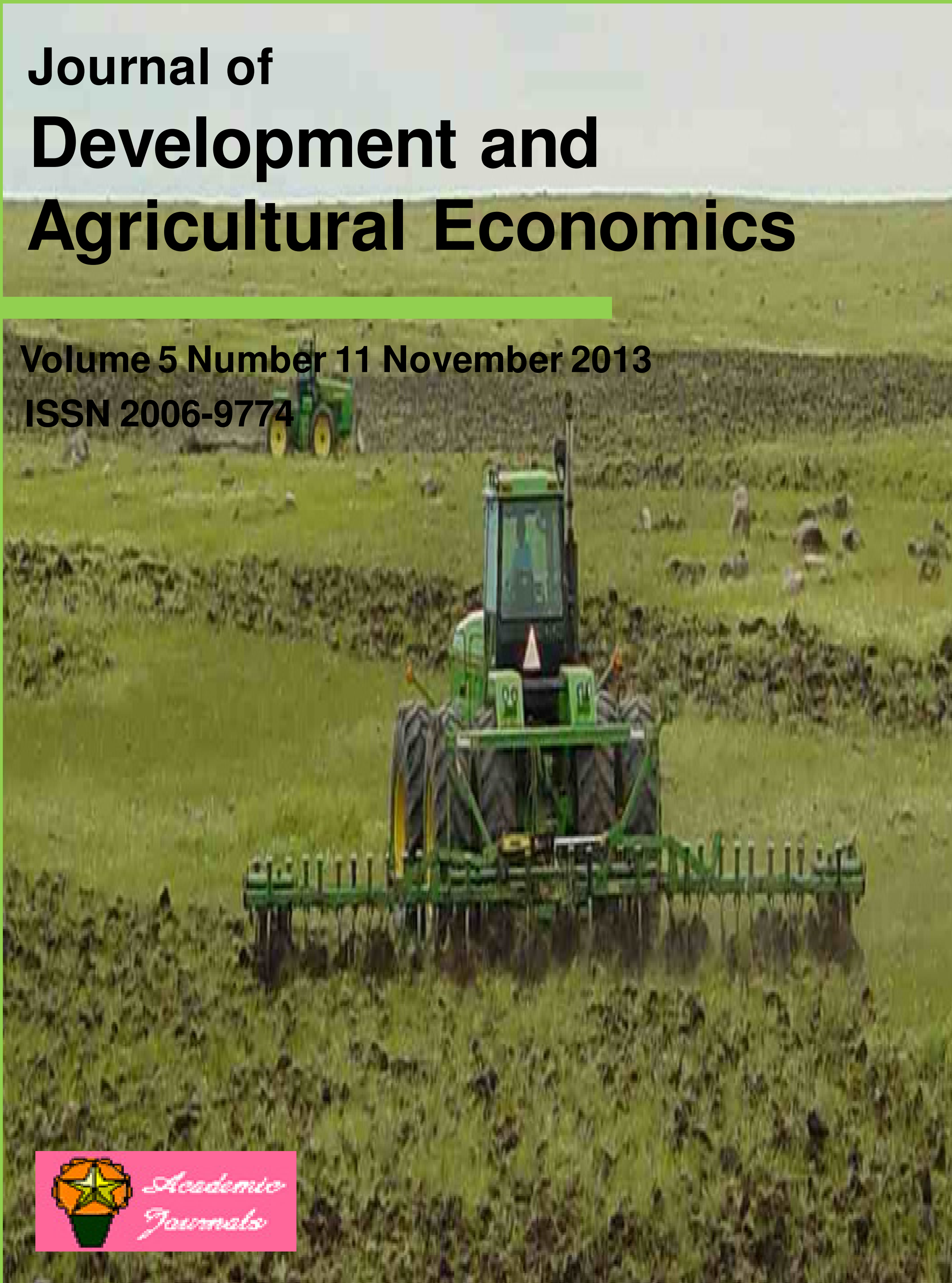

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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

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Journal of Development and Agricultural Economics

Review

Understanding the performance of food production in sub-Saharan Africa and its implications for food security

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The performance of the food production sector in Sub-Saharan Africa (SSA) is critical for a number of reasons. Domestic production is the principal avenue to ensuring access to affordable food in poor countries with limited capacity to import food. The multiplier effect of sustainable food production on the economy is considerable as it has direct linkage with other activities such as transportation, marketing, tourism and local trade. In countries where the growth of food production outpaces demand, social and political harmony as well as macroeconomic stability can be maintained, paving the way for sustained economic growth. This paper examines changes in food production performance among 30 SSA countries over the period of 1968 to 2008. The results support previous findings that not many countries have managed to achieve a food production growth rate in excess of 3% per annum. Annual food production performance averaged 3% or more in 60% of the sample countries following the policy reforms. Nevertheless, rates of output growth varied from one period to the other and the recent improved performances were achieved not only through unsustainable expansion of land under cultivation, but also failed to satisfy the rapidly growing food demand. With domestic supply lagging behind, most countries have experienced unaffordable food import bills. Addressing political instability and building institutions that foster partnership between governments, farmers, traders and other operators along the food value chain to address market failures and inefficiencies in input, output, credit and risk managementis critical to ensure food availability, accessibility and stability in SSA.

Key words: Sub-Saharan Africa, food production performance, food security.

INTRODUCTION

Over the past thirty or forty years, there has been a growing concern over poverty and food insecurity in Sub-Saharan Africa (SSA). Various attempts and commitments have been made to address the problem both at global and continental levels. At the global level, the most prominent commitments include the 1996, 2003 and 2009 World Food Summit which pledges to achieve food security; the 2000 Millennium Development Goals (MDGs) declaration of the UN which specifically sets the objective of halving the proportion of the world's poor and hungry people by the year 2015; and the 2009 L'Aquila Food Security Initiative (G8, 2009) that announced a goal

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of mobilizing US$20 billion over a period of three years for increasing G8 assistance to Agriculture and Food Security (GAFS). Priority is often given to SSA countries in the global initiatives. At the continental level, there have been numerous commitments from as far back as the 1980s in the Lagos Plan of Action for the Economic Development of Africa (UNECA, 1979) and in the early 1990s in the African Economic Community initiative (AEC, 1991). One of the more recent ones include the Maputo Declaration on Food Security (African Union, 2003); the committed member countries to allocate at least 10% of national budgetary resources to agriculture and rural development policy implementation within five years. Nevertheless, the reform institutionalized under the name Structural Adjustment Programs (SAPs) is by far the most significant and far-reaching policy initiative (Rono, 2002; FAO, 1999; Zawalinska, 2004; Munthali, 2004; Maxwell, 1999; Lele, 1990).

On the basis of this framework, many SSA countries implemented, to varying extents, reforms which included, among others, macroeconomic stabilization, trade liberalization and reduction in the public sector. It was expected from the outset that through an implementation of a set of macroeconomic and microeconomic policy reform measures, SSA countries would see enhanced food production as well as sustainable growth and development.

The aim of this paper is to contribute to the understanding of food production performance of SSA countries and its implications for food security. This analysis is carried out by paying particular attention to good and poor performing countries and assessing differences between growth trends across three different periods: before the SAPs or pre-reform period (1968 to 1983), the introduction of SAPs or transition period (1984 to 1993), and after SAPs implementation or post-reform period (1994 to 2008). Thus, the study performs an indirect assessment of the impact of these reforms in different countries, with also documenting available research evidences on key challenges in addressing the long standing concerns over sustainable increase in food production and food security objectives. To analyze the performance of different SSA countries, the paper uses the Food Production Index (PIN) of the FAO statistics (FAOSTAT). The food PIN measures the value of the final food output in ‘international dollars’, which are the same in all countries, implying that the weight given to each commodity is the same across different countries[1].The analysis covers the performance of 30[2] SSA countries over four decades (1968 to 2008).

The least-squares growth rate is used to measure food production performance. The least-squares growth rate, *r*, is estimated by fitting a linear regression trend line to the logarithmic annual values of production in the relevant period (OECD, 2005; Kakwani, 1997). Least-squares growth rates are used whenever there is a sufficiently long time series to permit a reliable calculation. No growth rates are calculated if more than half the observations in a period are missing. The regression equation takes the form:

$\ln X_t = a + b_t.$

This expression is equivalent to the logarithmic transformation of the compound growth equation,

$X_t = X_o (1 + r)*t,$

Where: X is the variable, t is time, and $a = \ln X_o$ and $b = \ln (1 + r)$ are parameters to be estimated. The calculated growth rate is an average rate that is representative of the available observations over the entire period. It does not necessarily match the actual growth rate between any two periods[3]. On the basis of their food production performance, the countries have been grouped into three: better performers [with a food PIN average annual growth rate (AAGR) greater than 3%], medium performers (with a Food PIN AAGR between 2 and 3%) and poor performers (with a food PIN AAGR for 1968 to 2008 of less than 2%).

FOOD PRODUCTION PERFORMANCE IN SSA: BETTER, MEDIUM AND POOR PERFORMERS

As a region, SSA relies heavily on agriculture. The sector accounts, on average, for close to 20% of total gross domestic product and about 60% of the region’s total labour force – although many countries in the region depend on agriculture to a much greater extent than indicated by these regional averages (FAO, 2008; World Bank, 2009). Traditionally, the agricultural sector has been the overwhelming driving force for Africa’s economic growth and development (World Bank, 2008; IFPRI, 2011; AFDB, 2010; ECOWAS, 2009; Kydd et al., 2007). The output and employment multiplier effects of food production on the economy are considerable as it has direct linkage with other activities such as transportation, marketing, warehousing, food processing, tourism and local commerce. Figure 1 presents the challenge facing SSA countries. The net value of production doubled more than in the period of 1968 to 2000, increasing from about I$35,000 million to about I$100,000 million. However, the net per capita production decreased by about 10% during this period indicating that food production did not keep pace with population

[1]The food production index number (PIN) includes commodities that are considered edible and that contain nutrients. As such, cocoa is included in the food PIN but excludes coffee and tea, although edible, along with inedible commodities, because they have little to no nutritive value.

[2] We considered countries with significant agricultural sector and with complete or nearly complete food production index (PIN) database in the FAOSTAT of FAO.

[3]The World Bank website: http://data.worldbank.org/about/data-overview/methodologies

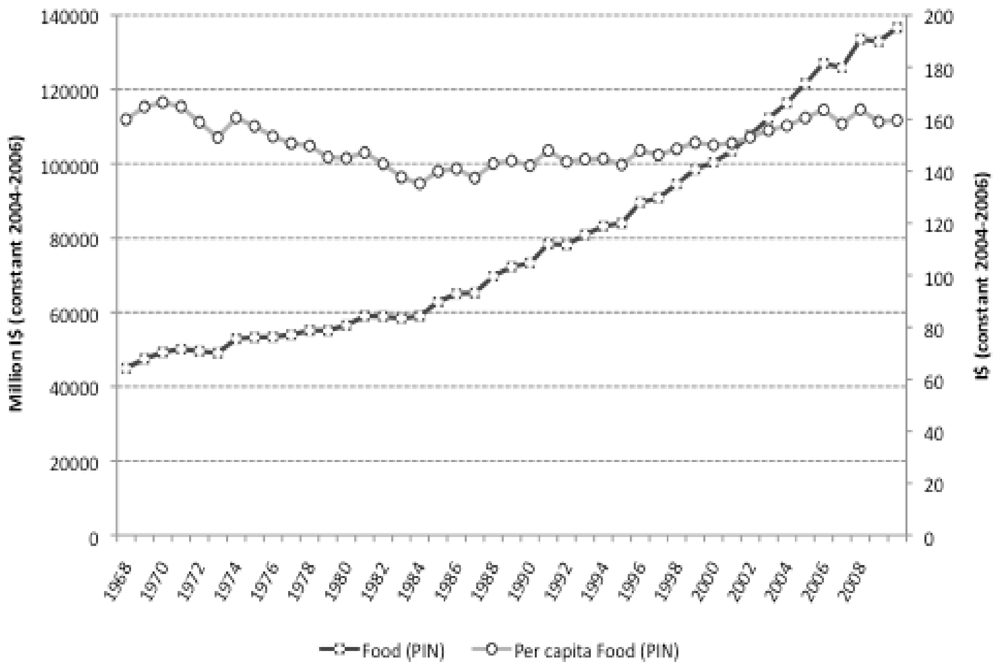

Figure 1. Production indices (PIN) - trends in net production and net per capita PIN base.
Source: Authors' elaborations based on FAOSTAT data.

growth in the region. However, this general trend conceals many differences between countries and periods. Table 1 in the annex compares the growth of food production in the pre-reform, transition and post-reform period, and also presents a ranking of the good and poor performing countries.

As indicated earlier, this ranking of 30 countries, which is obtained by looking at food production performance for the whole period (1968 to 2008), gave rise to three groups referred to as better, medium and poor performers. Over the last 40 years, only nine of the 30 countries (30%) (group one) were able to achieve a food production average performance of 3% or more per annum. The majority of these better performing countries (six of them) are from West Africa (Benin, Burkina Faso, Nigeria, Cote d'Ivoire, Ghana and Niger). The other three countries, namely Sudan, Malawi and Kenya, are from eastern and southern Africa. Nevertheless, growth rates varied between countries and across the different periods. In Malawi, for instance, negative growth was registered during the transition period but very high growth in the post-reform period (Chilowa, 1998; Harrigan, 2003, 1997). Growth during the pre-reform period was poor for group one as a whole (2.2%) with negative growth rate in Ghana -possibly due to macroeconomic instability (Weissman, 1990)- and almost zero growth in Nigeria (Moser et al., 1997). Benin had one of the highest growth rates, especially during the transition and post-reform periods and this could be attributed to the dramatic increase in rice production following the 1994 currency devaluation which made imported rice expensive and raised domestic prices for farmers (Noameshi et al., 2007). In addition, the increase of manioc production, in response to increasing commercialization and cross-border exports, has contributed to the country's agricultural growth (Kherallah et al., 2001). In countries such as Ghana and Nigeria, good performance in the transition and post-reform period was partly related to a sharp increase in cassava production, resulting from widespread adoption of high-yielding varieties and improved pest management practices (Ugwu, 1996, Nweke, 2004; Camara, 2000). This has contributed in making Nigeria the world's top producer of cassava.

For the second group of nine countries (medium performers), the growth rate of food production averaged 2.6% per annum over the period of 1968 to 2008. The group, which includes Central African Republic, Mali, Cameroon, Guinea, Chad, Togo and Congo from central and western Africa, and Tanzania and Zambia from eastern and southern Africa, had an average growth rate of food production which fell well short of population growth rate in the pre-reform period and barely caught up with it in the transition period. Within the group, the performance of Congo was particularly poor in the pre-reform and transition period, probably because of the Marxist policies and political/macroeconomic instabilities during this period (Clark, 2002). Tanzania also performed poorly in the transition period probably due to disruptive policies such as villagization program, removal of fertilizer subsidies and bad weather (Skarstein, 2005; Wobst, 2001). On the other hand, annual growth rate of food

Table 1. Country performance ranking based on food (PIN) average annual growth rate (AAGR) (1968 to 2008) - net production value (constant 2004 to 2006 1000 I$).

Country	Annual average growth rate food PIN			
	Pre-reform	Transition	Post-reform	Whole period
	1968-1983	1984-1993	1994-2008	1994-2008
Better performers				
Benin	1.8	3.8	4.6	4.1
Burkina Faso	1.5	6.1	3.8	4.1
Nigeria	0.1	8.0	3.5	4.0
Côte d'Ivoire	4.9	3.3	2.3	3.8
Ghana	-1.4	5.7	4.4	3.5
Niger	2.6	4.7	6.4	3.3
Sudan	3.7	2.8	3.0	3.2
Malawi	3.2	-0.1	6.9	3.1
Kenya	3.6	4.4	3.5	3.1
Mean	2.2	4.3	4.3	3.6
Medium performers				
Central African Republic	2.8	3.1	3.0	2.8
Mali	2.7	3.1	4.4	2.8
U.R. of Tanzania	3.8	1.1	4.4	2.8
Cameroon	2.2	2.3	3.4	2.6
Guinea	1.3	3.4	2.9	2.6
Chad	0.9	3.9	3.3	2.6
Togo	0.9	3.2	2.7	2.5
Zambia	2.5	3.8	2.7	2.3
Congo	1.1	0.5	3.0	2.1
Mean	2.0	2.7	3.3	2.6
Poor performers				
Rwanda	3.8	1.1	6.4	2.0
Ethiopia	1.5	1.0	4.9	2.0
Uganda	0.5	4.0	2.7	1.8
Mauritania	0.7	2.3	2.3	1.6
Senegal	0.2	2.4	2.2	1.5
Madagascar	1.5	1.5	1.6	1.5
Liberia	2.9	-3.6	3.5	1.2
Mozambique	-0.7	-1.0	2.6	1.2
Sierra Leone	1.2	0.2	3.8	1.1
Somalia	2.3	-2.4	1.2	1.1
Democratic Republic of Congo	2.0	3.1	-1.2	1.0
Burundi	0.7	2.8	1.1	1.0
Mean	1.4	1.0	2.6	1.4

Source: Authors' calculations based on FAOSTAT database, Note*: All selected African countries.

production among poor performing countries averaged only 1.4% in 1968 to 1983 and 1.0% in 1984 to 93. There has been a recovery in the post-reform period of 1994 to 2008 (2.6%) but the growth was mainly driven by strong performance in Rwanda, Ethiopia, Sierra Leone and Liberia.

Following the introduction of the policy reforms, food production performance has improved in most countries in all the three groups. Annual growth rates in group one countries averaged 4.3% during the transition and post-reform period, compared to 2.2% during the pre-reform period. In group two countries, average annual growth rates increased to 2.7% in the transition period and 3.3% in the post-reform period, compared to 2.0% in the pre-reform period. Growth rates declined to 1% in the transition period but increased to 2.6% in the post-reform period in group three countries. Overall, growth rates averaged or exceeded 3% in 18 of the 30 countries (60%) between 1994 and 2008.

IMPACT OF FOOD PRODUCTION PERFORMANCE ON FOOD SECURITY

The impact of food production performance on food security is assessed in terms of per capita food supply, number of undernourished people and food self-reliance. Although, a direct correlation between food production performance and food security has not been proven, it is observed that domestic production plays a critical role in food security, particularly for regions like sub-Saharan Africa where it represents the main source of food consumption (FAO, 2012; O'Connell, 2008; Boon, 2007). Our results confirm that better food production performance is correlated with food security as measured by per capital food supply and FAO's estimations of undernourished people (Table 2 annex). Among the three groups, better performing countries experienced a longer period (1968 to 2007) of sustained increase in per capita food supply, increasing from 2,077 kcal/capita/day in 1968 to 1983, to 2,118 in 1984 to 1993 and 2,337 in 1994 to 2007 (Table 2 Annex). In the case of medium performers, average per capita food supply declined in the transition period and slightly improved in the post-reform period. The situation rather worsened in the case of poor performing countries, which lessen the level of food supply from 2,145 in 1968 to 1983 to 2,042 kcal/capita/day in 1994 to 2007. The difference between the three groups is more striking in terms of undernourishment. The prevalence of undernourishment in the total population averaged 14% in 2006 to 2008 among better performers, compared with 30% of medium and poor perfuming countries (Table 2). However, there are again marked variations between countries within each group.

Kenya and Malawi have the highest prevalence rate of undernourishment among the better performers while Niger, Cote d'Ivoire and Burkina Faso have the lowest rate (8% or less). The dominance of maize in daily diets and low rates of dietary diversity among low-income groups may explain the high rate of undernourishment in Kenya and Malawi (Smale et al., 2011). Levels of undernourishment are particularly high in Burundi, Ethiopia and Mozambique (among poor performers) as well as Zambia, Central African Republic and Chad (among medium performers). Over the years, there has been a steady decline in the proportion of undernourished people in most SSA countries over the past 18 years (2008 as compared to 1990) (FAO, 2011a), but the decline is more significant in better performing countries (-40%) than in medium (-23%) or poor performing countries (-8.5%) (Table 2). It is also evident that here are countries that are still at risk in better as well as medium and poor performing countries. For some countries such as Kenya (group one), Zambia (group two), and Uganda, Liberia and Burundi (group three), the proportion of undernourished people has changed very little or even increased (Table 2). Many SSA countries are not food self-sufficient and are expected to have export earnings that allow them to meet their food import needs (Fafchamps, 1992; Kasfir, 1986). This study compared the food trade balance and share of food import in total merchandise export to determine if SSA countries are exposed to food security risks emanating from trade. The results show that the food trade balance of good performing countries is better than medium or poor performing countries but the trend over time is one of a growing deficit in nearly all cases. For instance, the average food trade balance of the first group, which was positive for six of the nine countries during the pre-reform period (1968 to 1983), turned negative for all countries except Cote d'Ivoire and Ghana in 1994 to 2008. It should be noted that the positive food trade balance in Cote d'Ivoire and Ghana is mainly due to the fact that the two countries are the first and second biggest producers and exporters of cocoa in the world (ODI, 2007). For the first group as a whole, food trade balance changed from surplus in the pre-reform and transition period to negative in the post-reform period (Table 3a).

The food trade balance in group three countries as a whole worsened considerably over the years: the food trade deficit increased sharply in the transition and post-reform periods, averaging 1.65 billion USD per annum. No group three country registered a positive food trade balance in 1994 to 2008. The deficit also increased considerably in group two countries in the post-reform period. In general, the number of net food exporting countries declined from 15 in 1968 to 1983 to only 4 in 1994 to 2008 (Table 3a). The negative food trade balance on its own may not signify any danger to self-reliance in SSA countries. It is thus important to check if a country has sufficient export earnings to meet its food import needs. Indeed, with few exceptions, SSA countries have very limited importing capacity. Even among group one countries, food imports accounted for about 28% of the total value of export earnings during the period of 1968 to 2008, compared to a threshold share of 8.8% or less which is considered as food self-reliant or food secure at national level (Breisinger et al., 2010). For the poor performing countries, the share increased from 25% in the pre-reform period to 74% in the post-reform period, averaging 49% for the entire period. Food imports are relatively more affordable for the second group of countries, mainly because they have significant foreign exchange earnings from export of oil and other minerals [for example, Central Africa Republic (diamonds), Cameroon (petroleum), Chad (petroleum) Guinea (bauxite), Zambia (copper) and Congo (petroleum)]. For

Table 2. Performance in terms of food supply and undernourishment.

Country	Average food supply (kcal/capita/day)				Prevalence of undernourishment in total population	Proportion of undernourished in total population
	Pre-reform	Transition	Post-reform	Whole period	(%)	Change so far
	1968-1983	1984-1993	1994-2007	1968-2007*	2006-2008	1990-2008
Better performers						
Benin	1929	2127	2398	2143	12	-41
Burkina Faso	1723	2260	2574	2155	8	-40
Nigeria	1808	2097	2588	2154	11	-61
Côte d'Ivoire	2690	2539	2459	2572	6	-2
Ghana	1964	2074	2633	2226	14	-83
Niger	1979	1987	2136	2036	5	-55
Sudan	1956	1952	2155	2025	16	-44
Malawi	2322	1960	2052	2137	22	-37
Kenya	2319	2070	2042	2160	33	-1
Mean	2077	2118	2337	2179	14	-40.4
Medium performers						
Central African Republic	2335	1878	1900	2069	40	-8
Mali	1650	2094	2379	2016	12	-56
U.R. of Tanzania	2007	2174	1964	2034	34	15
Cameroon	2199	2024	2142	2135	22	-33
Guinea	2283	2393	2460	2373	16	-18
Chad	1773	1638	1940	1798	39	-36
Togo	1969	1866	2053	1973	30	-31
Zambia	2314	2037	1908	2103	44	23
Congo	1992	2037	2267	2099		-68
Mean	2058	2016	2113	2067	30	-23.6
Poor performers						
Rwanda	2180	1973	1898	2029	32	-28
Ethiopia	1644	1579	1794	1680	41	-40
Uganda	2296	2202	2254	2258	22	15
Mauritania	2091	2555	2746	2436	8	-34
Senegal	2230	2206	2190	2210	19	-14
Madagascar	2536	2304	2089	2322	25	24
Liberia	2402	2361	2140	2300	32	7
Mozambique	1844	1761	1960	1864	38	-36
Sierra Leone	2086	1950	2050	2040	35	-22
Somalia						
Democratic Republic of Congo	2227	2171	1649	2011	13	
Burundi	2056	1873	1689	1882	62	43
Mean	2145	2085	2042	2094	30	-8.5

Source: Authors' calculations based on FAOSTAT database, Note*: Data for 2008 not available.

Table 3a. Food trade balance (US$).

	Trade balance (1000$)			
	Pre-reform	**Transition**	**Post-reform**	**Whole period**
Country	**1968-1983**	**1984-1993**	**1994-2008**	**1968-2008**
Better performers				
Benin	-9140	-68966	-143027	-72715
Burkina Faso	-14428	-57204	-104203	-57706
Nigeria	-493362	-491904	-1444114	-840843
Côte d'Ivoire	340521	860851	1621715	936160
Ghana	376707	280625	335236	338100
Niger	13358	-38972	-78001	-32830
Sudan	32330	-27196	-191886	-64219
Malawi	19649	-23950	-18576	-4969
Kenya	18401	-13060	-144584	-48901
Mean	31560	46692	-18605	16898
Medium performers				
Central African Republic	-10432	-13403	-10087	-11030
Mali	26896	18126	-64715	-8760
U.R. of Tanzania	7474	-25004	-150318	-58176
Cameroon	117333	53850	3308	60133
Guinea	-8263	-75225	-153763	-77827
Chad	27048	19656	2088	16113
Togo	3168	-29923	-26493	-15754
Zambia	-51739	-38047	-36647	-42878
Congo	-19711	-71296	-137883	-75526
Mean	10197	-17919	-63834	-23745
Poor performers				
Rwanda	-10609	-41481	-63831	-37610
Ethiopia	10857	-169683	-195155	-108547
Uganda	-15016	-15891	-153927	-66051
Mauritania	-27990	-72881	-171876	-91580
Senegal	-34469	-174660	-533891	-251377
Madagascar	44039	61294	-12443	27583
Liberia	-39736	-65931	-95452	-66509
Mozambique	31748	-150614	-213827	-102575
Sierra Leone	-25483	-62621	-122084	-69883
Somalia	18115	-28758	-68211	-24900
Democratic Republic of Congo	-89502	-187735	-316656	-196567
Burundi	-11499	-20409	-35305	-22382
Mean	-12462	-77447	-165222	-84200

Source: Authors' calculations based on FAOSTAT database., Note*: Data for 2008 not available.

most of the non-mineral exporting countries, the share of food in total merchandise export is much higher.

Overall, only three countries, namely, Nigeria (better performer), Zambia and Congo (medium performers) registered a share below the critical threshold of 8.8% from the entire sample countries. SSA has become a net importer of food and of agricultural products, despite the region's vast agricultural potential and improved performance in recent years. For instance, Nigeria has a considerable agricultural potential, its food production performance averaged 3.5% in 1994 to 2008, and the country became the largest producer of cassava. At the same time, Nigeria's import of wheat increased from 675,282 tons in 1994 to 3,079,637 tons in 2008. Rice import increased from 350,000 to 971,815 tons over the same period. By 2010, wheat and rice import further

Table 3b. Share of food import on total merchandise exp.

Country	Pre-reform 1968-1983	Transition 1984-1993	Post-reform 1994-2008	Whole period 1968-2008
Better performers				
Benin	73.6	33.9	56.6	57.7
Burkina Faso	87.3	67.9	45.0	67.1
Nigeria	9.8	7.2	6.9	8.1
Côte d'Ivoire	13.6	12.4	9.1	11.7
Ghana	11.4	13.1	19.3	14.7
Niger	19.8	30.2	42.5	30.6
Sudan	24.4	41.0	23.9	28.2
Malawi	9.7	17.9	17.8	14.7
Kenya	9.5	13.8	20.0	14.4
Mean	28.8	26.4	26.8	27.5
Medium performers (AAGR for 1968-2008 greater than 2% and less than 3%)				
Central African Republic	20.7	18.2	16.2	18.4
Mali	37.1	31.4	17.8	28.7
U.R. of Tanzania	16.9	20.6	31.9	23.3
Cameroon	9.4	12.8	12.0	11.2
Guinea	14.2	14.1	22.5	17.2
Chad	20.8	17.4	11.5	16.6
Togo	17.3	27.3	18.7	20.3
Zambia	5.6	5.4	8.9	6.8
Congo	13.6	8.4	6.2	9.6
Mean	17.3	17.3	16.2	16.9
Poor performers (AAGR for 1968-2008 less than 2%)				
Rwanda	21.7	43.5	70.9	45.0
Ethiopia	11.6	65.8	48.6	38.3
Uganda	6.8	10.8	27.5	15.3
Mauritania	30.5	27.5	37.1	32.2
Senegal	41.5	40.4	53.6	45.6
Madagascar	18.5	16.6	28.1	21.5
Liberia	11.8	19.4	55.2	29.5
Mozambique	30.6	165.0	53.1	71.6
Sierra Leone	33.1	56.8	330.9	147.8
Somalia	60.2	99.3	84.9	78.8
Democratic Republic of Congo	13.2	25.2	34.3	23.8
Burundi	22.1	22.7	64.3	37.7
Mean	25.1	49.4	74.0	48.9

Source: Authors' calculations based on FAOSTAT database.

increased to nearly 4 and 2 million tons, respectively. Wheat import in Ethiopia (with one of the fastest production growth in recent years) increased from about 0.55 million tons in 1994 to 1.74 million tons in 2009[4]. It is also estimated that a significant proportion of sugar and sugar products, vegetable oils and milk products consumed in the countries of sub-Saharan Africa comes from abroad (OECD, 2008). Despite the recent improved performance, Africa's agricultural GDP per capita is the lowest in the world (one-fourth of world's average) (Rakotoarisoa et al., 2011), resulting in stagnat or declining per capita food production as shown earlier.

Various studies (Omamo et al., 2006; Diao et al., 2008; FAO, 2011a, 2010; UNCTAD, 2009) have documented the persistent rise in net food imports in Africa, and we will examine some of the key structural bottlenecks

[4] FAOSTAT: http://faostat.fao.org/site/535/DesktopDefault.aspx?PageID=535#ancor

subsequently.

SOURCES OF GROWTH AND THE KEY CHALLENGES TO SUSTAINABLE PRODUCTION INCREASE

Some experts agree that population growth, rising incomes, and urbanization will continue to drive demand growth for some foodstuffs, especially vegetable oils and livestock, with a higher derived demand for feed and industrial products (FAO, 2009; USDA, 2007; WHO, 2008). To cope with the rapidly growing demand, food production would need to increase significantly (Von Braun, 2008). The traditional response is expanding area under cultivation but a more sustainable option is yield improvement. The World Bank's report suggests that without improving technologies and raising yield levels, the "land rush" is unlikely to slow (Deininger et al., 2010). SSA countries have relied more on land expansion than on intensification to increase food production.

Sources of growth - area under cultivation and yield levels

Expansion of area under cultivation has remained the main strategy of increasing production in SSA countries. On average, area under cultivation expanded by 2.2% per annum over the last 40 years for better performers (Table 4a). The rate of expansion was greater than 3% per annum in the case of Sudan and Niger (Mosley, 2011). The pattern is similar in the medium performing countries, with an average expansion rate of 1.7% per annum. By contrast, growth in area under cultivation was slow (1.1%) among poor performers. Area growth rates were negative in Ethiopia [pre-reform and transition), Mauritania (pre-reform and post-reform), Liberia (transition), Somalia (transition and post-reform)]. While there is a substantial difference in the average growth rate of area harvested between the three groups, this rate drops to no significant difference when yield growth is considered. Yield growth averaged 0.6% in group one (better performing) countries, compared to 0.3% in group two and -0.3% in group three countries over the period of 1968 to 2008 (Table 4b). Within the first group, Benin experienced a negative yield growth rate over the 40 year period, while Malawi managed a relatively better performance (1.8%) and this is largely due to a significant yield improvement in the post-reform period (6.1% per annum). The yield performance of Chad (1.8%) and Mali (1.6%) is better than the other countries within medium performers, while Togo is the only country with negative growth rate (-2.9) among the group. On the other hand, within the poor performing countries, yield growth was negative for five out of the 12 countries and almost zero for further four countries (Table 4b). It is important to note that the performance of yield in Africa compares very unfavourably with the Green Revolution of Asia.[5]

African farmers have traditionally depended on shifting cultivation in response to the challenges of population growth and declining soil fertility. As shown earlier, opening new land is still a common strategy to increase production in nearly all the sample countries. The advantages of extensification are clear: new land means additional output at a lower cost than purchasing fertilizers and other inputs to increase yield on already cultivated lands. However, extensive agriculture is unsustainable for most countries (Dorward et al., 2004; Reardon et al., 2002). Average farm sizes are small (less than 1 ha for over 50% of the farms) and declining in sub-Saharan Africa, due to population pressures and an exhaustion of the arable land frontier, especially in the productive highland regions (Jayne et al., 2003). Extensive agriculture has also got major environmental drawbacks: extensification into permanent pasture, forest and watershed lands may lead to loss of biological diversity and land degradation (UNEP, 2012). On the other hand, increasing productivity on existing land enhances the economic value of food and agricultural production through forward and backward linkages in the form of input and output marketing, transport, export and processing increases. Increasing productivity also avoids greenhouse gas emissions and the large-scale disruption of existing ecosystems due to bringing new land into production (Edgerton, 2009). As discussed as follows, improving yield on a sustainable basis has eluded SSA countries.

Challenges to sustainable increase in food production

Sustainable intensification is producing more output from the same area of land while reducing the negative environmental impacts. It is commonly achieved through the use of high yield crop varieties along with fertilizers (both organic and inorganic) and management practices which conserve and improve soil and water productivity (FAO, 2011b). A number of challenges have made it very difficult for SSA countries to achieve a sustainable increase in food production.

Limited utilization of inputs and irrigation

There are no reliable data on the use of improved seeds but available evidences indicate adoption rates are very low in SSA. For instance, the adoption of improved open-pollinated varieties and hybrids of maize is estimated at 44% of maize area in Eastern and Southern Africa in 2006 to 2007, excluding South Africa. Some 56% of

[5]Between 1965 and 1982, average rice, maize and wheat yields increased by 2.54, 3.48 and 4.07% per year, respectively in Asia countries that adopted Green Revolution technologies. Cultivated area expanded by only 0.7, 1.09 and 1.3%, respectively, over the same period (Thapa and Gaiha, 2011).

Table 4a. Performance in terms of area harvested (average annual growth rate).

Country	Annual average growth rate			
	Pre-reform	Transition	Post-reform	Whole period
	1968-1983	1984-1993	1994-2008	1968-2008
Better performers (AAGR for 1968-2008 greater than 3%)				
Benin	0.8	2.5	2.6	2.5
Burkina Faso	0.6	3.7	2.3	1.9
Nigeria	-5.0	8.1	1.4	2.6
Côte d'Ivoire	1.8	3.3	-0.7	0.9
Ghana	-0.1	0.6	2.5	2.2
Niger	3.3	8.4	2.5	3.9
Sudan	5.2	1.1	0.5	3.2
Malawi	0.8	1.9	2.6	1.5
Kenya	0.6	4.0	0.5	1.0
Mean	0.9	3.7	1.6	2.2
Medium performers (AAGR for 1968-2008 greater than 2% and less than 3%)				
Central African Republic	1.2	0.3	2.3	0.3
Mali	1.5	7.7	3.1	2.8
U.R. of Tanzania	2.8	0.6	5.3	2.3
Cameroon	1.1	2.4	3.8	1.2
Chad	-1.5	3.5	3.8	2.4
Guinea	1.6	3.5	4.0	3.0
Togo	1.9	3.5	0.7	2.9
Zambia	-4.6	4.2	0.7	-0.4
Congo	-0.2	-1.2	1.9	0.5
Mean	0.4	2.7	2.8	1.7
Poor performers (AAGR for 1968-2008 less than 2%)				
Rwanda	3.6	2.5	5.2	2.2
Ethiopia	-2.0	-1.1	3.0	1.3
Uganda	-0.2	3.1	1.9	1.3
Mauritania	-3.8	1.4	-1.2	1.3
Senegal	-0.6	-0.7	1.1	0.5
Madagascar	1.7	0.8	0.9	1.0
Liberia	2.1	-7.8	5.3	-0.3
Mozambique	2.4	0.4	0.4	1.8
Sierra Leone	1.6	2.1	8.1	1.6
Somalia	2.4	-6.2	-0.6	0.6
Democratic Republic of Congo	2.2	3.4	-0.8	1.3
Burundi	1.1	1.3	0.6	0.8
Mean	0.9	-0.1	2.0	1.1

Source: Authors' calculations based on FAOSTAT database.

smallholders have no access to improved varieties (Smale et al., 2011; Langyintuo et al., 2008). The situation is relatively better in West Africa where the adoption rate of improved seeds was estimated at 60% in 2005 (Smale et al., 2011). As already indicated, most of the better performing countries are from West Africa. Several factors have hampered the emergence of an efficient seed market in Africa: i) inadequate certification, licensing and enforcement capacity, ii) lack of knowledge on varietal characteristics and performance, iii) lack of credibility and adulteration of seed, and iv) limited access to credit facilities. These problems are clear indications of market failure, market inefficiency and institutional weaknesses. Adoption is often constrained by lack of finance. Lack of partnership and collaboration between public and private seed companies is a major gap in SSA

Table 4b. Performance in terms of yield (average annual growth rate).

Country	Annual average growth rate			
	Pre-reform	Transition	Post-reform	Whole period
	1968-1983	1984-1993	1994-2008	1968-2008
Better performers				
Benin	0.7	-3.0	1.9	-1.6
Burkina Faso	n.a	n.a	n.a	n.a
Nigeria	0.5	2.2	0.3	0.6
Côte d'Ivoire	1.7	-1.0	1.3	1.1
Ghana	0.0	5.2	0.6	1.5
Niger	1.7	1.0	2.5	0.0
Sudan	0.5	0.4	-1.1	0.3
Malawi	0.4	0.7	6.1	1.8
Kenya	1.2	3.5	1.0	1.3
Mean	0.7	1.0	1.4	0.6
Medium performers				
Central African Republic	1.0	0.3	0.1	0.5
Mali	-0.9	3.5	3.8	1.6
U.R. of Tanzania	3.2	0.2	0.5	0.5
Cameroon	1.0	0.2	-1.0	0.3
Chad	0.6	1.8	1.1	1.8
Guinea	0.1	-0.1	-0.1	0.0
Togo	-0.7	-3.6	0.0	-2.9
Zambia	0.5	0.3	-0.2	0.1
Congo	1.5	1.1	0.3	1.0
Mean	0.7	0.4	0.5	0.3
Poor performers				
Rwanda	-0.1	-4.1	1.8	-1.0
Ethiopia	1.8	0.2	0.9	0.6
Uganda	0.2	0.8	0.9	0.5
Mauritania	-0.6	-0.6	-3.4	-0.9
Senegal	0.3	-2.8	-0.2	-1.0
Madagascar	0.1	0.6	0.4	0.2
Liberia	1.0	-0.1	0.1	0.3
Mozambique	-0.2	-0.6	0.7	0.3
Sierra Leone	0.3	-3.7	-0.4	-2.6
Somalia	-0.9	-1.6	-1.4	-0.9
Democratic Republic of Congo	0.2	0.2	-0.2	0.2
Burundi	0.0	1.5	1.0	0.6
Mean	0.2	-0.9	0.0	-0.3

Source: Authors' calculations based on FAOSTAT database. , n.a = not available or reliable.

(Erenstein et al., 2011; Odame and Muange, 2011; Scoones and Thompson, 2011). As far as fertilizer is concerned, FAOSTAT data shows that consumption is slightly higher among the first group: on average, better performing countries used 8 kg of fertilizer (plant nutrients) per ha, compared to 6 and 3 kg/ha among medium and poor performing countries, respectively (Table 5a). Despite the inherently low soil fertility, the quantity of fertilizer consumption per unit of farmland in SSA is the lowest in the world and well below the level that sustains rapid yield increases. Fertilizer application rates in SSA as a whole is only 10 kg of nutrients per hectare (ha) of arable land, compared with 86 kg/ha in South Asia, 118 kg/ha in Latin America, 198 kg/ha in an average middle-income country, and 288 kg/ha in a high-income country (Hernandez and Torero, 2011).

Apart from shortage of complementary inputs such as high yield varieties and irrigation, both supply and

Table 5a. Fertilizer consumption nutrient per ha of arable land.

Country	Kilograms fertilizer nutrient per hectare of arable land			
	Pre-reform	Transition	Post-reform	Whole period
	1968-1983	1984-1993	1994-2008	1968-2008
Better performers				
Benin	2	5	8	5
Burkina Faso	1	4	7	4
Nigeria	2	9	6	5
Côte d'Ivoire	9	9	23	14
Ghana	6	3	6	5
Niger	0	0	0	0
Sudan	4	5	4	4
Malawi	9	21	23	17
Kenya	13	20	28	20
Mean	5	8	12	8
Medium performers				
Central African Republic	1	1	0	0
Mali	4	9	9	7
U.R. of Tanzania	3	5	4	4
Cameroon	3	4	6	4
Guinea	2	1	2	2
Chad	1	1	1	1
Togo	1	4	5	3
Zambia	23	33	26	27
Congo	2	2	4	3
Mean	4	7	6	6
Poor performers				
Rwanda	0	1	2	1
Ethiopia	2	6	12	6
Uganda	1	0	1	1
Mauritania	3	8	3	4
Senegal	5	4	7	6
Madagascar	3	2	3	3
Liberia	8	2	0	4
Mozambique	5	1	3	3
Sierra Leone	3	3	1	2
Somalia	2	2	0	1
Democratic Republic of Congo	1	1	0	1
Burundi	1	3	2	2
Mean	3	3	3	3

Source: Authors' calculations based on FAOSTAT database.

demand constraints have made fertilizer expensive in Sub-Saharan Africa. The cost of importing fertilizer is high because of the small volume that many countries import and inadequate port facilities. Transport and logistics costs in Africa are often very high, making fertilizer in Sub-Saharan Africa at least double more expensive than in Asia and the US (Smale et al., 2011; Morris et al., 2007). Market failures and inefficiencies affecting seed markets (discussed earlier) have also constrained the emergence of a viable fertilizer markets in SSA. Turning to irrigation system, it is clear that SSA countries have made little effort to expand area under irrigation. The share of arable land under irrigation showed no change over the past 40 years and stayed at an average of 2.3% among group one or better performing countries (Table 5b). The only country with

Table 5b. Share of total area equipped for irrigation in total arable land.

Country	Period average (%)			
	Pre-reform	Transition	Post-reform	Whole period
	1968-1983	1984-1993	1994-2008	1968-2008
Better performers				
Benin	0.4	0.6	0.5	0.5
Burkina Faso	0.3	0.5	0.6	0.5
Nigeria	0.7	0.7	0.8	0.8
Côte d'Ivoire	1.8	2.5	2.6	2.2
Ghana	1.0	1.0	0.8	0.9
Niger	0.2	0.5	0.5	0.4
Sudan	13.9	13.9	10.9	12.8
Malawi	0.6	0.9	1.7	1.1
Kenya	1.0	1.1	1.7	1.3
Mean	2.2	2.4	2.2	2.3
Medium performers				
Central African Republic	0.0	0.0	0.1	0.0
Mali	3.2	3.2	4.1	3.6
U.R. of Tanzania	1.0	1.6	1.8	1.4
Cameroon	0.2	0.4	0.4	0.3
Guinea	8.8	11.4	6.9	8.7
Chad	0.3	0.5	0.7	0.5
Togo	0.1	0.3	0.3	0.2
Zambia	0.7	1.5	5.6	2.7
Congo	0.2	0.2	0.4	0.3
Mean	1.6	2.1	2.3	2.0
Poor performers				
Rwanda	0.6	0.5	0.8	0.7
Ethiopia	1.2	1.6	2.6	1.8
Uganda	0.1	0.2	0.2	0.2
Mauritania	16.2	13.6	10.2	13.4
Senegal	2.2	2.7	3.4	2.8
Madagascar	21.3	34.9	37.1	30.4
Liberia	0.5	0.7	0.8	0.6
Mozambique	1.6	3.0	2.8	2.4
Sierra Leone	3.2	5.8	4.2	4.2
Somalia	11.8	19.7	18.2	16.1
Democratic Republic of Congo	0.0	0.1	0.2	0.1
Burundi	1.5	1.7	2.2	1.8
Mean	5.0	7.0	6.9	6.2

Source: Authors' calculations based on FAOSTAT database.

significant level of irrigated agriculture is Sudan and the trend over time is a decline instead of an expansion. In Zambia, area equipped for irrigation increased from 46,000 in 1996 to 156,000 ha in 2008. The level of irrigation is relatively better among poor performing (Group 3) countries with an average of 6.2% of arable land under irrigation over the period of 1968 to 2008. The proportion also increased over time, from 5% in 1968 to 1983 to 6.9 to 7.0% in the transition and post-reform period (Table 5b). However, the extent of irrigation in the group is influenced mainly by three countries, Madagascar, Mauritania and Somalia. The latter two countries are arid and rely on irrigation for much of their agricultural production, while Madagascar has a traditional irrigation-based rice cultivation system. Given the poor performance of the three countries, it appears that irrigation systems have not been effectively utilized probably due to lack of complementary inputs and effective management practices. Lack of technical expertise, inconsistent and poor government policies and programs, weak research capacity, and underdeveloped markets, among others, seem to have hampered the emergence of productive irrigation agriculture in SSA (ICID, 2010).

Inadequate policy support to intensification

Between the mid-1980s and early 1990s, several African countries adopted the structural adjustment programs (SAPs) that included liberalization of output and input prices, devaluation of local currency, removal of subsidies and dismantling of parastatals. Most SSA countries moved to market-determined exchange rates and open trade regimes. Net taxation of agriculture decreased, which, together with competition in the market place, created a more positive environment for agricultural investment (Anderson and Masters, 2009; Jayne et al., 2002). However, the fact that the production increase was obtained largely through area expansion indicating that the reform has not provided sufficient incentive to intensify production even in better performing countries. Besides, currency devaluations and subsidy removals tended to temporarily reduce fertilizer consumption in nearly all regions of SSA (Kelly, 2006). The cost of inputs such as fertilizer rose sharply, making it unaffordable for many smallholders. As a result, some countries were forced to re-introduce subsidy programs. For instance, Malawi (from group one) implemented a large scale input subsidy program known as 'starter pack' in the 1998/1999 and 1999/2000 agricultural seasons. The program was scaled down to 'targeted input program' in 2000/2001 but expanded as large scale Agricultural Input Subsidy Program in 2005/2006 (Dorward, 2009). Malawi's exceptional performance in the post-reform period (1994 to 2008) could be related to the fertilizer and hybrid seed subsidy program of the government that has been in force since the late 1990s (Buffie and Atolia, 2009).

In Nigeria (group one), the Developing Agricultural Inputs Markets in Nigeria (DAIMINA) project introduced vouchers in 2004 to support agro-dealer development and improve producer access to and use of inputs. Other countries, including Burkina Faso, Ghana, and Kenya from group one as well as Mali, Tanzania and Zambia from group two, and Rwanda and Senegal from group three have implemented input subsidy programs since 2007/2008 (Druilhe and Barreiro-Hurlé, 2012). Inadequate rural financial services following the economic reform and the poor performance of state-owned agricultural development banks have also constrained farmers' access to input loans and discouraged intensification. Private commercial banks have shown limited interest in expanding their operations in rural areas, following the financial liberalization programs (Gonzalez-Vega, 2003). The failure of special credit lines to agriculture has left gaps in financial services in many countries (World Bank, 2008). In Nigeria, for instance, agricultural financing has a long history and various attempts to supply loans to farmers was met with limited success (Mafimisebi et al., 2010; Ugwu and Kanu, 2012).[6] State-owned agricultural development banks were allowed to operate in some countries but they performed poorly, although, there have been some notable exceptions. The reformed Banque Nationale de Développement Agricole of Mali is currently operating as a second-tier institution offering refinancing facilities and savings products (Making Finance Work for Africa Secretariat, 2012). Liberalization of output markets was expected to raise producer prices and improve the incentive to use inputs. However, the performance of food staple markets in SSA is often hampered by poor infrastructure, limited capacity of grain traders, inadequate support services, and weak institutions, thus giving rise to high transaction costs and price volatility.[7] In Ethiopia, for instance, maize prices collapsed from 150 Birr/quintal to 20 to 30 Birr/quintal in 2001 to 2002. Ethiopian farmers could not repay their production loans and a major crisis occurred. Farmers generally consider such price collapse a principal factor discouraging new technology introduction (Sanders and Shapiro, 2006). In Tanzania, for instance, producer prices have shown considerable seasonal variability after market liberalization, falling to very low levels immediately after harvest (when most farmers sell their produce) and rising to very high levels just before the next main harvest. Price uncertainty has not encouraged investment in inputs (Skarstein, 2005). Unpredictable government operations in grain markets, lack of quality standards with respect to moisture content, and threat of grain confiscation, among others, have discouraged investment in market stabilizing activities such as grain storage (Jayne et al., 2010)[8]. A major problem in SSA is the absence of risk management tools to deal with price and

[6]Agricultural loans were given at concessionary interest rates and beginning in 1972 commercial and merchant Banks were mandated to extend a prescribed minimum percentage of their loan portfolio to agriculture. However, such measures were found inconsistent with financial-sector reform and the policy was abolished in 1996. Cooperatives, friends, and family members dominate the sources of farm credit among small farmers in Nigeria, and the total amount obtained from these sources is often very limited compared to the amount that formal financial institutions would have offered (Phillip et al., 2009).

[7]In Africa, high transport costs due to poor roads, high fuel prices, administrative procedures which cause delays, etc. have resulted in high marketing costs which lower grain prices for producers and raise prices for consumers. In East Africa, for instance, prices [per ton-kilometer (tkm)] on the Mombassa – Kampala (linking Uganda with Kenya) are more than two times higher than in Brazil and four times higher than in Pakistan (Teravaninthorn and Raballand, 2009).

[8] Jyne et al. (2010) Patterns and Trends in Food Staple Markets in Eastern and Southern Africa: Towards the Identification of Priority Investments and Strategies for Developing Markets and Promoting Smallholder Productivity Growth, MSU International Development Working Paper No. 104.

Table 6. Average number of conflict-related deaths.

Country	Number of people			
	Pre-reform	Transition	Post-reform	Period
	1968-1983	1984-1993	1994-2008	1968-2008
Better performers				
Benin	0	0	0	0
Burkina Faso	0	100	0	100
Nigeria	60484	0	124	60608
Côte d'Ivoire	0	0	1265	1265
Ghana	74	0	0	74
Niger	0	172	1284	1457
Sudan	23380	35389	21030	79799
Malawi	0	0	0	0
Kenya	318	0	0	318
Mean	9362	3962	2634	15958
Medium performers				
Central African Republic	0	0	546	546
Mali	0	150	247	397
U.R. of Tanzania	0	0	0	0
Cameroon	0	500	0	500
Guinea	19643	12402	5257	37302
Chad	0	0	1174	1174
Togo	0	262	0	262
Zambia	0	0	0	0
Congo	0	660	9945	10605
Mean	2183	1553	1908	5643
Poor performers				
Rwanda	0	10000	14454	24454
Ethiopia	224065	126882	9802	360749
Uganda	63613	50880	8137	122629
Mauritania	2615	0	0	2615
Senegal	0	384	889	1273
Madagascar	128	0	0	128
Liberia	27	15298	3469	18794
Mozambique	41253	123751	0	165005
Sierra Leone	0	1400	12812	14212
Somalia	1828	60761	12339	74928
Democratic Republic of Congo	919	0	151618	152537
Burundi	0	1984	9563	11547
Mean	27871	32612	18590	79073

Source: Encyclopedia of the Nations, http://www.nationsencyclopedia.com/WorldStats/WDI-poverty-conflict-fragility-deaths.html

production risks. Price and market stabilization schemes or commodity exchange systems with futures and options for price risk management are largely non-existent in SSA (Demeke et al., 2012).

High incidence of external shocks

Apart from deficient policies and inadequate economic incentives, external shocks in the form of conflict and uncertain rains have affected investment in farm inputs and technology. The majority of the 12 countries within the poor performers are known to have gone through some armed conflict and severe political instability during the period under consideration, namely: Rwanda, Ethiopia, Uganda, Mauritania, Senegal, Madagascar, Liberia, Mozambique, Sierra Leone, Somalia, Democratic Republic of the Congo and Burundi (Tables 6 and 7). Strong production performance in Rwanda, Ethiopia, Sierra Leone and Liberia in the post-reform period is also

Table 7. Average annual rainfall (mm).

Country	Average rainfall in mm			
	Pre-reform	Transition	Post-reform	Whole period
	1968-1983	1984-1993	1994-2000*	1968-2008
Better performers				
Benin	994	1002	1051	1017
Burkina Faso	745	715	771	747
Nigeria	1114	1097	1172	1131
Côte d'Ivoire	1309	1280	1326	1308
Ghana	1143	1137	1146	1143
Niger	151	145	166	155
Sudan	404	396	438	414
Malawi	1098	1034	1091	1080
Kenya	619	603	669	633
Mean	842	823	870	848
Medium performers				
Central African Republic	1335	1293	1350	1330
Mali	293	276	313	296
United Republic of Tanzania	1016	995	1014	1010
Cameroon	1581	1539	1598	1577
Guinea	1646	1542	1690	1636
Chad	325	298	351	328
Togo	1150	1139	1172	1156
Zambia	992	926	993	976
Congo	1603	1582	1605	1599
Mean	1105	1065	1121	1101
Poor performers				
Rwanda	1139	1036	1091	1096
Ethiopia	782	725	765	762
Uganda	1171	1120	1168	1157
Mauritania	79	77	92	83
Senegal	649	643	712	671
Madagascar	1418	1479	1481	1456
Liberia	2399	2264	2481	2396
Mozambique	983	938	1016	984
Sierra Leone	2460	2287	2403	2397
Somalia	235	238	274	250
Democratic Republic of the Congo	1510	1499	1480	1496
Burundi	1248	1215	1205	1224
Mean	1173	1127	1181	1164

Sources: Country aggregated rainfall time-series dataset was created by Hideki Kanamaru, NRC, FAO from CRU TS 3.1 of University of East Anglia Climate Research Unit (CRU). [Phil Jones, Ian Harris]. CRU Time Series (TS) high resolution gridded datasets 3.1, [Internet]. NCAS British Atmospheric Data Centre, 2008. Available from http://badc.nerc.ac.uk/view/badc.nerc.ac.uk__ATOM__dataent_1256223773328276, accessed April, 2011.

associated with the end of serious civil wars (Collier et al., 2002). Persistent conflict has resulted in poor or negative food production performance in Somalia, Democratic Republic of the Congo and Burundi. Among the first group of countries, Sudan is the most affected by violent conflict but it has managed to sustain its better performance because production is concentrated in irrigated areas where the problem of conflict is limited (Keen, 1994, 1998, 2000). Similarly, the recent conflict in Cote d'Ivoire can be considered as a major contributing factor to the slow growth in the post-reform period, which lowered the growth of food production to 2.3% compared to 3.3% recorded during the transition period (Table 1). Comparably, Nigeria's poor growth during the pre-reform period could also be associated with the violent – the Biafra War – of 1967 to1970 (Richards, 2006).

The impact of conflict on food production and food security has been documented by other studies. Messer et al. (1998), for instance, estimated that food production in 13 war-torn SSA countries during 1970 production in 13 war-torn food security has been mpared to peace years. FAO study also estimated that conflict induced losses of agricultural output totalled $121 billion in real terms (or an average of $4.3 billion annually) during the period of 1970 to 1997 (FAO, 2000). Climate variability is another major risk constraining the adoption of improved technologies and inputs in many parts of Africa (Barret, 2002). Globally, Africa faced the highest frequency during the period of 1960 to 2006 with a total of 382 reported drought events, compared to 165 in Asia, the region the next highest frequency (Gautam, 2006). It is reported that about 60% of SSA is exposed to drought and 30% so extremely. Part of the Sahel as well as Eastern and Southern Africa are among the most affected (Benson and Clay, 1998). African countries are also affected by floods that cause loss of life, damage to property, and promote the spread of diseases such as malaria, dengue fever and cholera. Rainfalls accompanying tropical cyclones often result in flood disasters in Mozambique. Many parts of Ethiopia, Kenya and Somalia are also vulnerable to flood. Madagascar and Mozambique are among countries most often affected by cyclones (ICSU Region Office for Africa, 2007). With little or no access to insurance or other production risk management tools, hazards related to weather, pests and diseases have impeded technology adoption, resulting in poverty traps in SSA.

CONCLUSION

The performance of the food production sector in Sub-Saharan Africa (SSA) is critical for a number of reasons. First domestic production is the principal avenue to ensuring access to affordable food in poor countries with limited capacity to import food. The multiplier effect of sustainable food production on the economy is considerable as it has direct linkage with other activities such as transportation, marketing, warehousing, food processing, tourism and local commerce. In countries where the growth of food production outpaces demand, social and political harmony as well as macroeconomic stability can be maintained, paving the way for sustained economic growth. This paper examines changes in food production performance among 30 SSA countries over the period of 1968 to 2008. The countries were grouped into three: the comparatively better, medium and poor performers – based on their food production performance. Three different periods, representing the pre-reform, transition and post-reform, were also identified to pay particular attention to the impact of policy reforms. The results support previous findings that not many countries have managed to achieve a food production average growth rate in excess of 3% per annum. Indeed, only 9 or 30% of the sample countries achieved such growth rates over the period of 1968 to 2004.

Annual food production performance averaged 3% or more in 60% of the sample countries following the policy reforms. Nevertheless, rates of output growth varied from one period to the other and the recent improved performances were achieved largely through unsustainable expansion of land under cultivation. At an average application rate of 10 kg of nutrients per ha of arable land, fertilizer use levels in SSA are only 5% of the level in an average middle income country. Not surprisingly, Africa's agricultural GDP per capita is only one-fourth of world's average and per capita food production is stagnant or declining. Better food production performance is associated with better availability of food supply and lower rates of undernourishment. The prevalence of undernourishment in the total population averaged 14% in 2005 to 2008 among better performers, compared with 30% among medium and poor perfuming countries. However, most countries have failed to achieve food self-reliance. With domestic supply lagging behind rapidly expanding demand, most countries have experienced a substantial increase in their food import spending in recent years (1994 to 2008) and have faced serious food security concerns following the hikes in international food price and high levels of volatility that began in 2007/2008. The deficit in food trade balance has sharply increased in nearly all cases, and with few exceptions, SSA countries have very limited capacity of financing their food import bills. Even among better performing counties, food imports accounted for about 27% of the total value export earnings during the period of 1994 to 2008. The share averaged 74% among poor performing countries over the same period. Imported food items are also expensive in the local markets owing to high cost of freight, port charges, domestic transport and marketing margins. Locally produced staples are cheaper, but a more sustainable and higher growth of domestic production is constrained by lack of public support programs and absence of effective measures to address market failures and inefficiencies in input, output, credit, land and risk management markets. Weak institutions, which are often aggravated by conflict and political instability, have hampered investment in the food value chain and made it very difficult for farmers to access inputs and new technologies.

Building institutions that foster partnership between governments and farmers, traders, processors and other stakeholders along the value chain and facilitate the emergence of a stable and competitive markets is critical to ensure food availability, affordability/ accessibility and stability in SSA. Without a significant increase in budgetary allocations to build institutional capacity, develop market infrastructure, expand irrigation schemes, ensure sustainable natural resource utilization, transform agricultural research and development, and build capacity for climate change mitigation and adaption, as rightly advocated by the Comprehensive Africa Agriculture Development Program (CAADP) of the African Union, the food security situation is likely to worsen further for many SSA countries. The views expressed are purely those of the writers and may not in any circumstances be regarded as stating an official position of FAO and the European Commission.

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Review

Eradicating extreme poverty among the rural poor in Uganda through poultry and cattle improvement programmes - A Review

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Uganda is still struggling with chronic poverty and malnutrition especially among women and children despite the targeted efforts towards eradicating poverty by transforming subsistence agriculture to intensive or commercial agriculture that have been in place for the last 13 years. The aim of this paper was therefore to analyze the Republic of Uganda's current strategy on eradication of extreme hunger and poverty, identify the major constraints and suggest possible strategic interventions using examples of poultry and cattle. The article has identified unemployment and persistent inflation as major constraints to modernization of agriculture in Uganda and has offered development of small holder poultry production, promotion of poultry crossbreeds, rehabilitation of community dip tanks and promotion of dairy crossbreeds as strategic intervention areas to alleviate extreme hunger and poverty in Uganda. In conclusion, the strategies used by the government of Uganda to fight poverty and hunger did not favour the rural poor but have supported the rich and thus failed to cause a notable impact. It is therefore recommended that adoption of the suggested intervention areas shall overcome the said bottlenecks and accelerate eradication of hunger and poverty.

Key words: Livestock improvement, poverty eradication, rural farmers.

INTRODUCTION

Over 85% of Uganda's population lives in rural areas where agriculture is the major contributor to their livelihoods. Livestock accounted for 16% of agricultural Gross Domestic Product (GDP) in 2003, fisheries (12%), cash crops (17%) and the rest came from food crops (RoU, 2004). Despite the fact that agriculture supports most livelihoods and is the main source of exports, contributing as much as 85% of export earnings, the overall share of agriculture in GDP has declined in recent years, from 50% in the early 1990s to 23% in 2008 (RoU, 2004; FAO, 2009). A slowdown in the growth of agricultural production besides declining agricultural prices and insecurity in northern and eastern Uganda have all contributed to the drag on agriculture (FAO, 2010). Consequently, many communities in Uganda struggle with chronic malnutrition, especially among children. The prevalence of stunting growth among children less than five years of age is nearly 40% across the country, and is higher in Karamoja and the southwest, where it exceeds 50% (Kikafunda et al., 1998; FAO,

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2010; WFP, 2011). Malnutrition accounts for 40%of all child deaths in Uganda (Bridge et al., 2006), and the prevalence of childhood anemia exceeds 70% (WFP, 2011). According to von Grebmer et al. (2011), Uganda has a Global Hunger Index (GHI) score of 16.7, placing it 42nd out of 81 countries ranked in 2011 and a hunger situation considered as being *serious*. The Millennium Development Goal (MDG) which seeks to cut the number of underweight children in half before 2015 thus remains elusive. However, the agricultural sector presents a great opportunity for poverty eradication since it employs over 80% of the labour force (MAAIF, 2000).

The Plan for Modernization of Agriculture (PMA) has been part of the government of Uganda's broad strategy on poverty eradication contained in the Poverty Eradication Action Plan (MAAIF and MFPED, 2004). The mission of the PMA has been to eradicate poverty by transforming subsistence agriculture to commercial agriculture. Under PMA, the government of Uganda formulated the National Agricultural Advisory Services (NAADS) programme (RoU, 2001) to transform natural resource based communities out of poverty to better livelihoods. The programme was meant to increase farmer access to information, knowledge and technology through effective, efficient, sustainable and decentralized extension service delivery with increased private sector involvement. However, poverty levels in Uganda have remained high. Uganda's national poverty levels stood at 24% in 2010 with Northern region registering 46.2%, the highest in the country (UBOS, 2010). The impact of poverty reduction strategies has been minimal (Kaduru, 2011). The aim of this article was therefore to analyse the Republic of Uganda's current strategy on eradication of extreme hunger and poverty, identify the limitations and suggest possible strategic interventions using examples of poultry and cattle.

OVERVIEW OF UGANDA'S NAADS PROGRAMME

The NAADS programme has gone through a number of policy changes. The strategic frame work that guided NAADS Phase I was a decentralized, farmer owned public/private sector serviced extension system contributing to the realization of the agricultural sector objectives (RoU, 2001). Advisory services were provided by service providers termed Agricultural Advisory Service Providers (AASPs) contracted by the sub-county on behalf of sub-county farmer forum. In contracting AASPs, the following guiding principles were observed: Farmer participation, competitive and transparent selection process, previous performance, qualification and integrity. Sources of AASPs have been contracted service providers, researchers and private sector providers under public/private sector partnerships. These were supported by subject matter specialists (SMSs), model farmers and community based facilitators.

In 2010, the National Development Plan was formulated (NDP, 2010).

Thus, NAADS was redesigned under phase II to align NAADS with National Development Plan and Strategic Investment Plan (MAAIF, 2010; NDP, 2010; MFPED, 2010) and to enhance the effectiveness of Agricultural Advisory Services delivered within the frame work of NAADS vision, mission and principles.The strategic elements of NAADS phase II were to create option for financing and delivery of extension/advisory and technical services appropriate for different farmer categories, gradually reduce the share of public financing of public advisory/extension service cost to the extent that by the end of 25 years of NAADS it will account for less than 50% through PPP, utilize professional and certified service providers competitively recruited and on performance based contracts, empower subsistence and other farmer categories to access extension/advisory services and relevant information for informed decision making and to develop public and private sector capacity professional capability and service systems. Under NAADS Phase II (MAAIF, 2010), the Agricultural technology and agribusiness advisory services (ATAAS) project was aligned to NDP and the DSIP. ATAAS was designed to support implementation of programmes of the National Agricultural Research Organisation (NARO) and NAADS. The project is to support key activities along research, extension, farmer-market value chain continuum through five components.

The mandate of ATAAS is to promote productivity and Agricultural Production through close collaboration between research by NARO and extension by NAADS under the DSIP of MAAIF. The ATAAS Project began in July 2011 (MAAIF, 2010). The first component comprises technology promotion and farmer access to information. This targets advisory service provision to accelerate farmer progression towards commercialization while ensuring food security. Component two is concerned with agribusiness development for supporting market access so to shift from direct intervention by NAADS in supporting farmer enterprises to facilitate the performance for value chain and functioning or emergence of businesses that can provide production support services that contribute to value chain development and input and output market access among others. The third component comprises institutional development and programme management. This handles roles, responsibilities and institutional relationships between NAADS and all institutions (public and private) especially local government to accommodate new changes to the NAADS mandate. Component four involves planning, monitoring and evaluation to enhance the use of participatory monitoring and evaluation (PM&E) information in management decision making and to develop human organizational financial and network capacity for PM&E (MAAIF, 2010). Studies conducted have however demonstrated that NAADS interventions have not had a notable impact (Benin et al., 2007; EPRC, 2011).

MAJOR CONSTRAINTS TO MODERNISATION OF AGRICULTURE IN UGANDA

Like most developing countries, Uganda's economy is dominated by two large problems: unemployment and inflation. These form the major constraints for the planning of the development of the livestock sector. This section will discuss these constraints and how they could have impacted on the modernisation of the livestock sector in Uganda.

Unemployment

According to UBOS (2010), 66% of all working persons in Uganda are employed in agriculture, 82% of the workers live in rural areas where agriculture is the main source of livelihood, 70% of the labour force does not have any formal education while the unemployment rate stands at 4.2%. If the increase in production is to be brought about by modernisation and intensification of animal production, and technically it could be, this will only occur in a capitalist form that is to say by substituting capital for labour by relatively elaborate techniques which will not permit the use of the rural youth and the unemployed (Tacher, 1992). Introduction of modern large-scale industrial livestock units would lead to problems for smallholder producers who cannot compete for available feed resources and markets (Ogle and Phuc, 1997) and may not have the skills for the more sophisticated management which is required (Preston, 1995). Uganda's strategy of distributing broiler and layer chicks to rural youth groups could have failed due to limited management skills. This usually results in a reduction of rural employment opportunities and easily turns the problem of rural unemployment into an even greater problem of urban unemployment.

Besides, often these techniques cause a transfer from the peasant class towards the well-off classes of the population, classes more open to modern technology (Tacher, 1992). For example an increase in milk production can mainly be brought by a leap in technology, which often can only be done by people with sufficient means who have received some level of education. This type of person is found among those sectors of the population already in the favoured position. In Uganda over two thirds of the working population work in the rural areas and 70% of the labour force does not have any formal education (RoU, 2004; UBOS, 2010) and often provide production which is insufficient at the national level. Modernisation might then permit an increase in production but might never help in the resolution of the crucial problem of unemployment and might even risk accentuating it. The disadvantaged people will be faced with impoverishment, the gap between the few rich and the major poor will become larger and larger, and social evils will become a heavy burden (Trach, 2009). Already, data indicates that Uganda's Gini coefficient has been rising over the years, and currently stands at 0.426, (UBOS, 2010) indicating a worrying trend towards increased income inequality. Intensification could moreover have two other major disadvantages. It might be situated in the areas around towns, which might increase regional disequilibrium and it might not favour the fight to improve the living standards of the rural poor, which could ensure the continuation of the actual vicious cycle of poverty: the crisis of the rural areas leads to shrinking of aggregate demand, which in turn is the source of unemployment (Tacher, 1992).

Persistent inflation

Uganda has witnessed regular surges in inflation over the past years. In October 2011, for example, Uganda recorded the second highest level of inflation (30.5%) in the East African region (Kabundi, 2012). This rise in price has been an issue of concern for policymakers and the general public. Constraints on agricultural production together with high demand both domestically and from neighbouring countries push domestic food price and hence creates a rise in overall price level, given high age share of food price in Consumer Price Index (CPI) (RoU, 2004; FAO, 2009; Kabundi, 2012). As explained by Tacher (1992), politicians are extremely sensitive to variations of food prices. In developing countries such as Uganda, nominal salaries are very low and low food prices create a salary which finds itself increased accordingly, in real terms.

However, an increase in prices always leads to claims for salary increases. Trying to stifle this inflation generates tensions, particularly in towns, and so governments seek to keep prices as low as possible. This has frequently been done without success by fiscal means. There is evidence of considerable rise in real money growth, attaining a maximum of 36% in November of 2010, prior to the rise in inflation (Kabundi, 2012). As suggested by Nachega (2001), monetary aggregate portrays an equilibrium relationship with Inflation. It means that expansionary policy that drives up money supply is inflationary over the long-run. As a result of lack of success, the government then tries to keep the consumption price at a low level by other means such as liberal import policies. However, the liberal import policy stifles the development of local production (IMF, 2011). That is even truer with exports from developed countries, with which the local product must compete, and which are often subsidised in a more or less disguised way. This pressure on prices is thus implicitly a transfer from livestock rearing to the rest of the economy (Tacher, 1992).

WHAT SHOULD BE THE STRATEGIC INTERVENTIONS FOR THE LIVESTOCK SECTOR?

Poultry

The total poultry population in Uganda was projected to be about 32.6 million birds for 2006/2007 year from 23.5 million in 2002. Of this, about 80% is free-range indigenous type of breeds while the commercial types mainly composed of exotics are about 20% (Byarugaba, 2007). Similarly, the economic and nutrient contribution of the indigenous free-range poultry has been estimated to be over 80% of the per capita consumption of poultry meat and eggs (Byarugaba, 2007). This is therefore an excellent intervention area. The approaches below are thus suggested as strategic interventions areas in the poultry enterprise.

Smallholder poultry (village chicken) development

The capacity for broodiness has been bred out of commercial-strain layer and broiler hens so as to maximize meat and egg production. They are therefore incapable of natural reproduction, and their value in a village environment is thus quite limited. Besides, they also have limited ability to withstand the harsh environment (FAO, 2010). The development of smallholder poultry production systems in Uganda, particularly village chicken production is thus crucial in meeting the nutritional, income, employment and gender needs of rural people (Kusina and Kusina, 1999). The hens become broody, so can reproduce without the need for artificial incubation and brooding; They are agile and can run fast, fly and roost in trees, so can escape predators; They have been shown to be more resistant to bacterial and protozoan diseases and to parasitic infestations than commercial broilers and layers. Their meat and eggs are generally preferred to those from commercial birds, not only by rural communities but also by urban dwellers because of their taste, leanness and suitability for special dishes (Ssewanyana et al., 2001; FAO, 2010). The major disease constraints affecting production include Newcastle disease, fowl typhoid, Salmonelloses among others. Fortunately, there are effective vaccines against these diseases. This is where the government should heavily invest in addition to distribution of commercial broiler or layer chicks.

Development of crossbred chicken

Indigenous hens often lay only 40 to 60 eggs per year while commercial layers developed from imported parent stock have the capacity to lay more than 300 eggs per year. The growth rate of indigenous genotype of chickens is also generally much slower than that of commercial chicken. Indigenous cocks often weigh not more than 1.0 kg at 20 weeks while broilers under typical confinement may reach 2.0 kg live weight at five weeks of age (FAO, 2010). There is therefore need to integrate the good features of local chicken that make them adaptable to the local conditions and those that are responsible for high productivity among exotic chicken (Kyule, 1994). To improve productivity of the indigenous chicken, the Malawi government introduced the Smallholder Poultry Improvement Programme (SPIP) in the 1950s with the main objective of increasing egg and meat production of indigenous chicken through crossbreeding with the Black Australorp (Safalaoh, 2001).

The future of cross bred chicken is promising in Uganda. At the National Semi-Arid Resources Research Institute (NaSARRI) chicken breeding project, the growth capacity of local chicks was compared with chicks from crosses of the local bird with the Bovans Brown and raised at the farms from day old by using ordinary feeding regimen at the farm. The results showed that 50% of the Bovans gene had higher body weights compared with local chicks and chicks with 25% Bovans gene. Furthermore, at 120 days of age, the difference was at maximum when expressed as a proportion of body weight of local chicks. However, they also recommended studies on the reproductive capacities of the crossbreeds (Sorensen and Ssewanyana, 2003).

Ssewanyana et al. (1998) further studied on-farm performance of the crossbreeds and found that; mean body weight of F_1 chickens (50% BBxLH) increased by 34%, egg number per clutch by 94%, egg weight by 29%, egg circumference by 10% and egg length by 2% over that of the local chickens. These results indicated that the technology of improving indigenous chickens through crossbreeding with exotic cocks was technically and economically viable even under on - farm conditions. Therefore, poultry production based on a genetic improvement of the local breeds is possible in using appropriate breeding programme that includes traits of importance for reproduction and survival under the smallholder environment, which also enhances the welfare of hens that can incubate and brood chicks as required by the rural farmers (FAO, 2010).

Cattle

Rehabilitation of community dip tanks

Tick-borne diseases are a major constraint to the improvement of livestock production in the developing world particularly the sub-Saharan Africa (Norval et al., 1992; Bell-Sakyil et al., 2004). The cost of controlling ticks and tick-borne diseases was reported to constitute about 85.6% (pastoral) and 73.8% (ranches) of total disease control costs (Ocaido et al., 2009). The major tick-borne diseases in Uganda are anaplasmosis, babesiosis, cowdriosis and East Coast fever (ECF). Together, these constitute the single most important constraint to the livestock production in Uganda. Originally, government of Uganda under the Ministry of Agriculure, Animal Industry and Fisheries (MAAIF) had established community dip tanks in strategic locations at all districts in the Country. However, following decentralisation, these communal dips have either collapsed or are neglected. The presence of many non functional dip tanks in the districts has been attributed to failure by the districts to rehabilitate and maintain the communal dips (King and Mukasa-Mugerwa, 2002; RoU, 2009). Dipping of livestock in dip tanks as a practice to kill off ticks and nuisance flies is no longer undertaken in most districts of Uganda. Farmers have since then failed to dip their livestock resulting in high prevalence of ticks and tick-borne diseases. There is therefore need to rehabilitate and construct community dip tanks as a key intervention in the control of ticks and tick-borne diseases.

Promotion of dairy crossbreeds

Currently the average live weight by a cow in most herds of Uganda is 180 to 350 kg and this requires about 5 years to be attained even if pastures are available (Jain and Muladno, 2009). However, they carry great advantages of relative resistance to tropical diseases, and ability to survive in high temperature zones and these should be conserved. By choosing exotic breeds from industrialized countries had been intensively selected for increased productivity and crossbreeding with local breeds, rapid improvement of local breeds can be realized. Crossbreeding, which uses complementary breed differences, avoids antagonistic genetic relationships and utilizes heterosis, is recommended for genetic improvement of farm animals (Smith, 1964; Moau, 1966; Dickerson, 1969, 1972). Such an approach would focus on crossbreeding of the indigenous breeds of cattle (Zebu) and Ankole longhorn (Sanga cattle) with large fast growing dairy breeds of Friesian, Jersey, Guernsey, Ayshire. Half crosses would be the most suitable genotype in most parts of Uganda. Previous studies have shown that at various heat intensities above 27°C, half Friesian-Zebu cattle produce more milk when compared to the three-quarter cross during the stage of maximum lactation inspite of the higher genetic potential of the latter (Igono and Aliu, 1982).

CONCLUSION

The strategies used by the government of Uganda to fight poverty and hunger, did not favour the rural poor since they were not considered in the conceptualization, formulation and implementation of these strategies. Instead, they have supported the rich and thus failed to cause a notable impact. It is therefore recommended that adoption of the suggested intervention areas will overcome the said bottlenecks and accelerate eradication of hunger and poverty in the country.

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Full Length Research Paper

Econometric analysis of suitability and marginal value productivity of farmlands for cassava production in Imo State, Nigeria

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Indiscriminate allocation of farm farmlands beyond efficient level affect farmers return, hence suitability and standard value of lands for cassava production for optimal use were investigated. Data were obtained using a multi-stage sampling technique, from a sample of 203 cassava farmers in the state and were analysed using descriptive statistics, land productivity ratio and econonometric tools. Most farmers are female of 55.7 6.8 years of age and post primary education status. Nutrient ammendment is at the rate of 442.36 ± 102.73 Kg/Ha and at mean cost of N36401.77 ± 28575.84/Ha. The performance rate of 0.96 tons/person/Ha was obtained. The suitability index ranges from 0.139 to 0.908 with 46.3% cultivating on non-suitable land of 0.0-0.339 while only 20.7% cultivated on suitable lands of above 0.723 suitability index with a smaller mean area of 1.48Ha. The performance rate across these classes of land ranges from 0.44 tons/Ha/person to 2.11 tons/Ha/person for non-suitable land and suitable lands respectively. Suitable lands had the highest land productivity of 5.71 while moderate and non suitable lands had only 4.00 and 3.72 respectively, hence about 53.4% and only 7.5% increase in production is achieved as a piece of land is improved from non-suitable and moderately suiatble lands respectively to suitable land in the area. The MVP ranges from N302429.76/Ha for non-suitable lands to N718535.2/Ha for suitable lands. The study noted that suitable lands have higher opportunity cost than others for cassava production, hence recommentds that opportunity cost of land must be based on higher MVP for optimal use.

Key words: Farmland, suitability, marginal, value, productivity, cassava.

INTRODUCTION

Land is a portion of the earth surface that houses the biosphere, soil with its geological properties (which include the hydrological portion) and the atmosphere (FAO, 1976). Each of these portions is subject to some natural and human factors that have advertently, accounted for its development and value. The framework of farmland comprises of economic and social attribute that enhances its value (Anyigo, 1982). Farmland has a

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derived demand and its demand is for the minerals and nutrient it has for crop production (Olayide and Heady, 1982). Hence, its value (opprotunity cost) is therefore, the amount (of money, goods or services) that is considered to be a fair equivalent for its use and or what the land can produce. This means that land must be suitable having possessed a high potential for maximum output. Hence suitable farmland produces a relatively increased quantity of crop per unit area than other parcels of land within the same area.

Suitable farmlands are linked with increased opportunity cost. Such lands are productive, hence attract more opportunity cost than other areas (Okere, 2013). Land productivity is the ratio of output per unit piece of land used in crop production (Olayide and Heady, 1982), hence a suitable piece of land is at a high productivity potential. Land with high marginal value products (MVP) must have equivalent high marginal factor cost (MFC) to attract optimum allocation (Olayinde and Heady, 1982). Al-Kaisi (2012) noted that soil conservation practices can play a significant role in sustaining soil quality and suitability even in adverse himan activities and climate change. This implies that with good soil conservation and management practices, productivity of agricultural land will be sustainably high, thus making such land more valuable for crop production. Agricultural Lands are valued based on their suitability for crop production and its productivity.

Agricultural lands are no doubt scarce with high opportunity cost when project and infrastructural development are present. However, the value is to a greater extent, determined by the MVP of the farmland (Bassey, 2008). Although climate change and environmental degredation have been fingered for the low productive potentials of most arable land used for cassava production in Nigeria, the mining of sand and graver deposits (of solid and liquid minerals) as well as excavation of topsoils for urban development, have left extensive tracts of exposed subsoils with adverse soil chemical and physical properties that do not support plant growth (Hornick and Parr, 2010). Such degraded and marginal soils properties or destructions result to infertile (low in organic matter), often acidic and are subject to severe erosion and surface runoff.

Soil ammendment and conservation practices increase the suitability of soil for crop production and consequently the value system (Al-Kaisi, 2012). Research has shown that proper soil management practices such as liming and timely use of organic amendments such as animal manures and sewage sludge compost on lands can restore increased land productivity (Oyekale, 2008; Hornick and Parr, 2010; Al-Kaisi, 2012). Hence, the relative suitability of land is mainly dependent on the available soil management practices, which farmers adop t to gradually return improvised farm lands to a suitable land for crop production. This presupposes that lands can be classified into different value systems based on its degree of suitability to arable crop production (Oyekale, 2008).

Cassava adapt to marginal soils though, its productivity varies within soils in the same location and between locations in geographical space depending on the constituent minerals and management practices. Projects Coordinating Unit (2003), noted that though Enugu and Imo dominated the production of cassava in the South East with an output of 0.56 tonnes/per person in 2002 the output is not commensurate with the area of land allocated to it and farmers returns has not improved their consumption and welfare need. As a food security component, its ability to close food gap is declning. The dietry need of man with his livestock and industrial needs for cassava products have intensified (without careful management), the use of farmland, thus making lands vulnerable to farming farming risk and low output that fall short of its demand (FDALR, 1982; Ehirim et al., 2006).

To bridge this rising food gap, efforts need to be made by farmers to improve land productivity so that output can be raised to meet the food consumption needs (Adetunji and Adeyemo, 2012). Low level of farm size, technical and economic inefficiency of food and primitive technology may be a draw back to the effort to achieve the progress in food production (Adetunji and Adeyemo, 2012). The arguement that increased crop production requires increased use of farm inputs, which of cause does not exclude expanded use of land, may not translate to production efficiency (Olayide and Heady, 1982). Therefore, an optimal allocation of land base on its MVP placed cassava enterprise at a ventage position for maximum profit and economic sustainability. This study investigated the the productivity of different suitabilty levels of land for cassava production and the expected opportunity cost so that allocation of resources especially for land will generate optimum returns for cassava farmers in Imo state.

MATERIALS AND METHODS

The study used a multi-stage sampling technique to draw 203 cassava farmers for the study. First was a purposive selection of the three agricultural zones for proper representation of the state. Second was a purposive selection of three Local Government Areas (LGA) with evidence of erosion, high and moderate topography, and traditional farming systems such as bush burning, continuous cropping and excessive grazing form each zone, thus giving a total of nine (9) LGA's. The LGA's selected were Ngor Okpala, Owerri North and Owerri West LGA's from Owerri zone while Orsu, Isu and Nwangele LGAs were from Orlu zone and Isiala Mbano, Obowu and Okigwe North from Okigwe Zone. Third is random selection of cassava farmers from the list of cassava farmers with ADP's in each of the selected LGA. The study sampled about 316 (70%) of the total registered farmers from these LGAs and only 203 of the responses were found useful for data analysis.

Data on socio-economic features of the farmers, the type, quatity and prices of farm inputs especially the opportunity cost of land as well as quantity and prices of cassava output and the various land management and soil conservation practices used were collected. Data were analysed using both descriptive, partial productivity of land and econometric tools.

Land suitability index was used to classify land into suitable, moderately suitable and non suitable for cassava production. The suitability index was obtained from the number of ‘yes’ response (as it affect farmers) on the improved land managementand and or soil conservation practices as well as “no” responses to bad management farm and or soil conservation practices on his land. The practices are application of fertilizers or organic manure to the soil, the use of lime or wood ash for soil acidity, the use of mulch materials to protect the soil, use of bush fallow or shifting cultivation, the use of disease resistant varieties, construction of drainages and trench to remove excess or water logging, crop rotation system in case of mixed crop farming as well as ensuring adequate spacing distance and early planting. Others are bad management practices of the farmers in which a “no” response are expected. They include bush burning, continuous cropping, excessive grazing, making ridges along the slopes, deforestation and the use of heavy machines for tilling the soil. A total of 8 yes response and 6 no response gave a total of 14 responses that suitabily sustain the marginal value productivity of the farmland (FAO, 1991; Oyekale, 2008).

Suitability index is therefore, the ratio of the actual aggregate number good management practices and bad practices avoided to the total score. This is expressed as;

$$SI = \frac{V}{N} \quad \text{and} \quad 0 \le SI \le 1 \qquad (1)$$

Where SI = Suitability index, V = Actual number aggregate good land management practices and bad practices avoided by an ith farmer in the area and N = The Total number of both good land management activities that farmers responded yes and the bad practices avoidable as used in this study. As the SI approaches 1, then the land is very suitable for arable crop production but if it approaches 0, then it is non-suitable inbetween these extreems lies moderately suiatble land for cassava production. This is statistically classified using normal distribution approach adopted by Olowu and Oladeji (2004). The estimated mean and the standard deviation of the distribution were used to classify the land into three classes; Suitable, moderately suitable and non-suitable.

$$SC = S\bar{I} \pm SD \qquad (2)$$

Where; SC = Suitability class, $S\bar{I}$ = Mean suitability index and SD= Standard deviation

Partial productivity of land is the ratio of total output of an ith class of land to a unit area of that land cultivated by cassava. This is expressed as:

$$A = \frac{Y}{L} \qquad (3)$$

Where, A = Productivity of land; Y = Output of cassava tubers from an ith class of Land in kg, and L = Area of an ith class of land in hecatres.

The value placed on each class of farmland is based on the MVP of such farmland in the area. The suitability potential of farmlands determines its MVP, hence allocation of farmland for cassava production is efficienct where the ratio of MVP and the MFC is equal to unity.

$$Optimum\ Allocation\ of\ Land = \frac{Marginal\ Value\ productivity}{Marginal\ factor\ Cost} = 1 \qquad (4)$$

Marginal Value Productivity (MVP) $= MPP_L \, X \, P_Y$ (5)

Where MPP_L is the marginal physical product of cassava from an ith class of land and P_Y is the unit market price of cassava produced in the area. The marginal physical product of cassava from an ith class of land is simply an additional unit of cassava from an additional unit ith class of land (Olayide and Heady, 1982). This is obtained as a partial derivative from a linear production function of cassava from an ith class of land in the area. The model is implicitly expressed as;

$$Q_c = f\left(Labour + Farmsize + Pl_{mat} + capital + \varepsilon\right) \qquad (6)$$

Where; Q_c = Output of cassava in kg, Pl_{mat} = Plant Materials in naira, Labour = man-days, Farm size = hectares and Capital = sum of depreciation of fixed inputs, rent and interest in naira. ε = the error term.

RESULTS AND DISCUSSION

Socio-economic features of cassava farmers in Imo State

Table 1 shows that majority (40.4%) of cassava farmers falls within 50 to 59 years while only few (3.0%) of them are between 30 to 39 years. The mean age of the cassava farmers is 55.7 years. This implies that cassava farmers in the State are relatively old. This finding is supported by Alfred (2001) that farming is now in the hands of old farmers whose risk absorption, adoption of innovation and productive effort per unit of labour may be declining. Again farming may go extinct with older men dominating the occupation. The result also showed that majority (40.9%) of cassava farmers in the State had post primary education and 17.7% of them had up to tertiary education.

However, only 9.4% of the farmers had relatively no formal education in the area and the mean formal education attainment is 9.5 years. This implies that at average, the farmers most have acquired post primary education. Williams (1984) noted that secondary education can equip farmers with some managerial skills for agri-business and may help in understanding innovations. The result showed mean farming experience of 26.4 years with 48.8% of the cassava farmers having between 11 and 20 years. Only less than 1% has planted cassava in less than 10years. This showed that cassava farming is an old enterprise and can increase mastering of different technologies. This finding is consistent with Ehirim et.al. (2006) who observed that changes is expected over time due to high farming experiences. It could be deduced from the result that extension contact to cassava farmers is small with a mean extension visit 8 visits per farmer in a planting season. Majority (75.9%) of cassava farmers have extension visit of only less than 10 times and 10.8% of them had less than 15 times visit per farmer in a farming season. The result showed that 19.2% of the cassava farmers have less than 4 members per household and 34.5% of them have less than 8 members per household. The mean household size per farmer is about 7 persons per household. This shows that

Table 1. Socio-economic characteristics of cassava farmers in Imo State.

Variable	Frequency	Percentage	Mean ± SD
Age			
30-39	6	3.0	
40-49	43	21.2	
50-59	82	40.4	
60-69	65	32.0	
70-79	6	3.0	55.7 ± 6.8
≥ 80	1	0.5	
Total	203	100	
Education			
0	19	9.4	
Less than 2 Years	8	3.9	
Not more than 6 years	57	28.1	
7 – 12 Years	83	40.9	9.5 ± 2.3
13 – 18 Years	36	17.7	
Total	203	100.0	
Experience			
Less than 10	2	1.0	
11-20	99	48.8	
21-30	31	15.3	
31-40	34	16.7	
41-50	24	11.8	26.4 ± 5.8
≥ 51	13	6.4	
Total	203	100.0	
Extension contact			
Less than 5	25	12.3	
5-10	154	75.9	
11-15	22	10.8	
≥ 16	2	1.0	8.0 ± 2.0
Total	203	100.0	
Household size			
Less than 4	39	19.2	
4-8	70	34.5	
9-12	62	30.5	
≥ 13	32	15.8	7.0 ± 3.0
Total	203	100.0	
Gender			
Male	95	46.8	
Female	108	53.2	
Total	203	100.0	
Marital status			
Single	72	35.5	
Married	81	39.9	
Divorced	35	17.2	
Widowed	15	7.4	
Separated	0	0.0	
Total	203	100.0	

Source: Field Survey, 2010.

Table 2. Descriptive statistics of input and output of cassava production in imo state.

Variable	Units	Mean	Standard deviation
Farm size	Ha	1.62	1.38
Rent	₦	9459.36	6016.25
Labour	Manday	25.00	9.81
Wage		15957.88	14470.42
Plant material	₦	13759.36	1397.50
Cost of improving land	₦	36401.77	28575.84
Soil nutrients	₦	442.36	1002.73
Depreciation	Kg/Ha	1257.07	1246.63
Output	₦	9584.19	2016.56

Source : Field Survey, 2010.

cassava farmers in the area have a relatively large household size to supply the family labour neede for cassava production in the area. This finding is supported by Nweke et al. (2002) about the significant population of cassava growers in Nigeria. The enterprise is female dominated with 53.2% of them as females and 46.8% as males. This finding is supported by the works of Ugwoke et al. (2004) who observed that agricultural activities are female dominated in Imo State.

Decriptive statistics of inpus and output of cassava in Imo State

The reuslt in Table 2 showed a mean area of land cultivated is 1.62 ± 1.38Ha. This implies that cassava production is still within small scale production as a relatively small fragment of land is allocated to its production in the area. A mean labour size of 25 ± 9.81 man-days and a mean wage of ₦15957.88 ± ₦14470.42 per labour per hectare is spent per farmer. This finding implies that the quantity of labour allocated to cassava production in the area is very small as a farmer can hardly make more than one visit to his farm in every 2 weeks within a cropping season. The mean depreciation of all fixed inputs used in the production of cassava in the area is ₦1257.07 ± ₦1246.63. Soil nutrient is applied at the rate of 442.36 ± 1002.73 kg/ha. The wide standard deviation for soil nutrient could be as a result of extensive application of the nutrient in the areas where arable crop lands are not suitable. The mean cost of improving land (which include construction of irrigation and drainage facilities etc) for cassava production is ₦36401.77 ± 28575.84/Ha is very high. There is a slight increase in rate of performance of 0.56 tonn/person in 2002 (PCU, 2003), to 0.96 tons/person in the area during the study.

Land suitability, productivity and mariginal value productivity for cassava production in Imo State

The suitability index ranges from 0.139 to 0.908. Majority (46.3%) of the farmers cultivated on non-suitable lands with suitability limit of between 0 to 0.339 while 33.0% of them cultivated cassava on moderately suitable lands of 0.340 to 0.722 (Table 3). Only a few of them (20.7) had cultivated their cassava on suitable lands of between 0.723 to 1.00 suitability index. Non Suitable land is relatively larger in area of about 2.08 ha, it has a relatively smaller output performance rate of 0.44 tons/Ha/person than suitable land that has about 28.8% lower land area but demonstarted a high performance rate of 2.11 tons/ha/person. The increased performance could be due to suitability of land cassava production. This finding is consistent with Oyekale (2008) that improved land use system can ensure a high performance rate than degraded lands.

Similarly, suitable land had the highest land productivity of 5.71. This is greater than the land productivity of moderatel and non suitable lands of 4.00 and 3.72 respectively. There is about 53.4% and only 7.5% increase in production as a piece of land is improved from non-suitable and moderately suiatble lands respectively, to suitable land in the area. This shows that non-suitable lands have higher potential productivity with intensified sustainable land management practices. This will make the non-suitable lands most suitable for crop production in the area. This can be achived by applying suitable soil ammendments and soil conservation practices.

In a similar way, the marginall physical productivity estimates from cassava production function showed the changes in the quantity of cassava produced as farmsize increased by 1 unit. The estimated model for the three different classes of land is shown in Table 4. It could be deduced from the result that an increase in farmsize by 1 hectare will increase output of cassava tubers by 2351.42 kg in non-suitable farmlands, 2087.45 kg in moderately suitable farmlands and 4959.52 kg in suitable farmlands.

Again, the MVP of land in Imo State is very high for all classes of farmland. The value ranges from ₦302429.76 in non-suitable land to ₦718535.2 in suitable lands. This implies that areas with suitable farmlands must attract

Table 3. Land suitability classes and rate of performance in cassava production in Imo State.

Variable	Non suitable land	Marginal suitable land	Suitable land
Suitability index class limit	0 to 0.339	0.340 to 0.722	0.723 to 1.000
Frequency	94	67	42
Relative frequency (%)	46.0	33.0	20.7
Area cultivated mean (std error) (ha)	2.08 (0.92)	1.32 (0.74)	1.48 (0.92)
Mean output (std error)	9327.78 (6087.89)	10365.31 (7083.60)	31191.95 11087.89)
Rate of performance (tons/ha)	0.444	0.79	2.11
Mean Land productivity (std error)	3.72 (2.32)	4.00 (2.47)	5.71(3.22)
Percentage change in productivity	-	7.5	53.5
Marginal productivity of land (std error) (kg)	2351.42 (650.70)***	2087.45 (823.03)***	4959.52 (2000.03)***
Unit price of cassava	₦144.88/kg	₦144.88/kg	₦144.88/kg
Value marginal product of land	₦302429.76/ha	₦340673.73/ha	₦718535.20/ha

The mean suitability is 0.5304 and standard deviation is 0.1913); Source: Field Survey, 2010.

Table 4. Linear production model showing the marginal productivity of the various classes of lands in Imo State.

Variable	Suitable lands		Moderately suitable lands		Non-suitable lands	
	Co-Efficient	t-Value	Co-efficient	t-Value	Co-efficient	t-Value
Constant	-3972.52	1.011	5176.54**	2.352	13380.83***	7.087
Labour	269.70**	2.376	-35.76	0.46	-09.18**	2.390
Farm size	4959.52**	2.48	2087.45***	2.536	2351.42***	3.614
Plant Materials	30.51	1.35	45.92	1.140	8.32	0.389
Capital	-0.974	0.355	0.516	1.175	-0.75	0.749
R2	0.505		0.437		0.611	
Adj R^2	0.451		0.304		0.483	
F-value	9.420***		12.275***		36.13***	
No. of observation	42		67		94	

Source: Field Survey, 2010.

higher opportunity cost than others. Again, there is only a marginal difference in MVP of Moderately suitable land and non suitable land. This could be due the slight differences in their marginal productivities. The study suggests an equal opportunity cost with MVP on suitable farmlands for efficient resource allocation in the area. It is therefore suggested that land use intensification through soil ammendements and conservative practices will make no only make non-suitable lands sustainable but increases its value and returns.

CONCLUSION AND RECOMMENDATION

There is a strong evidence that land allocation for agriculture does not follow its productivity. Standard value of land are estimated from the MVP, hence the comparism with the opportunity cost for oprimal land use system. The study disintegaterd arable farmlands in Imo State based on their suitability for cassava production, hence estimated the MVP for each so as to establish a standard value for their optimal allocation. The study revealed that productivity follows suitability level and to increase the suitability farmers need to employ soil conservative and good management practices as listed in the study to increase the MVP. The study recommends that opprotunity cost of different suitability level of farmlands should based on their corresponding MVP for oprimal allocation.

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Economic impacts of cassava research and extension in Malawi and Zambia

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This paper estimates the economic impacts of cassava research and extension in Malawi and Zambia over the period 1990-2008. The data come from sample household surveys, planting material production records, and a series of cassava improvement experiments conducted in the two countries. Past investments in cassava improvement have led to the development and release of a good number of high-yielding and cassava mosaic virus disease (CMD)-tolerant cassava varieties. The results show relatively higher adoption rates for the CMD-free local varieties compared to CMD-tolerant varieties that have been released in the two countries. The adoption of new varieties has been low and slow largely due to the fact that most of these varieties lacked the consumption attributes highly valued by farmers. The multiplication and distribution of CMD-free planting materials of the recommended local varieties led to greater adoption, but infection with CMD three to four years after adoption meant that the yield gains and economic benefits could not be sustained. Nevertheless, the multiplication and distribution of clean cassava planting materials generated a modest rate of return of 24%, which is actually consistent with an earlier rate of return estimate of 9 to 22% for cassava improvement in developing countries. Analysis of the ex ante impacts of current and future investments in cassava improvement shows that cassava improvement research that focuses on the development and dissemination of varieties with highly preferred consumption and industrial attributes would yield a greater rate of return of 40%.

Key words: Adoption, cassava, economic surplus, impact, Malawi, Zambia.

INTRODUCTION

Cassava is Africa's second most important food staple after maize and provides more than half of the dietary calories for over 200 million people (Nweke et al., 2002). In Malawi, cassava is a staple food for more than 30% of the population and occupies 60% of the area under roots and tubers and nearly 50% of the total production. Cassava has wide agro-ecological adaptation, but the main growing areas are the northern belt along the lakeshore (Karonga, Rumphi, Nkhatabay, and Nkhotakota), the southern cassava belt (Mangochi, Machinga, Zomba, and the southern Shire Highlands), and the central belt of Dedza and Lilongwe. The marketed surplus of cassava increased from 11% in 2002 to 75% in the central region and 60% in the southern region (Mataya et al., 2001; Phiri, 2001; Haggblade and Zulu, 2003). The fresh market takes up about 80% whereas the remainder is absorbed in the manufacturing and confectionary industries. Similarly, in Zambia, cassava accounts for roughly 15% of national calorie consumption (Dorosh et al., 2007) and is mostly grown in the five provinces of Luapula, Northern, North-Western, Copperbelt, and Western provinces where the crop is regarded as a staple

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(Soenarjo, 1992). The importance of the crop is fast increasing such that in the recent years cassava production has expanded to the Southern and Eastern parts of the country (Chitundu, 1999).

The expansion of cassava production in Africa in the face of longstanding as well as emerging threats to cassava production and productivity is largely attributed to sustained investments in research and extension aimed at addressing a wide range of biotic and abiotic constraints (Nweke et al., 2002). One of the major biotic constraints to cassava production is cassava mosaic virus disease (CMD) and is transmitted by the whiteflies and infected cuttings. Since recently, cassava brown streak virus disease (CBSD) has become yet another major constraint to cassava production. As part of a major long term crop improvement effort since its creation in 1967, the International Institute of Tropical Agriculture (IITA) initiated cassava research in the early 1970s with a focus on developing varieties with resistance to major diseases such as CMD. Cassava breeding was initiated using breeding materials from Moor plantation near Ibadan and a limited number of east African landraces with resistance to CMD developed through interspecific hybridization in the 1930s (Haggblade and Zulu, 2003). This work resulted in several elite genotypes that had resistance

to CMD as well as high and stable yields and good consumer acceptability. The development of these resistant varieties, and their delivery to national programs for testing under specific local conditions during the late 1970s and 1980s, has led to the successful deployment of CMD-resistant cassava in Sub-Saharan Africa (Nweke et al., 2002). In addition to their resistance to CMD, the improved varieties combine enhanced postharvest qualities, multiple pest and disease resistance, wide agro-ecological adaptation, and greatly improved yield potential where yield increases of 50-100% without the use of fertilizer were demonstrated in many African countries.

The national cassava improvement programs in Malawi and Zambia have developed and released varieties that outperform the local varieties using breeding materials received from IITA. The improved genetic materials from IITA, referred to as the Tropical Manihot Selections (TMS), were distributed to several countries in the cassava-growing belt of eastern and southern Africa during the late 1980s at a time when governments were dismantling large-scale maize subsidy programs. Over the period 1990–2011, IITA and the respective national programs released a total of 12 improved varieties in Malawi and 8 improved varieties in Zambia. The improved cassava varieties coupled with the declining profitability of maize due to the withdrawal of subsidies contributed to a surge in cassava production in Malawi and Zambia beginning in the early to mid-1990s (Haggblade and Zulu, 2003). The increased availability of improved cassava varieties opened up a range of profitable commercial opportunities for production of cassava-based foods, feeds, and industrial products. At the same time, improved disease tolerance and higher productivity as well as a flexible harvesting calendar offered prospects for improving household food security.

Despite major efforts to develop and disseminate a growing number of improved varieties, there is lack of comprehensive evidence on the adoption and economic impacts of improved cassava varieties. This paper used household survey data as well as planting material production estimates for measuring variety adoption and on-farm experimental data for estimating yield gains.

Cassava research in Malawi and Zambia

Cassava improvement dates back to the 1930s in Malawi and 1940s in Zambia. Cassava was then regarded as an important famine reserve crop and each household was encouraged to have a piece of land under cassava as a fallback plan. The research focus then was on agronomic practices as well plant health in order to generate information on local planting conditions and select mosaic disease tolerant varieties. In Malawi, some 22 local varieties were characterized and put under mosaic observations at Mulanje and other stations together with a number of new introductions from Amani in north-east Tanzania. Cassava production expanded following the removal of fertilizer subsidies in the late 1980s and the droughts in the early 1990s which required an emergency response involving accelerated multiplication and distribution of planting materials of the best local varieties.

In Malawi, the Root and Tuber Crops Research Program was established in 1978, whereas the Zambia Root and Tuber Improvement Program (RTIP) was established in 1979. National cassava research activities initially focused on identification of best local varieties, cleaning, and distribution of planting materials. The national programs in both countries adopted IITA’s breeding scheme in order to speed up selection, evaluation, and release of new varieties. The varieties released by the root and tuber improvement programs have IITA parent material introduced directly in the form of tissue culture or seed population (Tables 1 and 2). The cassava breeding program in Malawi released three waves of improved cassava varieties: first the best local varieties (Chitembwere, Gomani, Mbundumali, and Nyasungwi) were released in the 1980s and recommended to farmers on the basis of mosaic virus tolerance and early bulking. In 1992, IITA through SARRNET launched a three-year drought recovery program of accelerated multiplication and distribution of cassava planting materials. This program targeted to provide planting materials to 300,000 smallholder farmers throughout the country. Under the same program in 1995 there was massive planting material multiplication and

Table 1. Improved cassava varieties released in Malawi, 1980–2002.

Variety	Category	Release year	IITA material used	Major attributes			
				Yield (t/ha)	Maturity (MAP)	Taste	Disease tolerance
Nyasungwi	Local selection	1980s	None	12-21	12-15	Semisweet	
Chitembwere	Local selection	1980s	None	20-23	15-18	Sweet	
Manyokola	Local selection	1980s	None	25	9-15	Sweet	Tolerates CGM, CBSD but is susceptible to CMD
Gomani	Local selection	1980s	None	25	9-12	Bitter	Susceptible to CGM, CBSD, CMD
Mkondezi (MK91/478)	Improved	1999	Seed population	40	9-15	Bitter	Tolerates CMD and CM
Maunjili (TMS 91934)	Improved	1999	IITA introduction	35	9-12	Bitter	Tolerates CMD, CM and CGM
Silira (TMS 60142)	Improved	1999	IITA introduction	25	12-15	Bitter	Tolerates CMD and CM but is susceptible to CGM
Sauti (CH92/077)	Improved	2002	IITA seed population	25	12-15	Bitter	Tolerates CMD, CM and CGM
Yizaso (CH92/112)	Improved	2002	IITA seed population	25	12-15	Bitter	Tolerates CMD, CM and CGM
Phoso (LCN 8010)	Improved	2008	IITA introduction	35	9-15	Bitter	Tolerates CMD and CBSD
Mulola (TMS 83350)	Improved	2008	IITA introduction	40	9-15	Bitter	Tolerates CMD, CM, and CGM
Sagonja (CH92/082)	Improved	2009	IITA seed population	25-35	9-15	Bitter	Tolerates CMD, CBSD, CM, and CGM
Chiombola (TME 6)	Improved	2009	IITA introduction	45	9-15	Bitter	Tolerates CMD and CGM

distribution of existing cassava clones, including Gomani and Mbundumali (Haggblade and Zulu, 2003). The second phase of the accelerated multiplication and distribution program targeted the establishment of 15,000 hectares of cassava nurseries to be eventually distributed to 75,000 farmers. The second series of varieties came out of hybridization and screening trials which started in 1992 from which process three new clones were identified and released in May 1999 (Mkondezi, a bitter variety; Silira, categorized as semi-sweet, and Maunjili, a bitter variety). In 2002 a further two bitter varieties (Sauti and Yizaso) were released. These new varieties increased yield by about 54% from the already high 13 tons per hectare for the best CMD-free local varieties (Gomani and Mbundumali) to 20 tons per hectare (Benesi et al., 1999).

In Zambia, the breeding program by the Root and Tuber Improvement Program has led to two waves of varietal releases, the first was in 1993 and the second in 2000. In 1993, three varieties, namely Bangweulu (LUC55), Kapumba (LUC327), and Nalumino (LUC304), were released. These varieties have higher yield ability and possess superior attributes compared to other traditional cassava varieties (Table 3). Historically the heavy fertilizer subsidies provided a strong incentive for maize production in the country. However, these recommended varieties coincided with a policy shift towards cassava production following the removal of fertilizer subsidies (Haggblade and Zulu, 2003). Starting from 1988/89 there were a series of multiplication and distribution of cassava planting materials to respond to the increased demand for cassava material in the country. Through efforts of the Zambian Root and Tuber Improvement Program and a consortium under Program Against Malnutrition (PAM) engaged in the distribution of cassava planting materials, a total of 552,000 cuttings were distributed in three consecutive seasons (1989-1992) to individual farmers looking for planting materials Soenarjo, 1992). Most of the cassava materials were susceptible to cassava mosaic, but a local clone called Nalumino was identified as being resistant and has been used in breeding program as a source of resistance (Soenarjo, 1992).

Table 2. Improved cassava varieties released in Zambia, 1990–2000.

Variety	Category	IITA material	Year of release	Yield (t/ha)	Maturity (MAP)	Taste
Bangweulu	Local selection	None	1993	31	12-16	Bitter
Kapumba	Local selection	None	1993	22	16-24	Sweet
Nalumino	Local selection	None	1993	29	16-24	Bitter
Mweru	Improved	IITA male x Nalumino	2000	41	16	Sweet
Chila	Improved	IITA male x Nalumino	2000	35	16	Bitter
Tanganyika	Improved	IITA male x Nalumino	2000	36	16	Sweet
Kampolombo	Improved	IITA male x Nalumino	2000	39	16	Sweet

Source: Haggblade and Nyembe (2008).

Table 3. Average yields of cassava varieties across districts in Malawi.

District	Yield (tons/ha)		
	Local CMD-infected	**Local CMD-free**	**Improved CMD-resistant**
Nkhatabay	12	17	17
Mzimba	12	12	9
Nkhotakota	11	16	17
Lilongwe	10	11	11
Zomba	7	11	12
Mulanje	6	9	20
All	9	12	14
Yield gain (%)	**-**	**33**	**55**

The conventional breeding program was also started in 1988/89 in Mansa with 15,077 (seedlings from twelve different crosses (Soenarjo, 1992). By 1992, preliminary evaluation identified 15 clones as being tolerant to CMD. Further evaluations led to the release of four new varieties of Mweru, Chila, Tanganyika, and Kampolombo in 2000 (Soenarjo, 1992). A total of four out of the seven or 57% of the released varieties had IITA parent material crossed with best local variety in order to enhance local adaptation and variety attributes.

MATERIALS AND METHODS

The economic surplus method for ex-post impact analysis

Several impact studies of agricultural technologies have estimated aggregate economic benefits through extrapolation of farm-level yield or income gains using partial equilibrium simulation models such as the economic surplus model (Alston et al., 1995). The economic surplus method is the most widely used procedure for economic evaluation of benefits and costs of a technological change. Technological change due to research in agriculture increases the yield or reduces the cost of production once the new technology is adopted. If the new technology is yield increasing, the producer sells more of the good in the market and if demand is downward-sloping the price decreases. Technology adoption reduces the per-unit cost of production and hence shifts the supply function of the commodity down and to the right. If the market for the commodity is perfectly competitive, this will lead to an increase in the quantity exchanged in the market and a fall in price. As a result, consumers benefit from the price reduction and producers may benefit from selling a greater quantity.

The basic model of research benefits in a closed economy is shown in Figure 1. The demand for the commodity is denoted by D, whereas the pre-research supply curve is S_0 and the post-research supply curve following technological change is S_1. The initial equilibrium is denoted as (P_0, Q_0), while the post-research equilibrium is (P_1, Q_1). That is, the initial equilibrium price and quantity are P_0 and Q_0, whereas after the supply shift they are P_1 and Q_1. The total benefit from the research-induced supply shift is equal to the area beneath the demand curve and between the two supply curves (ΔTS=area *abce*). The total benefit comprises the sum of benefits to consumers (ΔCS=area P_0bcP_1) and the benefits to producers in the form of the change in producer surplus (ΔPS=area P_1ce minus area P_0ba). Under the assumption of a parallel shift (so that the vertical difference between the two curves is constant) area I_0de equals area P_0ba.

This allows estimation of the economic surplus in a closed economy as follows: (1) Economic Surplus $\Delta TS=P_0Q_0K_t(1–0.5Z_t\eta)$ for ex-post analysis and $\Delta TS=P_0Q_0K_t(1+0.5Z_t\eta)$ for ex-ante analysis of potential impacts; (2) consumer surplus $\Delta CS=P_0Q_0Z_t(1–0.5Z_t\eta)$ for ex-post analysis and $\Delta CS=P_0Q_0Z_t(1+0.5Z_t\eta)$ for ex-ante assessment of potential benefits to consumers; and producer surplus $\Delta PS=(K_t-Z_t)P_0Q_0(1–0.5Z\eta)$ for ex-post analysis and $\Delta PS=(K_t-Z_t)P_0Q_0(1+0.5Z\eta)$ for ex-ante assessment of potential benefits to producers. In this model, K_t is the supply shift representing per-unit cost reduction due to technological change and derives from net yield gains due to research and technology adoption rates, whereas $Z = K_t\varepsilon/(\varepsilon+\eta)$ represents the percentage

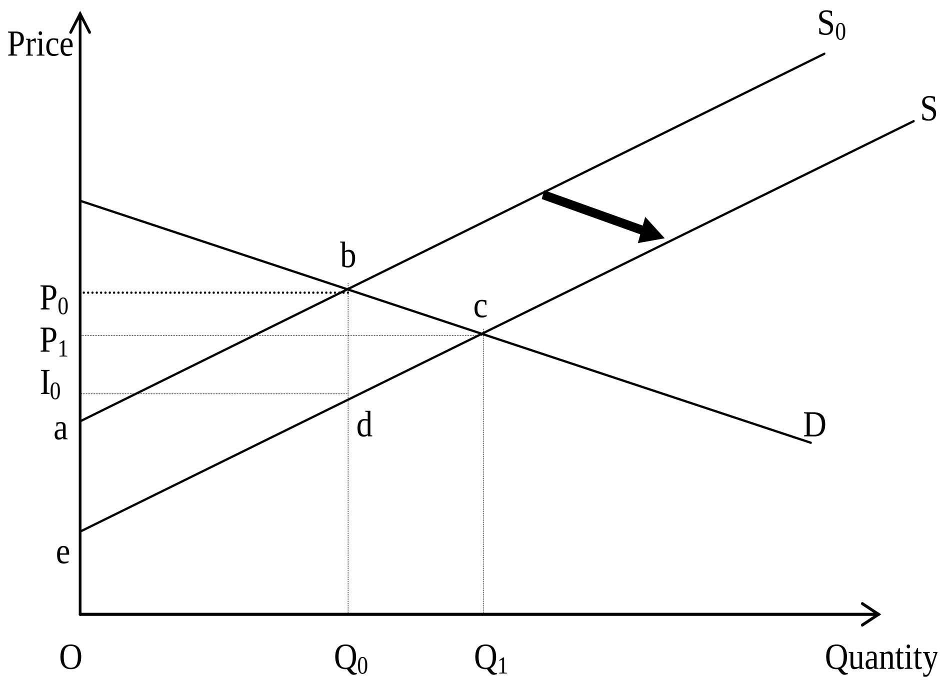

Figure 1. Effects of technological change on producer and consumer surplus.

reduction in price due to the supply shift and ε and η are price elasticity of supply and demand, respectively. Similarly, Alston et al. (1995) show that in a small open economy, change in economic surplus is equal to change in producer surplus and can be calculated as $\Delta TS=\Delta PS=P_w Q_0 K_t(1+0.5K_t\varepsilon)$ for ex-post analysis and $\Delta TS=\Delta PS=P_w Q_0 K_t(1+0.5K_t\varepsilon)$ for ex-ante analysis of potential impacts of research, where P_w is the real world price.

The research-induced supply shift parameter K_t is the single most important parameter influencing total economic surplus resulting from unit cost reductions. Following Alston et al. (1995), the supply shift was derived as:

$K_t=[(\Delta Y/Y)/\varepsilon-(\Delta PC/PC)/(1+\Delta Y/Y)]A_t,$

Where, ΔY/Y is the proportional yield increase per hectare, given that research is successful and the resulting innovation fully adopted; $\Delta PC/PC$ is the proportional increase or decrease in the variable production costs required to achieve the yield increase; and A_t is the rate of adoption of the innovation at time *t*. For improved performance, the adoption of improved verities may require some investment in new inputs like improved seeds or planting materials, chemical fertilizer, pesticide and more labor in operations. Such investments constitute adoption costs required to achieve the necessary yield advantage that improved varieties have over the traditional varieties. However, cassava is famous for its ease of cultivation and does not require more extensive use of labor than is required for the traditional varieties. In view of this, the supply shift equation reduces to $K_t=[(\Delta Y/Y)/\varepsilon]A_t$.

Data sources

Adoption of improved varieties

Adoption rates of improved cassava varieties over the years were estimated based on data coming from household surveys and planting material distribution efforts. In Malawi, a survey of adoption of improved cassava varieties was conducted in 2007. In Zambia, on the other hand, variety adoption data for 2007 were obtained from the Central Statistical Office. The adoption profiles of improved cassava varieties over time were derived using the S-shaped logistic function (Griliches, 1957), which has been used widely to analyze adoption patterns over time (Maredia et al., 2000; Feder et al. 1985; CIMMYT, 1993; Bantilan et al. 2005). Specifically, the diffusion of improved cassava varieties was assumed to follow a logistic curve given as a sigmoid function of time *t,* $Y_t = K[1-e^{-(a+bt)}]^{-1}$, where *K* is the long-run upper limit on adoption; *b* is the slope coefficient measuring the rate of acceptance of the new technology; and *a* is the intercept reflecting aggregate adoption at the start of the estimation period (Feder et al. 1985; CIMMYT, 1993).

The results of the adoption survey in Malawi showed generally high adoption of the local selection *Manyokola,* which is highly preferred by farmers but is susceptible to CMD. Only 7% of the farmers adopted improved varieties (that is, *Mkondezi*, *Silira*, *Maunjili*, *Sauti,* or *Yizaso*) that are tolerant to CMD but are less preferred by farmers due to lack of good consumption attributes. Improved cassava varieties like *Mkondezi* were mostly reported in the north by 7% of the sampled farmers, whereas *Silira* was found to be popular (10%) in the central region. Similarly, in Zambia, local varieties are still popular among cassava growers and thus the largest share of cassava area (over 70%) is still under local varieties. Eight years after their release, the improved varieties (Chila, Mweru, Tanganyika, and Kampolombo) have not been widely adopted. The results showed adoption rates of about 15% in 2007 for improved cassava varieties in Zambia. Nearly 75% of the households surveyed in Malawi cited lack of planting materials and information regarding their availability as the major constraint to the adoption of improved cassava varieties. Awareness, access to planting materials, and farmer perception are important factors in the adoption of improved varieties. Variety adoption will not take place unless farmers are aware of the varieties that exist and have access to planting materials.

Table 4. Average yields of cassava varieties across stations in Malawi, 1990–1997.

Varieties	Station					
	Mkondezi	Chitala	Chitedze	Bvumbwe	Makoka	National
Improved	Yields (tons/ha)					
Mkondezi	25	17	16	18	19	20
Maunjili	20	21	21	17	25	21
Yizaso	17	-	-	5	13	13
Silira	15	17	11	11	16	14
Sauti	-	17	-	-	-	17
Mean (Y_1)	19	19	16	15	20	18
Local						
Manyokola	7	16	16	11	21	13
Gomani	15	17	9	6	13	13
Chitembwere	12	12	13	3	12	11
Nyasungwi	10	11	-	4	17	11
Mean (Y_0)	12	15	12	9	17	13
$(Y_1\text{-}Y_0)/Y_0$ (%)	58	31	27	80	20	42

Source: Calculated from various SARRNET reports.

Table 5. Average yields of cassava varieties in Zambia, 2002-2004.

Variety	Lusaka province		Mansa	Mean	Yield gain (%)
	Yield 15 MAP	Yield 16 MAP	Yield 16 MAP		
Bangweulu (local, CMD-free)	21.30	22	31	24.8	21
Chila	18.20			18.2	
Mweru (Improved, CMD-resistant)	19.60	26	41	28.9	41
Muganga (local check)	20.50			20.5	
Manyokola	11.00			11.0	

Source: Calculated from various SARRNET reports.

Recognizing the high preference of farmers for the local selection *Manyokola* but also the high susceptibility of this variety to CMD, IITA and national program partners focused early efforts on the multiplication and distribution of CMD-free planting materials using tissue culture-based cleaning technology. The ex-post impact analysis in this study focuses first on this aspect of the IITA-led cassava improvement effort in Malawi and Zambia. The logistic function was used to estimate the adoption pattern of the CMD-free planting materials from 1993 to 2010 (Fig. 2). IITA and the national programs participated in the multiplication and distribution of clean cassava planting materials. As a result of such multiplication and distribution efforts, the area under improved and CMD-free local varieties reached an estimated 13% of the cassava area in 2003.

Yield gains due to research

Table 3 presents average yields of local and improved cassava varieties based on the household survey of adoption. The results show significant yield differences between the improved and traditional cultivars in the country. The average yield for CMD-free and newly released improved varieties were 12 tons/ha and 14 tons/ha, respectively, compared to 9 tons/ha for CMD-infected local varieties. This translates to a corresponding 33 and 55% yield gains through disease-free local varieties and newly bred varieties, over the generic local varieties. Manyong et al. (2000) reported that the improved cassava varieties have a yield advantage of up to 63% over local varieties grown under similar farmer-managed field conditions. The effects of cassava improvement program (either through cleaning or breeding) were dominant in all ecological zones as evidenced by significant yield gains for the CMD-free cassava varieties as well as improved cassava varieties over local check.

For purposes of comparison, the experimental yields recorded at five research stations in Malawi from 1990 to 1997 are presented in Table 4. The experimental results show that the yield gains for new varieties over local varieties range from 30 to 58% depending on the region but the national average was estimated at 42%.

In Zambia, experiments were conducted at Mansa research station and in Lusaka province from 2002 to 2004. These results are presented in Table 5. The experimental results show that variety Bangweulu gave 25 tons/ha compared to 21 tons/ha for Muganga, whereas Mweru, one of the improved varieties bred by the Zambian root and tuber improvement program, produced 29 tons/ha. Despite data limitations, this still demonstrates the marked effects of using CMD-free local varieties as well as improved varieties, with respective yield gains of 21 and 41% over the localcheck Muganga.

Supply and demand elasticity estimates for cassava

Supply elasticity estimates for cassava in Malawi and Zambia were not readily available. However, Masters et al. (1996) generalize estimates for supply elasticity to be within the range of 0.2-1.2 but are usually low for major crops with little expansion potential because they already take up large share of available resources. Alston et al. (1995) proposed unitary supply elasticity in the absence of exact measures indicating that a one percent increase in cassava prices would lead to an increase in cassava supply by the same margin. The relevant estimates for demand elasticity range from 0.4-10 and are lower for food crops in a small market and higher for export crops or import substitutes whose sales can grow quickly (Masters et al., 1996). Other studies in the recent past like Deaton (1989), Tsegai and Kormawa (2002), Alene et al. (2009) and Dorosh et al. (2009) reported price elasticity of demand of 0.33, 0.46, 0.38, and 0.20, respectively. Dorosh et al. (2009) found that a 10% price increase would reduce the demand for cassava products by 2%. On the basis of past empirical work and given the unique features of cassava as a major staple, this study adopted unitary supply elasticity and demand elasticity of 0.2.

Cassava multiplication and distribution costs

Massive cassava multiplication and distribution program started in the 1992/93 season as a joint response to the 1991/92 drought season. Initially, the Government of Malawi and NGOs established cassava and sweet potato multiplication scheme on a small scale. In the 1992/93 season, the Government of Malawi through IITA/SARRNET (1993/94) and NGOs launched the first phase of the accelerated multiplication and distribution of cassava and sweet potato planting materials. This project was worth US$700,000 in which US$250,000 came from USAID/Malawi and US$450,000 was from United States Department of Agriculture/Overseas Famine Disaster Administration (USDA/OFDA). The funded activities were planned for two years from September 1992 to September 1994 but were granted two-year no-cost extension to September 1995 and later to March 1996. The project was quite successful in terms of increasing area under cassava production and raising cassava productivity hence a second phase of the program was initiated in 1998 in order to intensify and sustain the project achievements realized. The second phase of the accelerated multiplication and distribution program was planned for two years from December 1998 to May 2001. The implementation of activities in the second phase was also made possible through US$382,334 financial support from USAID-Malawi.

The accelerated multiplication and distribution projects were running concurrently with other cassava improvement activities like breeding which also had a component of seed multiplication and distribution. The first phase of SARRNET was a US$7 million regional project launched in 1994 where Malawi, Mozambique, and Zambia benefited US$130,000, US$145,000, and US$100,000, respectively, for five years up to 1998. In 1996 the United States Foreign Disaster Assistance/Bureau for Humanitarian Response (OFDA/BHR) committed US$4.6 million in the SADC multiplication and distribution activities. From this, Malawi and Zambia were allocated US$492,000 and US$651,000. In the 1997/98 season, IITA/SARRNET received another funding from USAID/OFDA under the project framework of Strategic Action Plan for Root and Tuber Crops for El Nino Southern Oscillation (SAP-RT) mitigation in Eastern and Southern Africa. Malawi benefited with US$21,500 and Zambia got US$26,000. Zambia also got extra resources from USAID-Zambia in 1998 to the tune of US$781,700 for purposes of distributing disease free planting materials to the farmers.

The SARRNET phase II operating with a budget of US$3.5 million started in 1999 and ended in September 2002. At the end of the project period, US$895,460 was still available and was committed for a one year no-extra cost extension to September 2003. Between September 2003 and August 2004, a US$257,000 USAID/RCSA crop diversification and enhanced productivity was implemented under the umbrella project of improving rural livelihoods in Southern Africa where Malawi got US$48,000 and Zambia was allocated US$53,500.

From the year 1990 to 2008, a total of US$12 million is estimated to have been used for purposes of root and tuber crops research, multiplication and distribution of disease free planting materials in the SARRNET member countries. These expenses were incurred in the process of promoting planting materials for cassava and sweet potatoes in all the SARRNET countries. Based on the level of activities for the two crops, the costs were equally distributed such that 50% of the total costs accrued to cassava multiplication and distribution. This gives an average expenditure of US$0.32 million every year and a total of US$6 million as the investment in cassava research, multiplication and distribution program over the period of the analysis.

Cassava prices in Malawi and Zambia

The benefits for cassava multiplication and distribution (and the ex-ante benefits) are based on average domestic market prices prevailing in the two countries. In Zambia, the average cassava price was estimated at US$110 per ton dry weight after netting out the effect of inflation and was based on Otterdijk (1999), Haggblade and Zulu (2003), and Haggblade and Nyembe (2008). Otterdijk (1999) reported that farmers in 1994/95 season received an average price within the range of US$0.05 to US$0.08 per kilogram of fresh cassava root—equivalent to US$167–US$267 per ton dry weight using a conversion factor of 0.3 from fresh to dry weight. In another study, Haggblade and Zulu (2003) estimated that in 1985 producers got US$375/ha for a production of 6 tons/ha and in 2002 they realized US$675/ha for cassava yield of 12 tons/ha. This implied that the average cassava producer price was at US$63/ton in 1985 and US$56/ton in 2002. In a marketing margin analysis, Haggblade and Nyembe (2008) reported farm gate price of ZK10,000–ZK15,000 per 50 kg bag of dried cassava chips for the 2006 season. With the exchange rate in 2006 of US$1 to ZK3,500, this gives an average producer price of US$71/ton. For Malawi, cassava prices for the period 1990-2006 were readily available from FAOSTAT online publication. Therefore, the average price of about US$70 per ton of cassava was used in the ex-post analysis, whereas a four-year average price of US$138/ton dry weight (2003-2006) was used in the ex-ante analysis discussed below.

RESULTS AND DISCUSSION

Ex-post impacts of cassava research and extension

The estimated benefits from cassava research and extension involving multiplication and distribution of improved and CMD-free planting materials are presented in Table 6. In the base model, the stream of benefits and costs were compounded at a 5% rate to their respective 2008 values. The benefits were accumulated annually at a rate in tandem with that of cassava variety adoption and supply shift. The results show gross economic benefits of over US$17 million for Malawi and Zambia, which is equivalent to US$1 million per year for the two

Table 6. Benefits and costs of cassava improvement in Malawi and Zambia (US$ million).

Year	Malawi			Zambia			Total		NPV
	ΔTS	ΔCS	ΔPS	ΔTS	ΔCS	ΔPS	ΔTS	Costs	
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	-0.12
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	-0.05
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	-0.05
1993	0.11	0.09	0.02	0.08	0.06	0.01	0.19	0.11	0.04
1994	0.05	0.04	0.01	0.10	0.09	0.02	0.15	0.96	-0.41
1995	0.04	0.04	0.01	0.14	0.12	0.02	0.18	0.73	-0.29
1996	0.72	0.60	0.12	0.18	0.15	0.03	0.90	0.69	0.12
1997	1.02	0.85	0.17	0.23	0.19	0.04	1.24	0.75	0.28
1998	1.11	0.93	0.19	0.33	0.28	0.06	1.45	0.50	0.58
1999	0.31	0.26	0.05	0.49	0.40	0.08	0.80	0.50	0.19
2000	0.81	0.67	0.13	0.49	0.41	0.08	1.29	0.49	0.55
2001	0.93	0.78	0.16	0.66	0.55	0.11	1.60	0.48	0.80
2002	0.53	0.44	0.09	0.75	0.62	0.13	1.28	0.47	0.60
2003	0.42	0.35	0.07	0.83	0.69	0.14	1.25	0.12	0.89
2004	0.51	0.42	0.08	0.90	0.75	0.15	1.40	0.12	1.06
2005	0.44	0.37	0.07	1.05	0.87	0.17	1.48	0.11	1.18
2006	0.56	0.46	0.09	0.98	0.82	0.16	1.54	0.11	1.30
2007	0.50	0.42	0.08	1.00	0.84	0.17	1.51	0.17	1.28
2008	0.42	0.35	0.07	0.84	0.70	0.14	1.26	0.16	1.10
Total	8.48	7.06	1.41	9.05	7.54	1.51	17.52	7.00	9.03
Annual	0.47	0.39	0.08	0.48	0.40	0.08	0.92	0.37	0.48

countries combined. The results provide further insights into the distribution of research benefits where some 83% of the benefits accrued to consumers, whereas only 17% of the benefits were captured by the producers. Since the cassava markets in the two countries are not well integrated and developed, there is limited commoditytrading or movement outside production zones. This implies that the producer households are largely the same as the consumer households hence the total welfare gains accrue largely to the same cassava producing households.

The cassava multiplication and distribution program was quite successful and worthwhile when evaluated on the basis of benefit-cost ratio and internal rate of return (IRR). Using a discount rate of 5%, the benefit-cost ratio was estimated at 3:1 and the rate of return for the program was found to be 24%. A benefit-cost ratio criterion recommends as viable any investment plan with a ratio-value equal to or greater than one. If the ratio is greater than one, the project is returning more benefits than it costs. The rate of return is the rate that equates NPV to zero and the higher the rate above the opportunity cost of capital the better the investment plan. The benefit-cost ratio of 3:1 suggests that the returns were three times higher than the research investment costs incurred. In other words, every dollar invested in the multiplication and distribution activities paid back three times through production gains associated with the use of CMD-free planting materials. The accrued benefits are taken as a measure of success and it can be concluded that the IITA/SARRNET cassava multiplication and distribution program has achieved reasonable success in Malawi and Zambia.

Potential economic impacts of cassava research and extension

New variety development

Early efforts to control the effects of CMD in Malawi and Zambia through the IITA-led SARRNET project focused on breeding cassava for disease tolerance. Several varietal trails conducted from early 1990s showed successes achieved in terms of developing high yielding and CMD tolerant varieties. So far, all the five improved varieties released in Malawi have a bitter taste and are only suitable for traditional cassava consuming areas such as along the lakeshore. In addition, it has been observed that some of the varieties such as *Mkondezi* were rejected by many farmers because of poor *Nsima* quality. Given the low and slow adoption of the first generation improved varieties due largely to lack of attributes valued by farmers, the focus for future work on

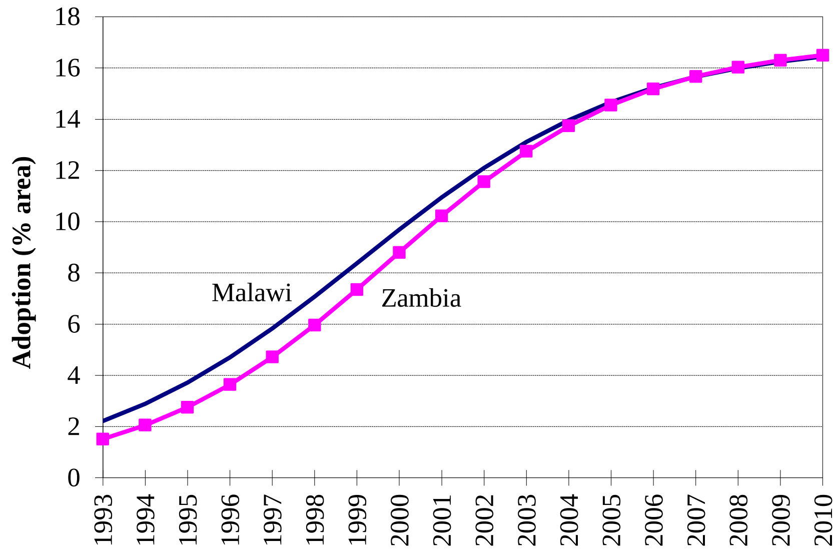

Figure 2. Adoption of CMD-free local cassava varieties in Malawi and Zambia.

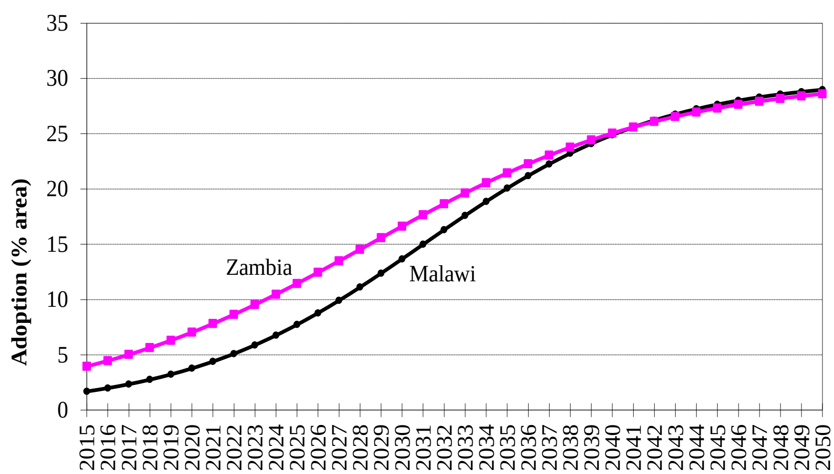

Figure 3. Projected adoption profile for new cassava varieties in Malawi and Zambia.

cassava research in the two countries should be on developing new varieties that are not only high yielding and CMD resistant but should also have consumption attributes highly valued by farmers who are also the major consumers of their own production. The other focus would be to enhance industrial characteristics in order to fast track industrial use and successfully catalyze the cassava commercialization process.

Expected adoption

If such line of cassava research succeeds in developing varieties with desired production and consumption characteristics, the adoption of the new cassava varieties is expected to be higher and faster in Malawi and Zambia, with an estimated adoption ceiling of 30%. On the basis of planting material production records and historical adoption rates of varieties preferred by farmers, expected adoption patterns for new varieties were projected using the logistic function for the period 2015–2050 (Figure 3). The economic surplus model for ex-ante analysis described earlier was used for the projection of potential impacts of cassava research that develops varieties with a range of characteristics preferred by farmers and other actors along the value chain.

Costs of variety development and dissemination

Estimation of net returns to cassava improvement research requires a comparison of the stream of benefits and the corresponding costs of the development and dissemination of improved cassava varieties. The research costs used in this analysis were adapted from previous and current cassava improvement activity budgets but were adjusted to cater for additional extension costs necessary to disseminate the new varieties upon release. The initial research costs were extracted from SARRNET project documents and are summarized in Table 2. Historical expenditures show that variety development accounts for 70% of the total cost, whereas variety dissemination accounts for the remaining 30%. The average annual expenditure for cassava research and extension in the SARRNET member countries was estimated at US$390,000 for twenty-three years until maximum adoption is attained. A total of US$8 million is estimated to be devoted to the development of the new varieties and dissemination of information to the farming families regarding their availability and potential benefits associated with the new varieties. As noted by Johnson et al. (2003), it is worth mentioning that when computing cassava research costs it is challenging to isolate breeding costs from other components of cassava improvement research investment.

Table 7 presents the net present value of potential economic benefits from cassava research and the corresponding estimates of the benefit–cost ratios and rates of return. The results show that, over the period 2015–2050, cassava research and extension can generate an estimated net benefit of US$97 million. This is equivalent to annual gross benefits of US$6 million for Malawi and US$3 million for Zambia following adoption of the new cassava varieties. The results also show nearly 85% of the benefits would accrue to the consumers and the remaining 15% go to the producers. Cassava research benefits are estimated to be higher in Malawi than in Zambia. International and national cassava research in Malawi and Zambia can have an impressive potential benefit–cost ratio of 21:1, indicating that each dollar invested in cassava improvement research generates US$21 worth of additional cassava.

Consistent with the payoffs implied by the estimated benefit–cost ratio, cassava research in Malawi and Zambia has the potential to generate a rate of return of 40%. The 40% internal rate of return to cassava improvement estimated for the two countries is much higher than the estimated rate of return to cassava research focusing on the multiplication and distribution of disease-free planting materials of the available farmer-preferred varieties such as Manyokola in Malawi and Muganga in Zambia. Furthermore, the estimated rate of return is much higher than the prevailing market interest rates and confirms that cassava research holds promise for generating a stream of benefits in excess of the expenditures. By all summary measures such as rate of return and benefit–cost ratios, the results suggest that benefits from cassava improvement are in excess of all cassava research costs in the region.

Sensitivity analysis

In an effort to gain confidence in the results, we evaluated the sensitivity of the base model estimates to variations in the values of some key parameters. Recognizing that the supply shift parameter is the major determinant of research benefits, the model was estimated with the proportional yield gains attributable to cassava research assumed to be half of the base yield gains. Given that the supply shift parameter is also a function of expected adoption of improved varieties, the model was estimated with the maximum adoption assumed to be 40%, up from the base value of 30%. The sensitivity of the estimated rate of return was also evaluated by estimating the model with research and extension costs assumed to be double the base value. The results of the sensitivity analysis presented in Table 8 show that, as a consequence of changes in supply shift, the present value of benefits is sensitive to changes in yield gains. Halving yield gains to about 20% has a proportional effect of halving research benefits to about US$46 million, but the rate of return drops only by 9 percentage points to 31%. On the other hand, raising the ceiling of expected varietal adoption from 30 to 40% has no proportional effect on net benefits and rate of return and has no effect on the benefit-cost ratio. More specifically, the net present value of benefits increases only by US$4 million and rate of return increases marginally from 40 to 42%, whereas the benefit-cost ratio remains the same as the base value of 21. Doubling of research and extension costs reduces net benefits by only 5% and the rate of return (to research and extension) also drops to 28%.

Overall, the summary measures suggest that the scenario with lower yield gains is the most conservative because it has a proportional effect of halving the net benefits to US$46 million as well as the benefit-cost ratios to 10. Similarly, the scenario with the research and extension costs double the base value has a comparable effect of halving aggregate benefit–cost ratio from 21 to 10 with a lower rate of return of 28%. The scenario with greater adoption of new varieties which reaches a maximum adoption rate of 40% before it stabilizes gives the highest rate of return of 42%. In general, the sensitivity analysis demonstrated that total net benefits from cassava research and extension in Malawi and Zambia vary between US$46 and 100 million and the benefit-cost ratio ranges from 10 to 21, with the rate of return varying from 28 to 42%. Although the sensitivity analysis lends credence to the main results, the minimum net benefits implied by the alternative scenarios are still an impressive US$46 million with a modest rate of return of 28% and benefit-cost ratio of 10.

CONCLUSION AND IMPLICATIONS

The national cassava improvement programs in Malawi

Table 7. Potential benefits of cassava research and extension in Malawi and Zambia.

Year	Malawi (US$ million)	Zambia (US$ million)	All (US$ million)	Net present value (US$ million)
2015	0.78	0.09	0.87	0.22
2016	0.92	0.15	1.07	0.35
2017	1.08	0.26	1.34	(0.28)
2018	1.27	0.43	1.70	1.06
2019	1.49	0.68	2.17	1.14
2020	1.74	1.05	2.79	1.48
2021	2.02	1.52	3.54	1.84
2022	2.35	2.05	4.40	2.15
2023	2.71	2.58	5.29	2.28
2024	3.12	3.03	6.14	2.93
2025	3.56	3.37	6.93	3.15
2026	4.05	3.60	7.65	3.26
2027	4.57	3.76	8.33	3.44
2028	5.13	3.85	8.98	3.52
2029	5.71	3.91	9.61	3.60
2030	6.31	3.94	10.25	3.66
2031	6.92	3.96	10.88	3.70
2032	7.53	3.97	11.50	3.71
2033	8.13	3.98	12.11	3.74
2034	8.72	3.98	12.70	3.74
2035	9.28	3.98	13.26	3.72
2036	9.81	3.98	13.79	3.68
2037	10.30	3.99	14.28	3.63
2038	10.75	3.99	14.74	3.57
2039	11.16	3.99	15.15	3.49
2040	11.53	3.99	15.51	3.41
2041	11.86	3.99	15.84	3.31
2042	12.15	3.99	16.13	3.21
2043	12.40	3.99	16.39	3.11
2044	12.62	3.99	16.61	3.00
2045	12.82	3.99	16.80	2.89
2046	12.98	3.99	16.97	2.78
2047	13.13	3.99	17.11	2.67
2048	13.25	3.99	17.23	2.56
2049	13.35	3.99	17.34	2.46
2050	13.44	3.99	17.43	2.35
Total	268.9	114.0	382.86	97.17
Annual	6.40	2.71	9.12	2.31
NPV (US$ million) = 97				
B:C ratio = 21				
IRR (%) = 40				

and Zambia have developed and released varieties that outperform the local varieties using breeding materials received from IITA. Past investments in cassava improvement have led to the development and release of a good number of high-yielding and CMD-tolerant cassava varieties. Over the period 1990–2011, IITA and the respective national programs released a total of 12 improved varieties in Malawi and 8 improved varieties in Zambia. The increased availability of improved cassava varieties opened up a range of profitable commercial opportunities for production of cassava-based foods, feeds, and industrial products. At the same time, improved

Table 8. Sensitivity analysis of the economic benefits of cassava research in Malawi and Zambia.

Parameter	Parameter value			NPV (US$ million)		IRR (%)		B:C ratio	
	Base	New	Δ (%)	New	Δ (%)	New	Δ (%)	New	Δ (%)
Yield gains (%)	0.40	0.20	-50	46	-47	31	-25	10	-50
Adoption ceiling (%)	30	40	33	101	4	42	5	21	0
Res. & Ext. costs (US$ m)	5	10	100	92	-5	28	-30	10	-50

disease tolerance and higher productivity as well as a flexible harvesting calendar offered prospects for improving household food security.

Despite major efforts to develop and disseminate a growing number of improved varieties, however, there is lack of comprehensive evidence on the adoption and economic impacts of improved cassava varieties. Using household survey as well as planting material production data for estimating variety adoption and on-farm experimental data for yield gains, this paper estimates the economic impacts of IITA-led cassava improvement research in Malawi and Zambia over the period 1990-2008. Historical as well as future adoption patterns were estimated using the logistic function with the minimum variety adoption data assembled from various sources. Consistent with the need for a gradual transformation of the scientific capacity of national programs, the content of earlier varietal releases points to the predominance of IITA germplasm supplied for direct release to farmers, whereas the content of recent releases shows that national programs are developing varieties using IITA material as a parent.

The results show relatively higher adoption rates for the CMD-free local varieties compared to CMD-tolerant varieties that have been released in the two countries. The adoption of new varieties has been low and slow largely due to the fact that most of these varieties lacked the consumption attributes highly valued by farmers. The multiplication and distribution of CMD-free planting materials of the recommended local varieties led to greater adoption, but infection with CMD three to four years after adoption meant that the yield gains and economic benefits could not be sustained. Nevertheless, the multiplication and distribution of clean cassava planting materials generated a modest rate of return of 24%, which is actually consistent with an earlier rate of return estimate of 9 to 22% for cassava improvement in developing countries. Analysis of the ex ante impacts of current and future investments in cassava research and extension shows that cassava research that focuses on the development and dissemination of varieties with highly preferred production, consumption, and industrial attributes would yield a greater rate of return of 40%.

Finally, it is worth noting that high rates of return to agricultural research are difficult to sustain in an environment where inputs are not accessible or affordable to farmers. A critical input for achieving greater adoption of improved cassava varieties is an efficient seed system for the production and distribution of highquality and disease-free planting material. Improved varieties can disseminate only with the help of an effective national seed industry, but this is still lacking in many countries in Africa especially for vegetatively propagated crops such as cassava.

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Economic assessment of yam production in Kabba-Bunu Local Government Area of Kogi State, Nigeria

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This study examined the economic assessment of yam production in Kabba- Bunu Local Government Area of Kogi State, Nigeria. Data used for the study were obtained using structured questionnaire. The questionnaire was administered to 150 randomly selected yam farmers in the area. Descriptive statistics, multiple regression and gross margin (GM) analysis were used to analyze the data. The regression result showed that, farm income (2.778), age (1.820) and education level (2.334) have significant effects on yam output in the area. The GM analysis also revealed that, yam production is profitable in the study area with an average profit of ₦ 121,200 ha^{-1}. It was therefore recommended that, farm inputs be made available to farmers at subsidized prices as a way of improving income from yam production.

Key words: Yield, profit, farmers, variables and socioeconomic.

INTRODUCTION

Yam *(Dioscorea* spp.) is an annual tuber and monocotyledonous crop. The plant Genus comprises of over 600 species with only 10 species producing edible tuber. Six of these edible species are cultivated in Africa and only 3 of them are available in Nigeria. In Nigeria, the primary species cultivated are the white yam *(Dioscorea rotundata*), yellow yam *(Dioscorea cayensis*) and water yam (*Dioscorea alata*), (Amusa, 2000).

FAO (2002) reported that Nigeria accounted for about 71% (26 000 000 tons) of the total world production of yam harvested from 2,760 ha. Yam production in Nigeria has more than tripled over the past 45 years from 8.7 000 000 tons in 1961 to 31.3 million tons 2006. This increase in output is attributed more to the large area planted to yam than to increased productivity (Izekor and Olumese, 2010). Though the area cultivated to yam production is still being increased, production growth rate declined tremendously from average of 27.5% between 1986 and 1990 to 3.5% in the period between 1991 and 1999 (FAO, 2002). However, between 2001 and 2006 production growth rate increased by 31.3%. Record of yield showed similar trend during the same period. Average yield per hectare dropped from 14.9% between 1986 and 1990 to 2.5% in the period between 1991 and 1999. However, the period between 2001 and 2006 recorded 23.4% increase in the average yield (Izekor and Olumese, 2010).

Yam production trend in Kogi State has been observed to be fluctuating for the past 15 years and has not kept pace with other major yam producing states in the country. The production index was estimated at 1.174 000 000 metric tons in 2000. Yam production output in the State dropped to 1.00331 000 000 metric tons in 2003, there was significant rise to 1.26428,000,000

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Table 1. Area cultivated and production of yam in Kogi State between 1994 and 2010.

Year	Area cultivated (‘000 ha)	Production (‘000 metric tons)	Yield (mt/ha)
1994	92.15	912.96	9.91
1995	87.50	911.18	10.41
1996	89.25	929.40	10.41
1997	92.09	1093.40	11.87
1998	88.823	11038.74	11.69
1999	110.75	1393.03	12.58
1999	110.75	1393.03	12.58
2000	100.03	1174.00	11.74
2001	94.00	1089.70	11.59
2002	92.20	1015.41	11.01
2003	89.46	1003.31	11.23
2004	91.28	1100.00	12.05
2005	101.89	1153.54	11.32
2006	120.43	1264.28	10.50
2007	100.06	1226.35	12.26
2008	104.56	1286.96	12.31
2009	109.37	1361.60	12.45
2010	114.62	1480.11	12.91

Source; Kogi ADP crop area and yield survey, 2011.

metric tons in 2006 with the cultivated area of 120,400 ha. In 2008, the total area cultivated for the state reduced to 104,560 ha and the corresponding production output was 1286.96 metric tons (Table 1).

The production figure for 2008 marked the beginning of increase yam production in the state as the production of yam increased to 1.36160 000 000 metric tons in 2009 with cultivated area of 114620 ha.

On the basis of quantity of root and tuber crops produced in Nigeria, yam ranks second to cassava. Yam is the perfect stable food appreciated in its state and cultural role. It is a major source of energy in diet of Nigeria people. Yam can be eaten when boiled, roasted, baked or fried. It can also be processed into crude flour by drying thin slices in the sun and then pound or ground into flour. Yam can further be processed into instant flakes producing a food similar to instant potato and can also be made into fried chip. Most of starch industries also make use of yam as one of their important raw materials. It provides job opportunities and income to both the producers and the marketers. Yam peels serve as feed for livestock and as a good component of farm yard manure. It is used as laboratory crop for scientific investigations.

As food crop, the place of yam in the diet of Nigerians cannot be overemphasized. It contribute more than 200 dietary calories daily, for more than 150 million people in West Africa as well as serving as an important source of income (Babaleye, 2003). According to Okenwe, Orewa and Emokaro (2008), yam contains a high value of rotein (2.4%) and substantial amount of vitamins and minerals than some other common tuber crops. It is also comparable to any starchy root crops in energy and the fleshy tuber is one of the main sources of carbohydrates in the diet of most Nigerians. Yam also plays vital roles in traditional culture, rituals and religion as well as local commerce of African people (Izekor and Olumese, 2010). Yam is reported to be part of the religious heritage of several Nigerian tribes and often play key role in religious ceremony (Amusa, 2000). Due to the importance attached to yam, many communities in Nigeria celebrate the new yam festival annually.

In Nigeria, some of the constraints to yam production are unavailability of planting materials, soil degradation, poor handling and storability, pest and disease and other environmental factors (Ibitoye and Attah, 2012). Seed yam for cultivation has continued to be a problem for the farmers. The cost of producing yam is also observed to be higher compared with other tubers in the country. This is largely due to the high cost of seed yam. On the average, about 25% of the annual yam harvest is used as seed yam (Kushwaha and Polycarp, 2001). This situation has caused yam cultivation to suffer a severe setback due to high cost of production. It is in light of these problems that, the study assessed the economic performance of yam production in Kabba-Bunu Local Government Area of Kogi State, Nigeria.

MATERIALS AND METHODS

The study area is Kabba-Bunu Local Government Area of Kogi State, Nigeria. Kabba-Bunu local Government Area is one of the 21 Local Government Areas in Kogi State. It is located in the western senatorial district of Kogi State. The Local Government was created in 1991. It is bounded in the North by Lokoja Local Government and by Ijumu Local Government to the South, Yagba- East and Mopamuron Local Government share boundary with the Local Government to the west and to the East by Okehi Local Government Area. According to the National Population Census (2006), Kabba-Bunu Local Government Area has a population of 145,446 people which is made up of 74,289 males and 71,157 females. It has land area of about 2,706 km^2.

The local government usually experience 2 district seasons, the wet and dry seasons. The wet season usually spans from the middle of March to October while the dry season cover the period between November and early March. The vegetation of the area comprise of derived savannah and rain forest in some areas. There are vast available lands for farming. Agriculture is the most important economic activities in the Local Government as majority of the population derive their livelihood from it. Agricultural practice in the area is still at subsistence level, which invariably makes the farmers vulnerable to poverty. The soil is viable for growing crops such as yam, maize, cassava, sorghum, cashew, cocoa, oil palm and coffee.

A total of 5 communities were purposively selected from the 2 districts of Kabba-Bunu Local Government Area for this study. Odolu and Okedayo were selected in Kabba district while Edumo, Iluke and Apaa were selected in Bunu district. They were purposively selected because of their high levels of involvement in yam production in the area. Twenty five respondents were randomly selected from each of the 5 communities to have a grand total of 150 respondents for the administration of the questionnaire. Well structured questionnaires were used for the collection of primary data. The questionnaire elicits information on the socioeconomic characteristics of the farmers, problems militating against yam production in the area and other related information on the inputs and output of yam production. Descriptive and inferential statics such as age (%), mean, gross margin (GM) analysis and multiple regression were used to analyze the data.

Model specification

The regression model was specified as follows:

$$Y = \alpha + b_1x_1 + b_2 x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7$$

Where, Y = Yam output (Tons), α= Constant (Intercepts), X_1 = Farm size (hectare), X_2 = Farm Income (naira), X_3 = Age (years), X_4 = Farming experience (Years), X_5 = Sex (male = 1, female = 0), X_6 = Family size (number), X_7 = Educational level (Years), B_1…..b7= Coefficients of independent variables, ei = Stochastic error term, GM analysis was used to determine the cost and returns in yam production in the studied area. The model used is specified thus:

$$GM = TR – TVC$$

Where, GM = Gross margin, TR = Total revenue, TVC = Total variable cost.

Gross ratio of the farm was also calculated. Gross ratio is a profitability ratio that measures the overall success of the farm. The lower the ratio, the higher the return per naira invested (Ekunwe et al., 2008):

$$GR = \frac{TFE}{G1}$$

Where, GR = Gross ratio, TFE = Total farm expenses and GI = Gross income (total revenue).

Return on capital invested (ROI) was also calculated. ROI uses accounting information as revealed by the financial statement to measure the profitability of an investment (Ekunwe et al., 2010). According to Izekor and Olumese (2010), the ROI measure the returns per naira invested. Any investments in which the ROI is greater than 1, indicates a potentially profitable venture and if less than 1, it shows a potentially unprofitable venture. ROI is the GM divided by total variable cost:

$$R1 = \frac{GM}{TVC}$$

Where, R1 = Return on capital invested, GM = Gross margin, and TVC = Total variable cost

RESULTS AND DISCUSSION

The results of socioeconomic variables of the respondents are presented in Table 2. The socioeconomic variables considered includes: Age, family size, sex, farming experience, farm size, educational status, and farm income. The study shows that, majority of the respondents (90%) are still within the productive age bracket of 21 to 60 years. The mean age of the respondent was 46 years. Odinwa et al. (2011) observed similar age bracket among yam farmers in Northern area of River State. The result generally reveals that, majority of the respondents are still energetic to carry on with yam production.

Family size of the respondent shows that majority of them (68%) belong to the family size of 6 to 10 members. The mean family size was found to be 7 members per family. The mean family size recorded for the study is lower than 13 members per family recorded by Pius and Odjurwuedernie (2006) for the Northern part of Nigeria.

Gender distribution of the respondents revealed that, 78% of the farmers are males while the remaining 20% are females. The result of farming experience also showed that, all of them had above 5 years experience in yam production. About 42% of the respondents had no formal education. About 33% others had primary education while about 25% of the remaining respondents attained either secondary or tertiary education. It is then obvious that, the educational standard of the respondents are generally low. Formal education enables the farmers to obtain useful information from media and other sources. Formal education aids farmers to accept new technologies.

The analysis of farm size showed that, 82% of the respondents had between 1 and 5 ha of farmland. The result of farm income of respondents showed that, about 52% of the farmers had less than ₦ 100,000.00 as annual farm income. About 22% had between ₦100,000 and ₦200,000 as annual farm income. The remaining 26% had above ₦ 200,000 as annual farm income. Going by the small farm size of the respondents in this study, couples with their low levels of farm income, it can be conducted that, most yam farmers in the study area are still operating at the subsistence level. This is in

Table 2. Distribution of respondents according to socioeconomic variables.

Socioeconomic variable	Frequency (No)	Age (%)
Age (year)		
Less than 21	0	0
21 – 40	45	30
41 – 60	91	60
Above 60	14	10
Total	150	100
Family size (number)		
1-5	18	12
6-10	101	68
Above 10	31	20
Total	150	100
Sex		
Male	117	78
Female	33	22
Total	150	100
Farming experience (year)		
Less than 6	0	0
6 – 15	88	59
Above 15	62	41
Total	150	100
Farm size (hectare)		
Less than 1	54	36
1 – 5	69	46
Above 5	27	18
Total	150	100
Educational status		
No formal education	63	42
Primary education	49	33
Secondary and above	38	25
Total	150	100
Farm income (naira)		
Less than ₦100,000	78	52
₦100,000 – ₦ 200,000	33	22
Above ₦200,000	39	26
Total	150	100

agreement with the opinion of Izekor and Olumese (2010) that over 90% of the country food supply comes from smallholder farmers.

The effect of socioeconomic variables of respondents on yam production is presented in Table 3. Some of the socioeconomic variables that were regressed on yam output (tones) includes: farm size (x_1), farm income (x_2), age (x_3), farming experience (x_4), sex (x_5), family size (x_6) and educational levels (x_7). The regression result of the estimated double log equation showed that, the coefficient of multiple determinants (R^2) is 0.79 which implies that, 79% variability in the output of yam was explained by the variables in the model while the remaining 21% could be attributed to error and omitted variable. The f-.value of 2.258 is significant at 1% level which confirms the significance of the entire model.

Farm income is positively related to yam output and significant at 1% level. This implies that, an increase in the income level of farmers will translate into increase in yam output. This result validates the findings of Ibitoye et al. (2012), who reported a positive and significant relationship between farmer's income and rice output. The educational level was found to be negatively related to output of yam production and significant at 1% level. This implies that, an increase in the number of years spent in school will lead to reduction in yam output. This may be attributed to the fact that, most of the respondents with higher qualification were not full time farmers but have other major occupations from which they earn their income. The regression result further showed that, age (X_3) is negatively related to yam output and only significant at 10% level. This implies that, as the farmer is ageing their productivity on the farm will decline. The significance of farm income, educational level and age of farmers is in conformity with earlier findings by Ibitoye et al. (2012), Pius and Odjurwuedernie (2006) and Ekunwe et al. (2008). Other variables like farm size (x_1), farming experience (x_4), sex (x_5) and family size (x_6) were found to be insignificant and therefore have no serious impact on yam production in the area.

Result of cost and return analysis in Table 3 suggests that, an average of 4,000 kg of yam tuber was realized from a hectare of yam farm. About ₦58,800 was spent on hiring labour and this constituted about 21% of total variable costs. The amount spent on procuring yam sett was 200,000 which is about 72% of the total cost of production. The cost of yam sett is still a major concern in yam production. The GM calculated for yam production per hectare of farmland was ₦121,200. This implies that, every one naira invested on yam production in the area generate a revenue of ₦1.43. This shows that, yam production in the study area is profitable.

The cost and return analysis of yam production per hectare in the study area is presented in Table 4:

(i) Gross margin (GM) Analysis of yam production:
Total revenue (TR) – Total variable cost (TVC)
GM = ₦ 400,000 – ₦ 278,800 = ₦ 121,200.
(ii) Return on investment (RI) = ₦121,200 / ₦278,800 = 0.43
(iii) Gross ratio (GR)= ₦278,800// ₦ 400,000 = 0.70

The ROI was 0.43 which implies that, every one naira invested in yam production generated a profit of ₦0.43. The gross ratio was also found to be 0.70 which is less than 1. This further confirmed that, yam production in the

Table 3. Regression results of the effect of socioeconomic variables on yam output.

Variable	Estimated coefficient	t- Statistics	Levels of significance
Farm size (x_1)	21.171	0.483	Not significant
Farm income (x_2)	0.012	2.778	1% level
Age (x_3)	-27.127	1.820	10% level
Farming experience (x_4)	10.233	0.855	Not significant
Sex (x_5)	-122.463	-0.323	Not significant
Family size (x_6)	-47.973	-1.374	Not significant
Educational levels (x_7)	-38.808	2.334	1% level
Constant	1257.523	2.984	
R^2= 0.79	f-value=2.258		

Table 4. Cost and returns analysis of yam production per hectare in the study area.

Items/operation	Unit of measurement	Unit cost (₦)	Total quantity	Total value (₦)
Labor cost				
Land clearing	Man day	800	18	14,400
Land cultivation	Man day	800	18	14,400
Planting	Man day	600	10	6,000
Fertilizer Application	Man day	600	5	3,000
Weeding	Man day	600	15	9,000
Staking	Man day	600	5	3,000
Harvesting	Man day	600	15	9000
Total				58,800
Other farm tools				
Yam sett	Sett	40	5,000	200,000
Fertilizer	50 kg bag	2000	4	8,000
Simple farm tools	Lump sum	-	-	4,000
Transportation	Lump sum	-	-	4,000
Miscellaneous expenses	Lump sum	-	-	4,687
Total farm input cost				220,000
Total variable cost (A + B)				278,800
Yam output				
Revenue				
Yam tuber	Kg	100	4,000	400,000

study area is profitable. This result agrees with the findings of Odinwa et al. (2011) who in their studies found yam mini sett production to be profitable.

CONCLUSION AND RECOMMENDATIONS

Yam is a valuable source of carbohydrate for human consumption. It can be processed into various staple, intermediate and end product forms which are used for direct consumption by both human and animals. It is used as basic ingredient for snacks or made into flour and for making instant chips. Judging by the value of yam in the society coupled with the fact that yam production is a profitable venture in the area, yam production will continue to play a prominent role in the area.

In order to ensure a better profitability level and a rapid improvement in yam production, it is recommended that:

(i) Agricultural mechanization should be encouraged as it would reduce labor cost. This can be achieved through the provision of tractors to farmers groups at subsidized prices and establishment of tractor hiring centre's at affordable prices.

(ii) Agro-chemicals especially fertilizers should also be provided by government to farmers at subsidized rate. This will also help to reduce the cost of farm inputs and increase productivity.

(iii) The cost of planting materials (yam sets) constitutes major part of variable costs of yam production. Government should therefore commercialize yam mini sett technique and make it available and affordable for rural farmers in the state.

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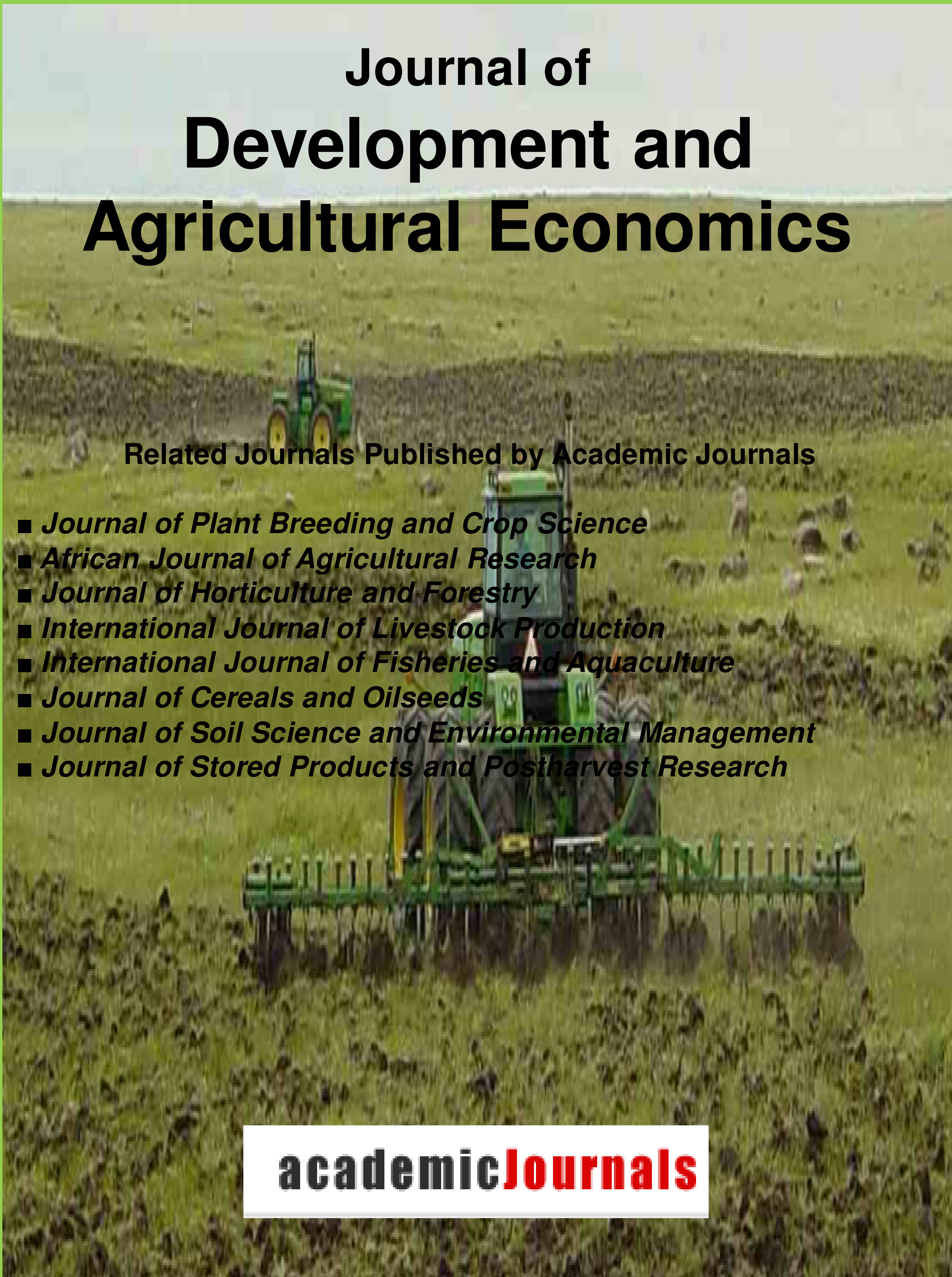

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