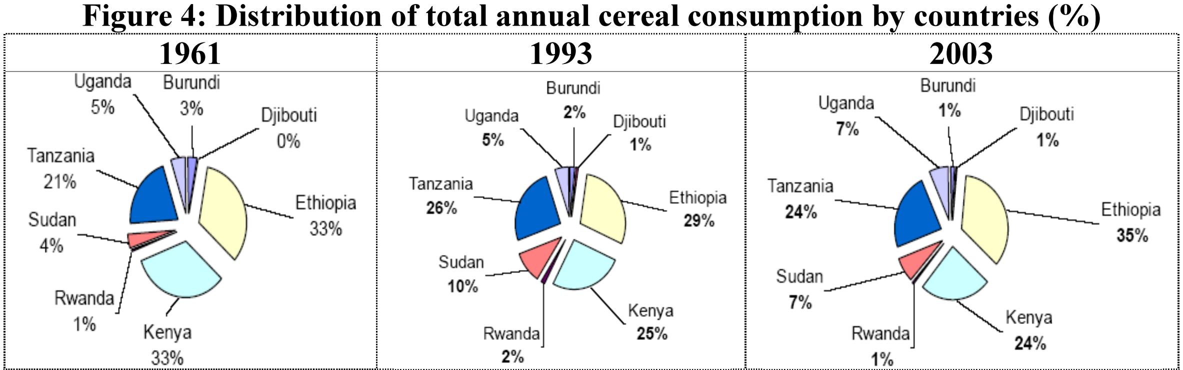
Figure 3: Distribution of total annual cereal consumption; 1961-70 and 2001-2003



Source of data: FAOSTAT

From Figure 4, about a third of the regional cereals are consumed in Ethiopia (33 per cent in 1961, 29 per cent in 1993 and 35 per cent in 2003) with Tanzania and Kenya coming second each consuming at least a quarter of the total cereal consumption (in tonnes) in the region.

Figure 4: Distribution of total annual cereal consumption by countries (%)



Source of data: FAOSTAT

4. Projections of food consumption

Demand projections in general are estimated on the basis of assumptions about the base year demand, population, income elasticity and economic growth. As used by Sekhar (2008), and Burney and. Akmal (1991), in this study, the demand projections for the commodities are obtained through,

$$D_t = d_0 * N_t (1+y*e)^t \qquad (1)$$

where D_t is household demand of a commodity in year t; d_0 is per capita demand of the commodities in the base year; y is growth in per capita income; e is the income elasticity of demand for the commodity; and N_t is the projected population in year t.

4.1 Price and income elasticity of demand

A semi-logarithmic (semi-log) function, estimated using an ordinary least squares (OLS) with fixed parameters over the sample period, was hypothesized to explain the relationship between the consumption of the cereals and the variables described. A number of studies of demand have used a similar functional form (Burney and Akmal, 1991; Nyariki, 2009; and Kumar et al., 2009).

The estimated equation can be written as:

$$Q_t = \beta_0 + \beta_1 lnP_t + \beta_2 lnY_t + \beta_3 lnH_t + \varepsilon_t \qquad (2)$$

Where Q_t is the quantity of cereals consumed per capita at time t; β_0 is a constant; P_t is the average price of the cereals at time t; Y_t is the income per capita in real terms at time t; H_t is the human population at time t; β_1 - β_3 are coefficients of the variables; ε_t is a random error term; and t stand for time in years. Economic theory hypothesized that signs of coefficients in equation (2) should be: β_1<0, and β_2 and β_3>0.

Table 3 presents the results of the regression analysis, based on equation (2).

Table 3: Demand of cereals, estimated coefficients for semi-log models

Cereal	Variable	Coefficient (β)	SE	t-value
Total cereals	Intercept	-92.486	15.507	-5.96*
	Ln (average cereal price)	-0.313	0.0861	-0.36
	LN (per capita GDP)	2.624	1.684	1.56
	Ln (total population)	8.521	0.823	10.35*
Maize	Intercept	-17.360	26.779	-0.65
	Ln (average maize price)	3.222	1.519	1.12
	LN (per capita GDP)	2.831	2.816	1.01
	Ln (total population)	1.704	1.323	1.29
Rice	Intercept	42.446	27.594	1.54
	Ln (average rice price)	-4.011	1.244	-3.22*
	LN (per capita GDP)	1.0931	3.083	0.35
	Ln (total population)	-1.125	1.523	-0.74
Wheat	Intercept	-295.519	32.265	-9.16*
	Ln (average cereal price)	1.853	2.020	0.93
	LN (per capita GDP)	4.414	3.629	1.22
	Ln (total population)	23.594	1.646	14.34*

Note: * significant at 5%; R^2 total cereals = 0.89; R^2 maize = 0.29; R^2 rice = 0.37, R^2 wheat = 0.92; N = 24.

The signs of the coefficients of the explanatory variables are as expected, except for maize and wheat prices that have a positive coefficient. This may imply that there is a shift towards more maize and wheat diets if international cereal prices are high. Earlier studies by Selvarajan and Ravishanker (1996) have also reported a tendency of dietary shifts to more maize or wheat based diets in the face of soaring international food prices. Also we have low R^2 for maize and rice implying that there is need for more variables to explain the demand for maize and rice than just the price, income and population. Even though the R^2 is rather weak, the estimates can be used for prediction purposes but they will have to be qualified as weak (Gujarati 1995; Armstrong and Green, 2005).

The coefficients derived from the semi-log function are used to calculate price and income elasticities of demand at mean values as follows:

$$Ep = \beta_1 (1/Q); \quad (3)$$

$$Ey = \beta_2 (1/Q) \quad (4)$$

Where ***Ep*** is the price elasticity at mean price and quantity; ***Ey*** is the income elasticity at the mean price and quantity; ***Q*** is the mean quantity of the cereals; and β_1 is the cereal price coefficient and β_2 is the cereals income coefficient in the semi-log function.

Income elasticities used for demand projections were computed (Table 4).

Table 4: Income elasticity used in demand projection

Food Items	Income Elasticity
Maize	0.082
Rice	0.084
Wheat	0.203
Total cereals	0.114

The income elasticities for maize, rice, wheat and total cereals are positive and less than one. Since they are positive, this implies that an increase in income will lead to a rise in demand for these commodities, and an income elasticity of less than one is associated with necessity goods, which is true for these cereals to the sub-regional consumers.

4.2 Population projections

Population projections used for demand projections are given in Table 5. The estimates are based on the US Census Bureau Projections. Except for Djibouti, all countries have total fertility rates above five births per woman, higher than average for sub-Saharan Africa of 4.86 births per woman (Yousif, 2009).

The population projections were derived by the following geometric progression formula:

$$P_{t+n} = P_t (1 + r)^n \qquad (5)$$

Where:

P_{t+n} is the population in the year you are projecting to, in this case, 2010, 2015 and 2020; P_t is the population in the base year, in this case, 2003; and r is the population growth rate, which is given by the formula, $r = (P_{t2}/P_{t1} - 1)$, where P_{t1} and P_{t2} and observed population in the recent two successive years.

Table 5: Population projections used in Projecting Demand

Country	Base year (2003) statistics			Projected population ('000)		
	Growth rate (%)	Total fertility rate	Population estimate ('000)	2010	2015	2020
Burundi	3.9	6.8	7,553	9,863	11,754	13,429
Djibouti	-10.5	3.8	691	741	828	922
Ethiopia	3.2	6.4	70,366	88,013	103,980	120,420
Kenya	2.7	5.0	33,042	39,003	44,753	48,319
Rwanda	2.7	5.7	9,098	11,056	12,662	14,327
Sudan	1.4	5.1	36,593	41,980	46,813	52,041
Tanzania	2.2	5.3	36,199	33,399	39,941	47,691
Uganda	3.3	7.0	26,322	41,893	46,123	49,989
Total		5.6	219,864	265,948	306,854	347,138

Source: US Census Bureau (Downloaded on 27 July 2009 from http://www.census.gov/ipc/www/idb/country.php)

In this study, the sub-regional cereal consumption demand is projected under two scenarios of per capita income (GDP) growth rate of two scenarios: five per cent and six per cent. The predictions under the scenario of six per cent GDP are considered to be more likely in the future because the GDP growth rate of six per cent is in the range of the International Monetary Fund projections for April 2009 projections (a GDP of five to seven per cent in the region (Table 6). That was the basis for per capita income growth.

Table 6: Projected annual GDP per capita growth (%, constant price year-on-year changes)

Country	GDP per capita* 2008 (US$)	Projected annual growth of GDP per capita (%)					
		2009	2010	2011	2012	2013	2014
Burundi	389.25	3.53	3.83	3.84	4.18	4.95	4.95
Djibouti	3,392.39	5.11	5.39	5.80	6.29	6.75	7.15
Ethiopia	896.64	6.52	6.54	6.99	7.24	7.50	7.65
Kenya	1,713.63	3.01	4.01	4.96	6.27	6.48	6.47
Rwanda	1,041.41	5.60	5.79	5.88	6.08	6.07	6.06
Sudan	2,305.15	3.96	5.04	5.03	4.33	4.66	4.97
Tanzania	1,351.56	4.97	5.66	7.17	7.49	7.48	7.52
Uganda	1,151.94	6.20	5.50	6.70	7.00	7.00	7.00
Average	**1,405.25**	**4.86**	**5.22**	**5.80**	**6.11**	**6.36**	**6.47**

* Based on purchasing power parity (PPP) current international dollars.
Source: IMF/World Economic Outlook April 2009 (27.07.09)
http://www.imf.org/external/pubs/ft/weo/2009/01/weodata/download.aspx)

Using Equation (1), cereal food demand forecasts for the years 2010, 2015 and 2020 are presented in Table 7.

Table 7: Projected domestic demand of cereals in the Eastern Africa

Food Items	Base Year Demand	Demand Projection (million metric tonnes)					
		Scenario 1: GDP growth is 5%			**Scenario 2:** GDP growth is 6%		
	2003	2010	2015	2020	2010	2015	2020
Maize	9.48	11.89	13.99	16.15	11.96	14.13	16.38
Rice	1.61	2.03	2.38	2.75	2.04	2.41	2.79
Wheat	5.51	7.22	8.75	10.40	7.32	7.75	10.77
The 3 Cereals	**16.60**	**21.14**	**25.12**	**29.30**	**21.32**	**25.50**	**29.94**

The table presents demand projections under two scenarios. The total cereal demand projected for 2010, if the economy grows at six per cent, is 21.2 million tonnes, with 11.96 million tonnes of maize demand, 2.4 million tonnes of rice demand and 7.3 million tonnes of wheat demand. In 2020 the projected domestic demand is 29.6 million tonnes, with 16.4 million tonnes of maize demand, 2.8 million tonnes of rice demand and 10.8 million tonnes of wheat demand.

On the other hand, on per capita cereal consumption basis, there are insignificant differences between the five and six per cent of GDP growth rates scenarios (Table 8). This implies that the projected growth in the demand for cereals is mainly due to population growth. Similar conclusion was drawn by Dyson (2001:49), who concluded that "in the period up to 2025, 70 to 90 per cent of the world cereal demand will be due to demographic growth".

Table 8: Projected annual per capita cereal demand (kg/year) in Eastern Africa

Food items	**Base year**	**Scenario 1** (GDP growth is 5%)			**Scenario 2** (GDP growth is 6%)		
	2003	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**
Maize	41.6	42.8	43.7	44.6	43.0	44.1	45.2
Rice	7.1	7.3	7.4	7.6	7.3	7.5	7.7
Wheat	24.2	25.9	27.3	28.7	26.3	28.2	29.7
Total	72.9	76.0	78.4	80.9	76.6	79.8	82.6

5. Past trends in cereal food productivity and production

The pattern of production of the selected cereal foods in the Eastern Africa sub-region is summarized in Table 9. Annual production has been averaged for decade to stablise the trends. During the last four decades[2] (1960s to 2000s), average annual cereal production in the sub-region almost tripled from about 11 million tonnes per year in the 1960s to about 30 million tonnes per year in the 2000s, with an average annual growth of 1.32 per cent.

[2] During the same period (1960s to 2000s), the sub-regional population quadrupled from 66.4 million to 267.5 million.

In the same period, the maize production grew at about four per cent per year from 3.3 million tonnes per year in the 1960s to 10.7 million tonnes per year in the 2000s, and wheat at 4.5 per cent per year from about one million tonnes per year in 1960s to almost three million tonnes per year in 2000s.

Table 9: Average annual cereal production in Eastern Africa; 1961 to 2007

	Average Production					**Annual growth rate**				
	1961-70	**1971-80**	**1981-90**	**1991-00**	**2001-07**	**1961-70**	**1971-80**	**1981-90**	**1991-00**	**2001-07**
	Area Harvested (thousand hectares)					**(per cent)**				
1. Total cereals	**13,415**	**15,173**	**17,067**	**21,175**	**26,584**	**1.33**	**0.19**	**1.20**	**2.28**	**2.88**
2. Maize, rice , wheat	4,592	5,388	5,776	7,050	9,540	3.6	0.4	2.1	1.0	6.3
	Yield (kg/ha)									
1. Total cereals	**849**	**951**	**1,109**	**1,177**	**1,230**	**0.48**	**1.12**	**0.53**	**-0.07**	**-1.30**
2. Maize, rice & wheat	1,154	1,414	1,599	1,639	1,870	2.5	1.7	1.1	0.1	2.4
3. Maize	864	983	1,366	1,366	1,411	2.2	1.5	3.4	0.4	0.1
4. Rice	1,746	2,204	2,153	2,224	2,626	2.2	1.9	-0.2	1.3	2.5
5.Wheat	980	1,231	1,392	1,384	1,638	5.0	2.1	1.8	-1.9	5.9
	Production (thousand tonnes)									
1. Total cereals	**10,989**	**14,155**	**17,191**	**20,820**	**29,158**	**1.60**	**1.37**	**1.13**	**0.94**	**1.58**
2. Maize, rice & wheat	4,387	6,445	8,579	10,704	15,377	3.9	3.8	4.3	1.0	7.2
3. Maize	3,262	4,972	6,699	7,974	11,088	3.6	5.1	3.9	1.0	5.8
4. Rice	148	347	595	850	1,362	10.4	9.6	10.5	3.6	29.4
5. Wheat	978	1,125	1,284	1,881	2,927	4.9	-0.4	4.6	1.6	12.0

Source of data: FAOSTAT

On the other hand, the regional average annual production of rice grew at 12.7 per cent and it increased almost tenfold from 0.15 million tonnes per year in the 1960s to 1.4 million tonnes per year in the 2000s.

On the other hand, cereal yield (productivity) grew marginally at an average rate of 0.15 per cent per year from 0.85 tonnes per hectare in the 1960s to 1.23 tonnes per hectare in the 2000s. Actually in the 1990s and early 2000s cereal growth rates in the sub-region were negative. With negative and/or very low cereal yield growth rates (0.15 per cent per year), it means most of observed growths in average annual cereal production in the past four decades was mainly due to growth in area harvested.

With respect to cereal production, area harvested per year more than doubled. For total cereals, it grew at 1.58 per cent per year from 13.4 million hectares per year in the 1960s to 23.6 million hectares per year in the 2000s.

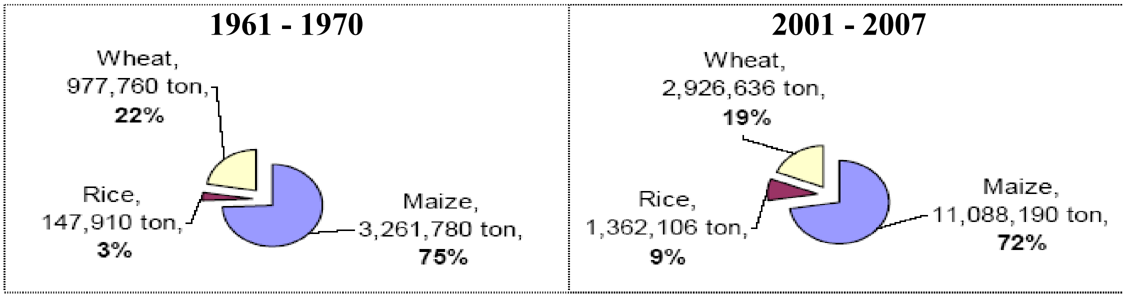
Across the decades, annual growth rates of area harvested, production and yields for cereal crops varied greatly. From the 1960s to the 1980s, with only 0.91 per cent per year growth rate in area harvested, the region enjoyed a relatively higher cereal production growth rate (1.37 per cent per year) mostly because of a positive cereal yield growth rate (0.71 per cent per year). In the 1990s and early 2000s, however, the yield growth rates were negative (-0.68 per cent per year).

6. Shifts in cereal food production patterns

Among the three main staple cereals, maize was the major commodity produced across the decades. In the 1960s it commanded 75 per cent of total regional cereal production quantity, followed by wheat (about 22 per cent), then rice (just three per cent). However, across the four decades, the proportionate share of rice has tripled from three per cent in the 1960s to nine per cent in the 2000s, while during the same period there was a reduction in the maize share from 75 to 72 per cent and wheat from 22 to 19 per cent (Figure 5).

Across the Eastern Africa countries, 35 per cent of cereal production was from Ethiopia in the 1960s that also contributed about 1.4 million hectares of land for cereal production (representing 42 per cent of the area harvested) in 1961.

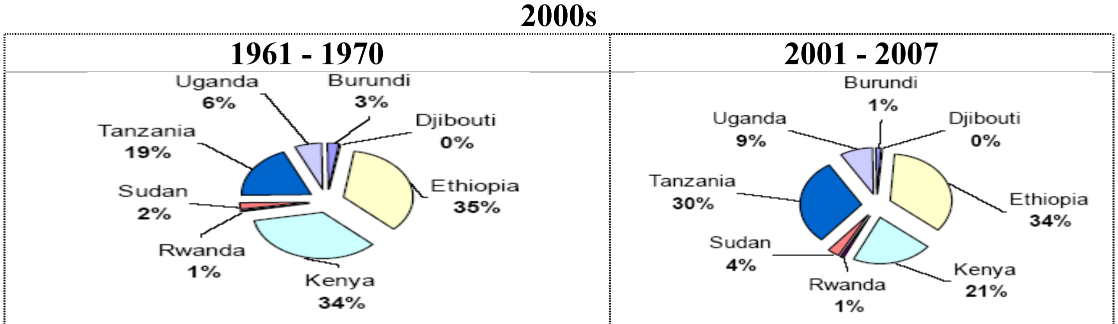
Figure 5: Average annual cereal production for Eastern Africa; 1960s and 2000s



Source of data: FAOSTAT

The second major cereal producer was Kenya (34 per cent), followed by Tanzania (19 per cent). Notable declines in the share of cereal production between the 1960s and 2000s were in Burundi from three to one per cent, Kenya from 34 to 21 per cent, and Ethiopia from 35 to 34 per cent. On the other hand, increases in the proportionate shares of average annual cereal for the period 2001-07 were recorded for Tanzania (from 19 to 30 per cent), Uganda (from six to nine per cent) and Sudan (from two to four per cent), while Rwanda maintained its one per cent share during the same period (Figure 6).

Figure 6: Share of cereal production by countries in Eastern Africa; 1960s and 2000s



Source: FAOSTAT

7. Projections of future cereal food production

In order to estimate future cereal production, assumptions must be made about the future yield growth rate and expansion rate of area harvested. As used in other studies by Mittal (2008) and Sekhar (2008) in India and Abdelrahman (1998) in Sudan, in this study it is assumed that the average annual yield growth will be the same as in the past decade. In terms of area harvested, two scenarios are assumed 1) that no expansion is possible; 2) that further area expansion will take place at the same rate as in the past decade.

Projected yield and area harvested, Y_t, has been estimated by trend extrapolation using the following compound growth rate formula:

$$Y_t = Y_0 * (1+r)^t \qquad (6)$$

where:

Y_t is the yield (or area harvested) in year t; Y_0 is the yield (or area harvested) in the base year; r is the annual rate of growth of yield (or area harvested); and t is the number of years from the base year to the year of projection.

Forecasts by trend extrapolation are based on the assumption that the factors which have influenced the past will continue to have the same influence in the future, and that if there is reason to doubt this, extrapolations should be modified accordingly (Sekhar, 2008 and Mittal, 2008). The sub-regional projected figures for yield and area harvested are presented in Table 10. They have been computed for the years 2010, 2015 and 2020 for maize, rice, wheat and total for the three cereals using the yield growth rate for the most recent decade (1998-2007) and taking 2003 as the base year for production.

Table 10: Projected regional cereal yield and area harvested; 2010, 2015, 2020

Food Item	Base Year (2003)		Annual rate of Growth (1998-2007)		Projected Yield			Projected Area		
	Area	Yield	Area	Yield	2010	2015	2020	2010	2015	2020
	(million Ha)	(Ton/Ha)	(%)	(%)	(Ton/Ha)			(million Ha)		
Maize	7.92	1.25	3.50	0.89	1.33	1.39	1.46	10.1	12.1	14.6
Rice	0.76	2.40	8.72	2.22	2.80	3.13	3.49	1.4	2.1	3.1
Wheat	1.52	1.42	4.01	2.83	1.73	1.99	2.29	2.0	2.4	3.0
All cereals	10.23	1.67	3.68	1.76	1.89	2.06	2.25	13.2	15.8	18.9

Source of data: FAOSTAT

We consider prospects to the year 2020 mainly because world population projections have a fairly reliable record over future time horizons of about 30 years (Dyson 1996).

Medium and long-term supply projections of food have been made using a straightforward approach. Supply projections have been calculated at different points in time by:

a) Scenario 1: multiplying projected yield by the base year (2003) area harvested.

b) Scenario 2: multiplying the projected yield by projected area harvested, and

Supply prospects for the years 2010, 2015 and 2020 are presented in Table 11.

Table 11: Projected Eastern Africa regional supply of cereals

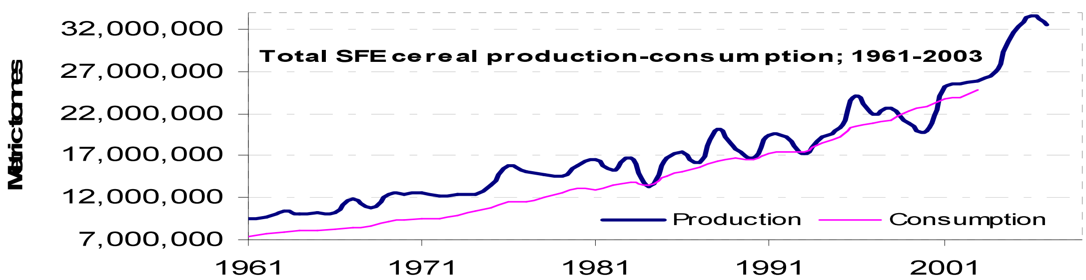
Food Items	**Base Year Supply**	**Supply projection (million metric tonnes)**					
		Scenario 1: Area harvested growth at 0%			**Scenario 2**: Area harvested growth at 1.67%		
	2003	**2010**	**2010**	**2010**	**2010**	**2015**	**2020**
Maize	9.63	10.57	13.51	13.51	13.51	11.05	11.55
Rice	0.89	2.13	3.83	3.83	3.83	2.38	2.65
Wheat	2.39	2.63	3.47	3.47	3.47	3.03	3.48
Total Cereals	12.91	15.33	20.81	20.81	20.81	16.46	17.68

Source of data: FAOSTAT

8. Past trends in the cereal food production and consumption balance

Eastern Africa Region has been, on average, self-sufficient in cereal food in the period prior to the 1980s; however, after 1980s to the current period, production has persistently fallen short of consumption (Figure 7).

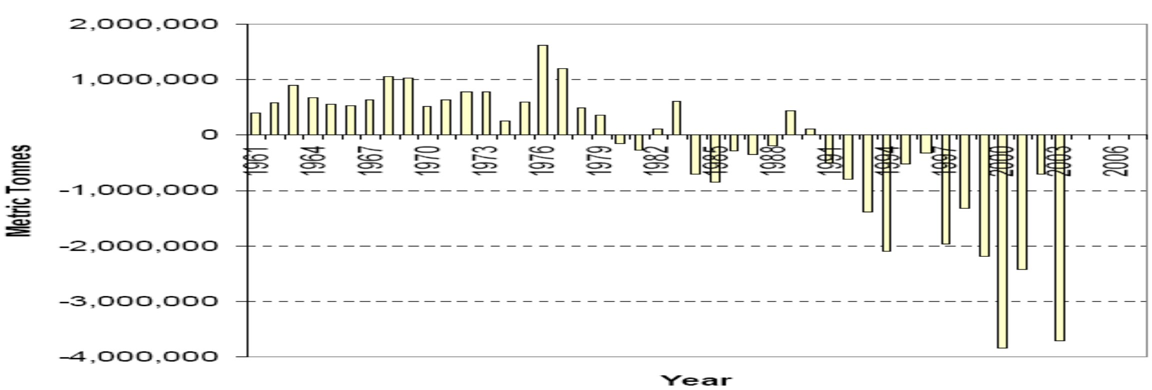
Figure 7: Total annual cereal production-consumption for East Africa; 1961-2007



Source of data: FAOSTAT

Actually the cereal food deficits have been on the rise since 1980 (Figure 8). This had been filled with commercial imports and food aid.

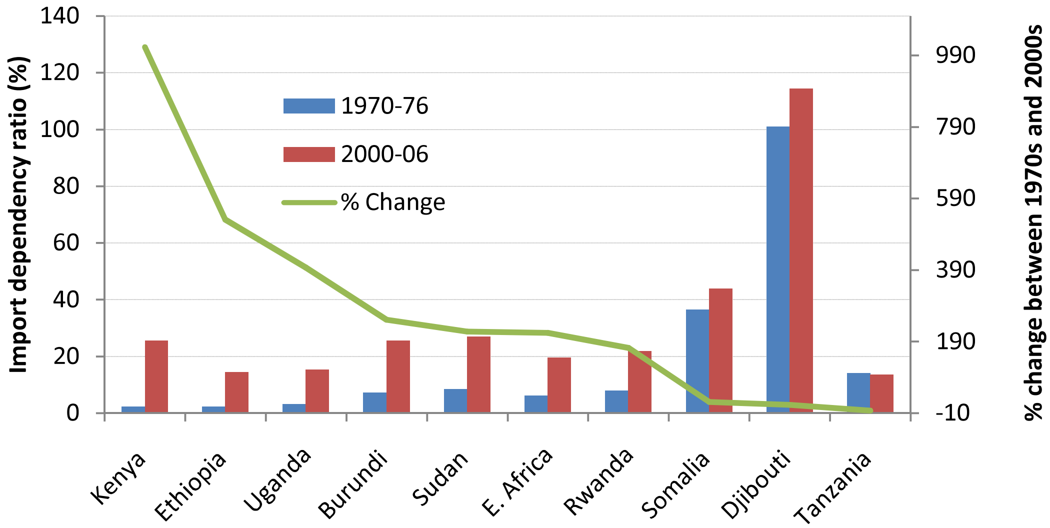
Figure 8: Total annual cereal production-consumption balance sheet for East Africa; 1961-2003



Source of data: FAOSTAT

As production often did not meet consumption demand, over the years countries in Eastern Africa have been relying on imports and food aid to fill the gap (Barrett, 1998; Belfrage, 2006; Hoddinott, et al., 2008; Mohapatra et al., 1999; Srinivasan, 1989; Mousseau, and Mittal, 2005; Blackie, 1990; Maren, 1997; WFP-FAIS, 2011; Barrett and Maxwell, 2005). Between the early 1970s and early 2000s, the sub-region's import dependency ratio (IDR3) in cereal food commodities has grown from six per cent to about 20 per cent (Figure 9).

Figure 9: Import Dependency Ratios 1970s and 2000s



Source of data: FAOSTAT

9. Projected cereal consumption-production gap

Table 12 presents the forecast cereal food gaps for the region projected under scenario 1 (constant area harvested and GDP at six per cent) and scenario 2 (area harvested growing at 1.67 per cent per year and GDP at six per cent). A negative gap indicates that the demand for the commodity is more than its supply and this implies a deficit of the commodity in future.

Under Scenario 1 the total cereal demand is expected to fall short of expected supply by about six million tonnes in 2010. By the next decade, i.e., 2020, the cereal deficit will have grown to 12.26 million tonnes. Under Scenario 2, total demand is expected to fall short by about half a million tonnes in the year 2010. There will be no danger to the region's cereal food security in. This is clearly illustrated in Figure 10.

3 Import dependency ratio $IDR = \frac{Imports}{Production + Imports - Exports} * 100$ (all quantities in metric tonnes)

Table 12: Supply-Demand gap under scenario 1 (million metric tonnes)

Food items	**Scenario 1:** Constant area harvested; GDP growth rate at 6%			**Scenario 2:** Area harvested at 1.67%; GDP growth rate at 6%		
	2010	2015	2020	2010	2015	2020
Maize	-1.39	-3.08	-4.83	1.55	2.70	4.59
Rice	0.09	-0.03	-0.14	1.79	4.08	8.21
Wheat	-4.69	-5.93	-7.29	-3.85	-4.11	-3.99
Total cereals	-5.99	-9.05	-12.26	-0.52	2.67	8.81

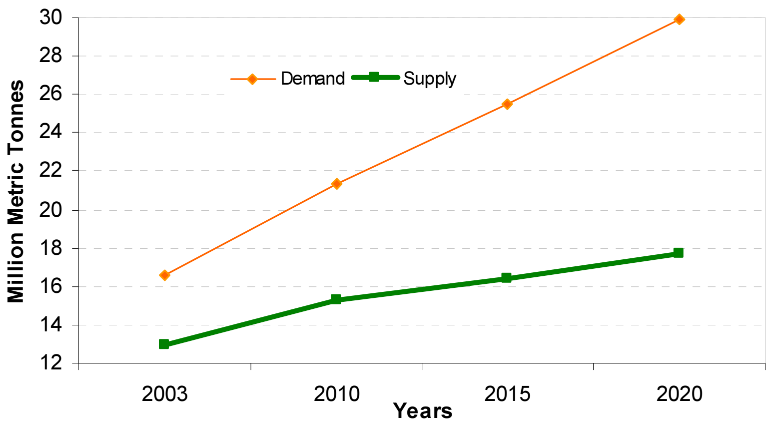
However, production at the assumed area harvested expansion rate may not increase in future because of the human population pressure[4]. Required production to meet the expected demand is more likely through improvement in productivity, as the possibility of area expansion under cultivation is minimal.

[4] Human population pressure is an issue in several of the countries only because of unwillingness of people to live where land is available, in many cases due to remoteness from other settlements, less attractive climate, or absence of infrastructure and other attractions. Thus, within any one country there are areas that are overcrowded while large expanses of land remain idle. Tanzania shows aspects of this, as do Ethiopia and Kenya.

Figure 10: Future Supply and Demand of Cereals in Eastern Africa Region

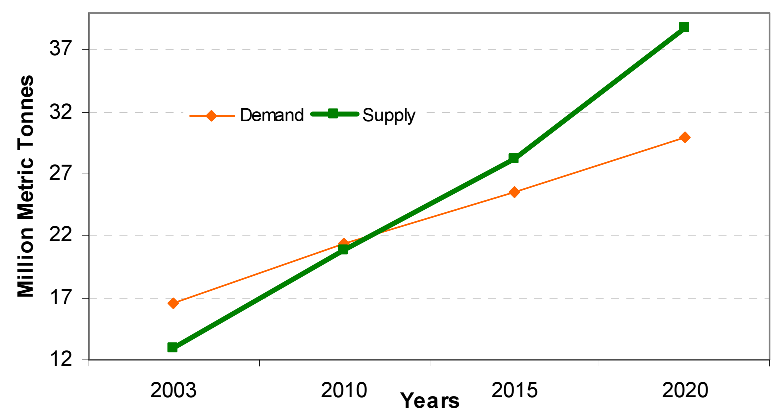
Scenario 1:

Area harvested growth at 0%; GDP growth at 6%



Scenario 2:

Area harvested growth at 1.67%; GDP growth at 6%



10. Policy implications

Demand and supply projections of food act as indicators for policy makers to formulate their medium and long-term food policies (FAO 2001; 1996; 1991). This document shows that the increase in total cereal demand is mainly due to growth in population. As far as supply is concerned, production is constrained by low yield growth.

To meet the expected consumption[5] under the assumptions of Scenario 1 (constant area harvested and GDP of 6%), Eastern Africa must attain the following yield (productivity) levels by 2015:

a) Maize: 1.78 tonnes/ha from the base yield level (average of 2003) of 1.25 tonnes/ha;
b) Wheat: 5.09 tonnes/ha from the base year's yield level of 1.43 tonnes/ha;
c) Rice: 3.17 tonnes/ha from the base year's yield level of 2.4 tonnes/ha; and
d) Total cereals (maize, wheat and rice): 2.48 tonnes/ha by 2015 from the yield level of 1.67 tonnes/ha in base year.

Table 13 shows that there were huge gaps between the average yields achieved in East Africa in 2003 and the yields that were achieved by other countries.

Table 13: Average yield and yield potential in 2007 (tonnes/Ha)

Food Items Commodity	Yield in Eastern Africa	Comparative Yield Achieved in the World		
		Highest in Eastern Africa	Highest in Africa	Highest in World
Maize	1.34	1.97 (Ethiopia)	8.05 (Egypt)	21.00 (Kuwait)
Rice	2.65	4.29 (Rwanda)	10.29 (Egypt)	10.29 (Egypt)
Wheat	1.53	3.40 (Kenya)	6.48 (Egypt)	8.50 (New Zealand)
Sorghum	1.12	1.48 (Ethiopia)	5.68 (Egypt)	13.01 (Jordan)
Millet	0.96	1.66 (Uganda)	1.66 Uganda	31.58 (Mexico)

Source: FAOSTAT

[5] Consumption here refers to total direct human consumption and does not include indirect demand (seed, feed, industrial use and wastage).

This shows the great possibility for yield enhancement that is achievable through technological enhancement. If the sub-region strives to achieve closer to these potential yield levels, then the increasing demand requirements can be met in future.

If we look at the sub-region's past yield performance (Table 9), it seems very difficult to attain the required yield level in the medium term (that is, by 2015). The sub-regional yield of most of the crops is very low compared to many regions, which indicates a gap in yield potential. Even within Eastern Africa, the top performing country can have as much as two-folds the sub-regional average productivity. Given the magnitude of gap with international commonplace achievements in yield levels, some of the increase in production of these cereals (maize, rice and wheat) must, in the short and medium term, unfortunately continue to come from area expansion.

Dyson (2001) estimated that in the period to 2025, 70 to 90 per cent of the rise in world cereal demand will be due to demographic growth. If population is going to be the main element behind the expansion of the regional food demand over this time horizon, then yield growth will be the key to the future expansion of the region's sustainable food supply.

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Appendix-Table A1: Cereal crop harvested area, yield and production in Eastern Africa

Country	Average Production					Annual growth rate				
	1961-70	**1971-80**	**1981-90**	**1991-00**	**2001-07**	**1961-70**	**1971-80**	**1981-90**	**1991-00**	**2001-07**
Area Harvested (thousand hectares)						**(per cent)**				
Burundi	148	167	217	205	214	1.29	3.33	0.57	-0.12	0.89
Djibouti	-	-	4	6	6	-	-	18.3	1.67	-2.04
Ethiopia	6,262	5,102	4,875	6,097	8,485	1.27	-3.03	-0.45	7.08	2.98
Kenya	6,262	1,855	1,678	1,851	2,075	3.98	-0.65	2.66	2.00	0.52
Rwanda	160	212	253	198	323	4.99	3.36	0.68	3.66	0.69
Somalia	513	539	734	551	596	-1.49	7.64	-2.2	10.49	-0.35
Sudan	2,186	3,862	5,647	8,047	8,895	6.51	7.04	9.41	5.59	11.36
Tanzania	1,531	2,252	2,764	2,951	4,412	3.65	5.20	2.19	-1.31	13.33
Uganda	1,133	1,184	901	1,277		3.22	-4.66	4.27	2.54	3.34
Yield (tonne/ha)						**(per cent)**				
Burundi	1.00	1.09	1.19	1.34	1.33	1.72	-0.08	2.60	-0.85	0.10
Djibouti	-	-	0.91	1.57	1.65	-	-	2.41	7.92	-1.24
Ethiopia	0.73	0.95	1.15	1.16	1.33	0.87	6.08	1.32	-0.90	3.46
Kenya	1.25	1.36	1.67	1.67	1.63	0.43	0.02	1.34	-1.43	-1.44
Rwanda	1.17	1.08	1.17	1.09	1.05	5.13	1.60	-0.36	-0.90	3.51
Somalia	0.47	0.46	0.70	0.51	0.56	0.08	-0.59	5.53	4.48	-8.40
Sudan	0.78	0.66	0.49	0.53	0.61	-0.48	-0.87	4.51	-0.09	1.08
Tanzania	0.75	0.93	1.30	1.35	1.35	-3.14	5.66	5.91	4.77	-0.88
Uganda	0.99	1.27	1.41	1.47	1.58	4.92	4.54	2.11	1.54	-0.82
Production (thousand tonnes)						**(per cent)**				
Burundi	149	182	258	275	284	2.91	3.46	2.92	-0.11	0.95
Djibouti	-	-	7	10	10	-	-	17.4	1.91	-2.22
Ethiopia	4,586	4,762	5,601	7,065	11,304	2.23	1.92	1.44	6.71	5.07
Kenya	1,854	2,541	2,808	2,901	3,370	4.34	1.71	6.04	2.95	-1.61
Rwanda	182	230	295	210	340	8.55	3.70	3.38	1.51	4.30
Somalia	243	247	513	280	332	1.31	8.62	-0.55	13.9	-9.87
Sudan	1,707	2,577	2,878	4,289	5,363	9.76	9.66	34.38	9.98	8.6
Tanzania	1,126	2,148	3,571	3,925	5,648	3.27	10.3	3.86	4.70	9.13
Uganda	1,141	1,468	1,266	1,875	2,478	5.44	-1.45	4.69	4.59	2.48

Appendix 2: Summary of Statistical Methods used

A number of statistical tools were employed to analyze, summarize and present the data.

1. Trends, shifts and growth rates of production and consumption

Descriptive statistical methods were used to analyze the historical trends and shifts over the years and to estimate the growth rates over time. In this analysis, data on area harvested, yield, production and consumption of cereal commodities has been drawn from *FAOSTAT*.

2. Projecting future cereal food production

In order to estimate future cereal production, assumptions must be made about the future yield growth rate and expansion rate of area harvested. As used in other studies by Mittal (2008) and Sekhar (2008) in India and Abdelrahman (1998) in Sudan, in this study it is assumed that the average annual yield growth will be the same as in the past decade. In terms of area harvested, two scenarios are assumed 1) that no area expansion is possible; and 2) that further area expansion will take place at the same rate as in the past decade.

Projected yield and area harvested, Y_t, has been estimated by trend extrapolation using the following compound growth rate formula:

$$Y_t = Y_0 * (1+r)^t \qquad (1)$$

where:

> Y_t is the yield (or area harvested) in year t; Y_0 is the yield (or area harvested) in the base year; r is the annual rate of growth of yield (or area harvested); and t is the number of years from the base year to the year of projection.

Forecasts by trend extrapolation are based on the assumption that the factors which have influenced the past will continue to have the same influence in the future, and that if there is reason to doubt this, extrapolations should be modified accordingly (Sekhar, 2008; Mittal, 2008; and Abdelrahman, 1998). In this study it is assumed that the average annual yield growth will be the same as in the past decade.

3. Projecting future food consumption

Demand projections in general are estimated on the basis of assumptions about the base year demand, population, income elasticity and economic growth. As used by Sekhar (2008), and

Burney and. Akmal (1991), in this study, the demand projections for the commodities are obtained through,

$$D_t = d_0 * N_t (1+y*e)^t \qquad (2)$$

where D_t is household demand of a commodity in year t; d_0 is per capita demand of the commodities in the base year; y is growth in per capita income; e is the income elasticity of demand for the commodity; and N_t is the projected population in year t.

3.1 Price and income elasticity of demand

Data used in estimation of price and income elasticity of demand is from the *IMF World Economic Outlook.* A semi-logarithmic (semi-log) function, estimated using an ordinary least squares (OLS) with fixed parameters over the sample period, was hypothesized to explain the relationship between the consumption of the cereals and the variables described. A number of studies of demand have used a similar functional form (Burney and Akmal, 1991; Nyariki, 2009; and Kumar et al., 2009).

The estimated equation can be written as:

$$Q_t = \beta_0 + \beta_1 lnP_t + \beta_2 lnY_t + \beta_3 lnH_t + \varepsilon_t \qquad (3)$$

Where Q_t is the quantity of cereals consumed per capita at time t; β_0 is a constant; P_t is the average price of the cereals at time t; Y_t is the income per capita in real terms at time t; H_t is the human population at time t; β_1 - β_3 are coefficients of the variables; ε_t is a random error term; and t stand for time in years. Economic theory hypothesized that signs of coefficients in equation (2) should be: $\beta_1<0$, and β_2 and $\beta_3>0$.

The coefficients derived from the semi-log function are used to calculate price and income elasticities of demand at mean values as follows:

$$Ep = \beta_1 (1/Q); \qquad (4)$$

$$Ey = \beta_2 (1/Q) \qquad (5)$$

Where $\boldsymbol{Ep}$ is the price elasticity at mean price and quantity; $\boldsymbol{Ey}$ is the income elasticity at the mean price and quantity; $\boldsymbol{Q}$ is the mean quantity of the cereals; and $\boldsymbol{\beta_1}$ is the cereal price coefficient and $\boldsymbol{\beta_2}$ is the cereals income coefficient in the semi-log function.

3.2 Population projections

The estimates are based on the US Census Bureau Projections. The population projections were derived by the following geometric progression formula:

$$P_{t+n} = P_t (1 + r)^n \quad (6)$$

Where $\mathbf{P_{t+n}}$ is the population in the year you are projecting to, in this case, 2010, 2015 and 2020; $\mathbf{P_t}$ is the population in the base year, in this case, 2003; and $\mathbf{r}$ is the population growth rate, which is given by the formula, $\mathbf{r} = (\mathbf{P_{t2}/P_{t1}} - 1)$, where $\mathbf{P_{t1}}$ and $\mathbf{P_{t2}}$ and observed population in the recent two successive years.

Projecting future consumption-production gap

The forecast cereal food gaps for the region is projected by subtracting projected consumption from projected production, under two scenarios 1 (constant area harvested and GDP at six per cent) and scenario 2 (area harvested growing at 1.67 per cent per year and GDP at six per cent). A negative gap indicates that the demand for the commodity is more than its supply and this implies a deficit of the commodity in future.