INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR

IFPRI Discussion Paper 00790

September 2008

Agricultural Growth and Investment Options for Poverty Reduction in Uganda

Samuel Benin
James Thurlow
Xinshen Diao
Allen Kebba
Nelson Ofwono

Development Strategy and Governance Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI) was established in 1975. IFPRI is one of 15 agricultural research centers that receive principal funding from governments, private foundations, and international and regional organizations, most of which are members of the Consultative Group on International Agricultural Research (CGIAR).

FINANCIAL CONTRIBUTORS AND PARTNERS

IFPRI's research, capacity strengthening, and communications work is made possible by its financial contributors and partners. IFPRI receives its principal funding from governments, private foundations, and international and regional organizations, most of which are members of the Consultative Group on International Agricultural Research (CGIAR). IFPRI gratefully acknowledges the generous unrestricted funding from Australia, Canada, China, Finland, France, Germany, India, Ireland, Italy, Japan, Netherlands, Norway, South Africa, Sweden, Switzerland, United Kingdom, United States, and World Bank.

AUTHORS

Samuel Benin, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division

James Thurlow, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division

Xinshen Diao, International Food Policy Research Institute
Senior Research Fellow, Development Strategy and Governance Division

Allen Kebba, Ark Consult Limited, Uganda

Nelson Ofwono, Africa Services Group Ltd, Uganda

Notices

[1] Effective January 2007, the Discussion Paper series within each division and the Director General's Office of IFPRI were merged into one IFPRI–wide Discussion Paper series. The new series begins with number 00689, reflecting the prior publication of 688 discussion papers within the dispersed series. The earlier series are available on IFPRI's website at www.ifpri.org/pubs/otherpubs.htm#dp.

[2] IFPRI Discussion Papers contain preliminary material and research results. They have not been subject to formal external reviews managed by IFPRI's Publications Review Committee but have been reviewed by at least one internal and/or external reviewer. They are circulated in order to stimulate discussion and critical comment.

Contents

List of Tables

List of Figures

ACKNOWLEDGMENTS

Funding for this study was made available under the COMESA-IFPRI agreement to support the Comprehensive African Agricultural Development Programme (CAADP) Round Table process in Uganda towards completion of a robust CAADP Compact. CAADP is a program of the New Partnership for Africa's Development (NEPAD) under the African Union (AU). We are particularly grateful to Josee Randriamamonjy for her research assistance.

ABSTRACT

Over the past two decades, Uganda has experienced strong economic growth. However, agriculture has not performed as well as the rest of the economy in recent years, and while the incidence of poverty has declined, it is still substantially higher in rural rather than urban areas. The Ugandan government, within the framework of its Plan for the Modernization of Agriculture (PMA) and the Prosperity for All (PFA) initiative, and in support of the upcoming National Development Plan, is in the process of implementing the Comprehensive Africa Agriculture Development Programme (CAADP), which provides an integrated framework of development priorities aimed at restoring agricultural growth, rural development and food security. This paper analyzes the agricultural growth and investment options that can support the development of a comprehensive rural development component under Uganda’s National Development Plan in alignment with the principles and objectives of the CAADP, which include achievement of six percent agricultural growth and allocation of at least ten percent of budgetary resources to the agricultural sector.

Our CGE modeling results indicate that it is possible for Uganda to reach the CAADP target of six percent agricultural growth, but this will require additional growth in a number of crops and sub-sectors. Uganda cannot rely on a few crops or sub-sectors to achieve its growth targets. Broader-based agricultural growth, including increases in fisheries and livestock, will be important if this target is to be achieved. So, too, is meeting the Maputo declaration of spending at least ten percent of the government’s total budget on agriculture. In fact, even under a more optimistic and efficient spending scenario, the Government of Uganda will have to increase its spending on agriculture in real value terms by about 25.3 percent per year between 2006 and 2015, and account for at least 14 percent of its total expenditure by 2015. While Uganda is currently on track to achieve the first Millennium Development Goal of halving poverty by 2015, achieving the CAADP growth target should remain a high priority, since it will substantially reduce the number of people living below the poverty line and significantly improve the well-being of both rural and urban households.

Keywords: agriculture, GDP, poverty, public investment, MDG

1. INTRODUCTION

Over the past two decades, Uganda has experienced strong economic growth. However, agriculture has not performed as well as the rest of the economy in recent years, and although the incidence of poverty has declined, it is still substantially higher in rural areas than urban areas. To accelerate growth and poverty reduction, Uganda's government has launched the Plan for the Modernization of Agriculture (PMA), which emphasizes the revitalization of agriculture as an engine of growth and development for the economy. The PMA is situated within the country's vision of Prosperity for All (PFA) and is supported by the broader Rural Development Strategy (RDS). This attempt to accelerate poverty reduction through agricultural growth is not surprising, since agriculture is an important mainstay of a large proportion of the population, contributing about one third of national GDP and half of export earnings, and employing four-fifths of the working population. In association with the New Partnership for Africa's Development (NEPAD), the Government of Uganda is in the process of implementing the Comprehensive Africa Agriculture Development Programme (CAADP), which provides an integrated framework of development priorities aimed at restoring agricultural growth, rural development and food security in the African region. The main target of CAADP is achieving six percent agricultural growth per year supported by the allocation of at least ten percent of national budgetary resources to the agricultural sector.

Faced with limited resources, the government must not only decide on how much to allocate for the agricultural sector as a whole, but also across sub-sectors within the agricultural sector, as well as across different non-agricultural sub-sectors, in overall economic development. Many investment and policy interventions will be designed at the sub-sector level, and strong inter-linkages occur across sub-sectors and between agriculture and the rest of the economy. To understand these linkages and how sectoral growth will contribute to the country's broad development goals, we need an integrated framework to help synergize the growth projections among different agricultural commodities or sub-sectors, and evaluate their combined effects on economic growth and poverty reduction. Moreover, agricultural production growth is often constrained by demands in both domestic and export markets, which in turn depends on income growth in both agriculture and the broader economy. Finally, although the majority of the Ugandan population lives in rural areas, both rural and urban sectors must be included in this framework in order for us to understand the economy-wide impact of agricultural growth.

This study analyzes agricultural growth options that can support the development of a more comprehensive rural development component under Uganda's PMA that is also in alignment with the principles and objectives collectively defined by African countries as part of the broader NEPAD agenda. In particular, the study seeks to position Uganda's agricultural sector and rural economy within the PMA. For these purposes, and to assist policymakers and other stakeholders in making informed long-term decisions, an economy-wide, computable general equilibrium (CGE) model of Uganda is developed and used to analyze the linkages and trade-offs between economic growth and poverty reduction at both the macro- and micro-economic levels. In addition, the study assesses the public resources required by the agricultural sector for achieving the development goals committed to by the government.

2. MODELING AGRICULTURAL GROWTH AND POVERTY REDUCTION

The Computable General Equilibrium (CGE) and Microsimulation Models

A new Ugandan CGE model was developed to capture the trade-offs and synergies arising from accelerating growth in various agricultural sub-sectors, and the economic linkages between agriculture and the rest of the economy.[1] Although this study focuses on the agricultural sector, the CGE model also contains information on the non-agricultural sectors. The model examines 50 sectors in total, 21 of which are in agriculture. The studied agricultural crops fall into five broad groups: (i) cereal crops, which are separated into maize, rice, and other cereals, such as sorghum and millet; (ii) root crops, which are separated into cassava, Irish potatoes, and sweet potatoes; (iii) horticulture, which is separated into vegetables and fruits; (iv) other food crops, which are separated into beans, matoke, and pulses and oil crops, such as groundnuts; and (v) higher-value export-oriented crops, which are separated into cotton, tobacco, coffee, tea, and other export crops, such as cocoa, sugarcane, and sunflower seeds. The CGE model also identifies three livestock sub-sectors, namely cattle, poultry, and other livestock, such as sheep, goats and pigs. To complete the agricultural sector, the model has two further sub-sectors capturing forestry and fisheries. A complete list of the sectors identified in the model is shown in Table 1.

Table 1. Agricultural commodities and non-agricultural sectors in the CGE model

Agricultural sub-sectors	
	Cereals
1	Maize
2	Rice
3	Other cereals (e.g. millet, sorghum)
	Root crops
4	Cassava
5	Irish potatoes
6	Sweet potatoes
	Horticulture
7	Vegetables
8	Fruits (e.g. passion fruits, other tree crops, sweet bananas)
	Pulses & oil seeds
9	Oil seed crops (e.g. simsim, sunflower seeds, groundnuts)
10	Beans (e.g. cowpeas, soybeans)
11	Matoke (plantains & food bananas)
	High-value export-oriented crops
12	Cotton
13	Tobacco
14	Coffee
15	Tea leaves
16	Other export crops (tea, cocoa, vanilla)
	Livestock
17	Cattle
18	Poultry
19	Other livestock (sheep, goats, pigs)
20	Forestry
21	Fisheries

[1] A detailed description of the model is provided in the appendix. See also Thurlow (2004).

Table 1. Continued

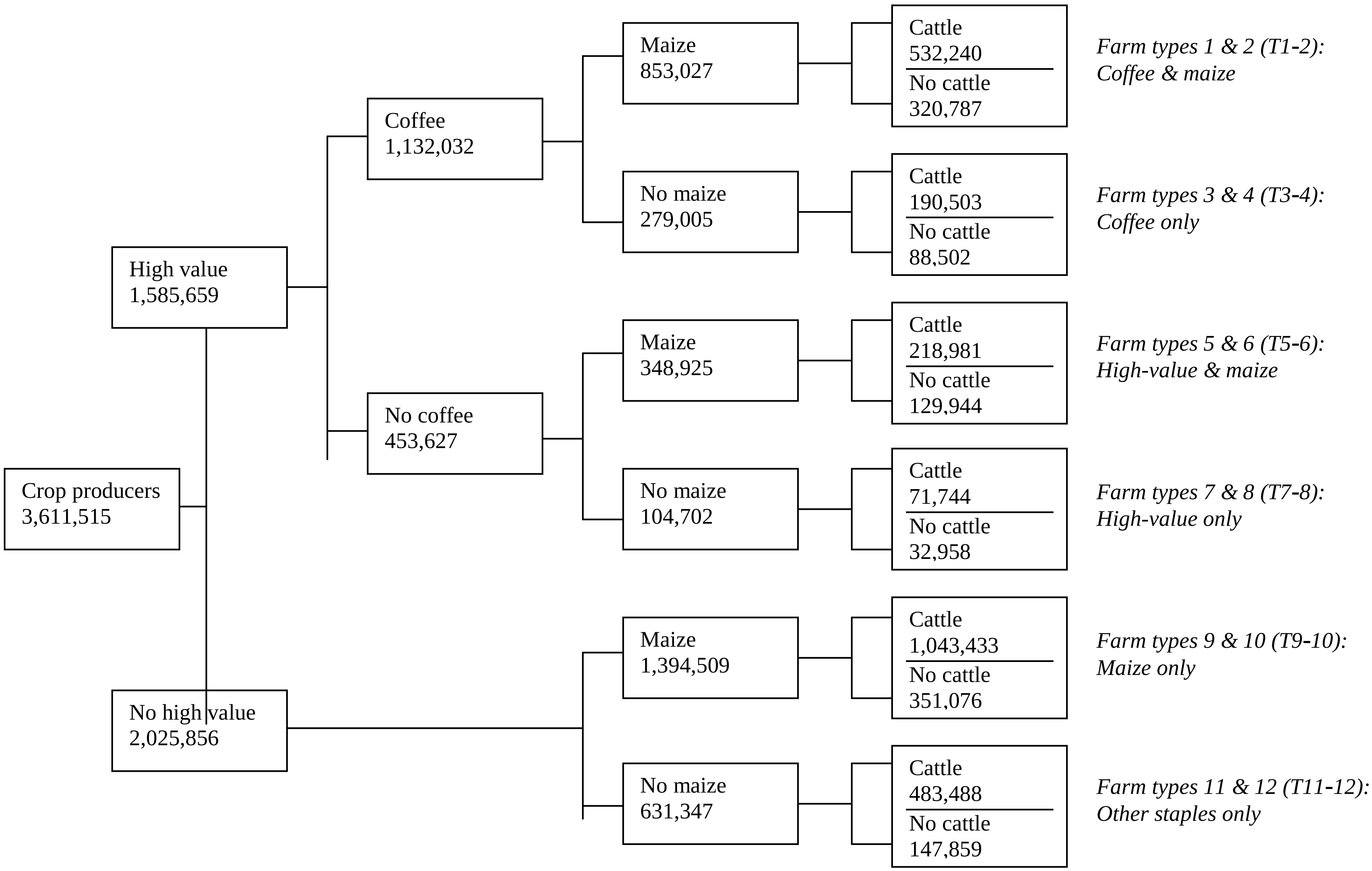
Industrial sub-sectors		Service sub-sectors	
22	Mining	39	Trade services
23	Meat processing	40	Hotels & catering
24	Fish processing	41	Transport services
25	Other food processing	42	Communication services
26	Grain milling	43	Financial & banking services
27	Animal feed processing	44	Real estate
28	Beverages & tobacco	45	Other private services
29	Textiles & clothing	46	Research & development
30	Wood & paper products	47	Public administration
31	Fuels	48	Education
32	Chemicals	49	Health
33	Fertilizer	50	Community services
34	Other manufacturing		
35	Machinery & equipment		
36	Furniture		
37	Utilities		
38	Construction		

Most of the agricultural commodities listed above are not only exported or consumed by households, they are also used as inputs into various processing activities in the manufacturing sector. The eight agricultural processing activities identified in the model, numbered 23–30 in Table 1, include meat, fish, grain, animal feed, other food, beverages and tobacco, textiles and clothing, and wood processing. The agricultural sub-sectors themselves also use inputs from non-agricultural sectors, such as fertilizer from the chemical sector and marketing services from the trade sectors.

Agricultural production is disaggregated across rural and urban areas. The model also captures differences in cropping patterns across farmers *within* rural areas. Information on crop production was drawn from the 2005/06 Uganda National Household Survey (UNHS5), which asked whether households were engaged in crop production and how much of their agricultural land was devoted to producing different crops. The survey also asked households whether they owned cattle. The main objective of the farm typology instituted in this study was to group farmers into major categories based on the crops they produce, which is assumed to reflect agro-ecological, technological and marketing constraints and opportunities.

For example, according to UNHS5, 3.61 million rural households reported agricultural crop incomes in 2005/06. This is shown in the left-hand box of Figure 2, which explains the general structure of the farm typology for all rural households in Uganda engaged in crop production, but this excludes urban and non-farm households, which will be addressed later. We first separate out farm households that reported producing high-value export-oriented crops, such as coffee, cotton, tobacco and tea. In 2005/06, 1.59 million farm households produced these export crops, corresponding to almost half of all rural farm households in Uganda. From the figure we can see that coffee is the dominant export crop, with 1.13 million households allocating land to coffee production. We then further split the farm households according to whether they produced maize. Here it is worth noting that, while matoke is the key staple food crop for most Ugandan farmers, it is less effective as a means of identifying distinct farm types. This can be seen in Table 2, which presents summary statistics for the various farm types in the model.

Figure 1. Farm typology structure for rural agricultural households



Source: Own calculations using the 2005/06 Uganda National Household Survey (UNHS5).

Table 2. Land and population distribution across regions and farm households

	National	Kampala	Other urban areas		Rural areas						
		Non-farm	Farm	Non-farm	Farm						Non-farm
					Coffee & maize	Coffee only	High-value & maize	High-value only	Maize only	Other staples only	
			T13-14		T1-2	T3-4	T5-6	T7-8	T9-10	T11-12	
Population (1000)	27,159	1,405	1,501	1,264	5,467	1,555	2,080	541	7,543	3,226	2,577
Number of households	4,717	311	229	282	769	252	315	94	1,258	569	637
With cattle	2,465	-	173	-	480	172	198	65	941	436	-
Without cattle	1,022	-	55	-	289	80	117	30	317	133	-
Household size	5.76	4.51	6.56	4.48	7.11	6.18	6.61	5.73	6.00	5.67	4.05
Per capita exp. ($US)	268	638	377	440	247	249	193	200	220	205	261
Poverty rate (%)	31.1	4.9	19.7	16.5	23.2	27.5	36.9	42.1	35.9	43.1	42.6
Share of poor (%)	100.0	0.8	3.5	2.5	15.0	5.1	9.1	2.7	32.0	16.4	13.0
Harvest area (1000 ha)	6,659	-	311	-	2,068	467	834	184	2,020	775	-
Average farm land (ha)	1.41	-	1.36	-	2.69	1.86	2.65	1.95	1.61	1.36	-
Maize	0.15	-	0.18	-	0.36	-	0.29	-	0.25	-	-
Other cereals	0.17	-	0.11	-	-	-	0.44	0.39	0.21	0.34	-
Root crops	0.22	-	0.29	-	0.42	0.23	0.41	0.19	0.28	0.20	-
Horticulture	0.05	-	0.05	-	0.13	0.09	0.06	0.04	0.05	0.00	-
Pulses & oilseeds	0.33	-	0.33	-	0.46	0.31	0.67	0.46	0.45	0.40	-
Matoke	0.35	-	0.25	-	0.82	0.83	0.18	0.15	0.37	0.38	-
Coffee	0.05	-	0.07	-	0.24	0.23	-	-	-	-	-
Other export crops	0.08	-	0.07	-	0.13	0.08	0.59	0.71	-	-	-
Crop yields (mt/ha)											
Maize	1.65	-	1.40	-	1.73	-	1.44	-	1.69	-	-
Cassava	6.70	-	10.72	-	7.38	5.42	5.03	6.36	7.06	5.20	-
Vegetables	5.99	-	5.06	-	4.11	7.62	7.18	5.87	-	-	-
Oilseeds	0.60	-	0.45	-	0.62	0.35	0.38	0.31	0.95	0.30	-
Matoke	5.76	-	5.11	-	5.31	5.54	4.56	5.45	6.53	6.14	-

Source: Own calculations using agricultural production data and the 2005/06 Uganda National Household Survey (UNHS5).

Note: ‘Per capita expenditure’ is the official consumption welfare measure; ‘poverty rate’ is poverty headcount based on the national poverty line (UGX204,810 or US$115 per person per year).

The table shows that although coffee farmers have larger-than-average farm plots, farmers growing coffee and maize (farm type (T) 1-2) tend to have even larger plots than coffee farmers without maize (T3-4) (2.69 hectares compared to 1.86 hectares, respectively). However, coffee farmers tend to allocate similar amounts of land to matoke (about 0.8 hectares) regardless of whether they grow maize. This is also true of other farm types.[2] More importantly, coffee and maize production is a key determinant for household incomes and poverty. Coffee farmers tend to have higher-than-average per capita incomes (about US$250 per year) and lower poverty rates. Furthermore, coffee and maize producers have significantly lower poverty rates compared to coffee farmers that do not grow maize. Thus, the sharp distinctions in cropping patterns and poverty rates among the farm types support their choice as separate farm groups within the model. It also supports the choice of maize production as a criterion for separating out less poor rural farm households.

Returning to farmers growing high-value crops, we focus next on non-coffee producers (T5-8). According to UNHS5, there were 0.45 million farmers who did not grow coffee but grew other export crops, such as cotton and tobacco. While these export-producing farmers have larger-than-average plot sizes, again the maize-growing farmers have considerably larger farms than those without maize. High-value crop farmers also devote a larger share of their land to non-maize cereals, such as sorghum and millet, and to pulses and oil seeds. Accordingly, their land allocation to matoke is lower than that of coffee farmers. Poverty rates are much higher among high-value farm households versus coffee-producing households, and Table 2 shows that high-value farmers who grow maize are less likely to be poor than farmers who do not grow maize. Thus, the typology reveals that while coffee and export crop farmers have similarly large farms, coffee appears to be a chief determinant of the extent of poverty amongst farm households.

Finally, we turn to the two million farm households in Uganda that are not engaged in export crop production. Two thirds of these farm households grow maize (T9-10), while the rest are more reliant on other staple crops, such sorghum, millet and matoke (T11-12). The non-export farm plot sizes are significantly below those of the other farm types, especially for producers of non-maize staples crops, whose farms average only 1.36 hectares. Despite having smaller farms, the per capita incomes and poverty rates of these farmers are broadly similar between staple-oriented farm households and the previously described high-value farm types. This suggests a greater reliance on non-farm income sources for staple-oriented households. Again maize producing households have lower poverty rates, although they remain above the average poverty rate for all rural areas. Due to these high poverty rates and the large number of these farm types, almost half of Uganda's poor population falls into one of these farm types.

Livestock is another important income source for many households. As shown in Table 2, about half of Ugandan households and more than two-thirds of Ugandan farm households own cattle. Furthermore, according to UNHS5, livestock ownership is a key determinant of poverty. This can be seen in Table 3, which shows average per capita expenditures for the various farm types, disaggregated according to whether the households own cattle or not. This clearly shows that households with cattle have significantly higher per capita expenditures and markedly lower poverty rates (20.7 percent for households with cattle compared to 33.5 percent for households without cattle). This correlation between livestock and 'welfare' also exists for individual farm types, with the exception of the 'high-value only' group.[3] Thus, over and above the crop-based disaggregation of farm households discussed above, we also separate each farm type into two sub-categories according to whether the households own cattle.

[2] Matoke land allocations are similar among high-value non-coffee producers (T5-8) and among staple food producers (T9-12).

[3] This farm type is much smaller than other farm groups and hence has a relatively small sample size in UNHS5. Thus, its characteristics should be treated with some caution.

Table 3. Per capita expenditures by livestock ownership

			Average annual per capita expenditure ($US)		
			Average	With cattle	Without cattle
National		All farm households	235	267	217
Rural	T1-2	Coffee & maize	247	271	229
	T3-4	Coffee only	249	307	217
	T5-6	High-value & maize	193	212	180
	T7-8	High-value only	200	176	212
	T9-10	Maize only	220	252	207
	T11-12	Other staples only	205	258	184
Urban	T13-14	Urban farm households	377	454	348

Source: Own calculations using the 2005/06 Uganda National Household Survey (UNHS5).
Note: Cattle ownership refers to bovines only; 'per capita expenditure' is the official consumption welfare measure.

Although Figure 2 shows the seven *rural* farm household types identified in the model, it does not show *urban* households engaged in crop production, which are also captured in the CGE model. This group is shown in Table 2. As can be seen from the table, urban agriculturalists are an important part of the agricultural sector, comprising about 229,000 households and 1.5 million individuals, which is approximately 5.5 percent of Uganda's total population. Urban farm households tend to be larger than rural households (6.2 individuals per household), although urban plot sizes are smaller than the national average (1.36 hectares). Very little urban agricultural land is devoted to high-value crops (about ten percent); most of this land (64 percent) is allocated to non-cereal food crops, such as roots, pulses and matoke. Urban farm households tend to be more heavily engaged in off-farm activities, and hence their per capita expenditures are well above the national average despite their smaller farm sizes. As with rural households, urban farm households are further disaggregated according to whether they own cattle.

The CGE model captures the initial cropping patterns of each of the 14 farm types described above. Each group of farmers (represented by the various farm types) responds to changes in production technology, commodity demand and prices by reallocating their land across different crops in order to maximize their incomes. These representative farmers also reallocate their labor and capital between farm and non-farm activities, including livestock and fishing, wage employment on other people's farms, and migration to non-agriculture in more urbanized sectors. Thus, by capturing production information at the farm level across sub-national regions, the CGE model effectively integrates data on different actors and activities into an economy-wide model that can assess growth effects at the national level, while taking into account the micro-level decision-making typically associated with more detailed farm models. The new Ugandan CGE model is therefore an ideal tool for capturing the growth linkages and income- and price-effects resulting from accelerating growth in different agricultural sectors.

Finally, the CGE model endogenously estimates the impact of alternative growth paths on the incomes of various household groups. These household groups follow the farm typology by including farm and non-farm households, and being disaggregated across rural areas, the major city of Kampala, and other smaller urban centers. Each of the households questioned in the 2005/06 UNHS5 are linked directly to their corresponding representative household in the CGE model. This is the microsimulation component of the new Ugandan model. In this formulation of the model, changes in representative households' consumption and prices in the CGE model are passed down to their corresponding households in the survey, where total consumption expenditures are recalculated. This new level of per capita expenditure for each survey household is compared to the official poverty line, and standard poverty measures are recalculated. Thus, poverty is measured in exactly the same way as in official poverty estimates, and changes in poverty draw on the consumption patterns, income distribution and poverty rates captured in the 2005/06 UNHS5.

Data

The data used to calibrate the base year of the model are drawn from a variety of sources. The core dataset underlying the CGE model is a new 2005 social accounting matrix (SAM) constructed using information from national accounts, supply-use tables, and balance of payments from the Uganda Bureau of Statistics (UBOS). Agricultural production data were provided by the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF). Whenever production information was unavailable for certain crops, such as horticulture, information was taken from the Food and Agriculture Organization (FAO) of the United Nations (FAO, 2007). Agricultural production was first disaggregated across sectors using official production estimates. Production was then disaggregated across farm types using information from the 2005/06 UNHS5. The CGE model is therefore consistent with official production levels and yields, while retaining the household-level distribution of production captured in the survey. Non-agricultural production and employment data were compiled from UNHS5, national accounts (UBOS, 2007), and the 2002/03 supply-use table (UBOS, 2008).[4] On the demand side, information on production technologies (i.e., intermediate and factor demands) was taken from the 2002/03 supply-use table, while the income and expenditure patterns for the various household groups were taken from UNHS5. The CGE model is therefore based on the most recent available data for Uganda.

[4] The supply-use table provides detailed production technologies for a large number of sectors, but is not consistent with national accounts at the time of publishing. For example, it estimates agricultural GDP to be about 20 percent of national GDP, which is well below previous estimates of around 30 percent. As such, we construct a new SAM that uses the disaggregation of detailed production sectors from the supply-use table, but maintains the broader sectoral disaggregation contained in the national accounts. The SAM is thus reconstructed (not updated) for 2005.

3. POVERTY REDUCTION UNDER UGANDA'S CURRENT GROWTH PATH

In this section, we use the CGE and microsimulation model to examine the impact of Uganda's current growth path on poverty reduction. This 'business-as-usual' or Baseline scenario draws on recent production trends for the various agricultural and non-agricultural sub-sectors. Uganda as a whole has performed well over the last few years, with national GDP growing above five percent per year (UBOS, 2007). However, during this same period, the agricultural sector experienced a far more modest growth of around two percent per year. Furthermore, agricultural growth has been erratic, with agricultural GDP rising during 2002-2003, falling in 2004, and then remaining stagnant during 2005-2006. In the Baseline scenario, we assume that agricultural GDP will perform slightly better than it has over the last two years, and will grow at an average of 2.7 percent per year during 2005-2015. This is consistent with Uganda's longer-term average agricultural growth rate since the early-1990s. Moreover, most agricultural production growth since 1990 has been due to area expansion, with average weighted yields falling over this period. In the Baseline scenario, we assume that land expansion will continue, but at a more modest pace, with only two-thirds of production increases driven by area expansion. This is equivalent to a two percent increase in harvested land per year during 2005-2015, and is lower than the rural population growth rate of 3.5 percent. As shown in Table 4, the non-agricultural sectors are expected to maintain their strong performance over the coming decade, with the industrial and services sectors growing at 5.7 and 6.1 percent per year, respectively.

The overall 2.7 percent agricultural growth rate in the Baseline scenario is based on more detailed assumptions for different agricultural sub-sectors. Table 5 shows the assumptions made about each sub-sector's yield growth. We initially adopt a slightly higher maize yield than was actually observed in 2005, because we calibrate the model to average production data for 2000-2006. We then assume that maize yields grow at 0.92 percent during 2005-2015, such that Uganda achieves a sustained maize yield of 1.81 tons per hectare by 2015. This modest yield growth is equivalent to returning to the maize yields achieved during 2001-2003, which were the highest seen since the early-1990s. Similarly, for rice and other cereals, we assume that initial yields are closer to longer-term trends at 1.45 and 1.50 tons per hectare, respectively, and that these yields will rise modestly to 1.51 and 1.65 tons per hectare, respectively, by 2015.

Although population growth exceeds cereal yield growth and demand rises due to non-farm growth in urban areas, a slightly smaller share of land is allocated towards maize. However, total agricultural land is growing at two percent per year, meaning that the physical amount of land allocated to cereal crops rises by 2015.[5] Together, rising yields and expanding land areas causes maize production to grow at around 2.5 percent per year during 2005-2015. Thus, in the Baseline scenario, we see small but stable improvements in cereal yields over the next decade, with modest production growth driven by population-driven land expansion. Since cereal production growth is below population growth, annual average per capita cereal consumption falls from 29.0 to 26.3 kilograms by 2015 under the Baseline scenario.

Based on the recent performance of root crops, we assume that these crop yields will grow at rates similar to those of cereal yields over the coming decade. Cassava yields in the Baseline scenario grow at 0.75 percent per year (see Table 5). Cassava dry-weight yields gradually rise from 6.7 tons per hectare to 7.2 tons by 2015, which is equivalent to the historical peak yield achieved in 2005. The slow pace of cassava yield growth in the Baseline scenario is consistent with the relatively constant yields achieved since 1999. Similarly, Irish potato yields rise to 7.4 tons per hectare, which is well below the 8.4 tons achieved during the mid-1990s, but is consistent with recent trends. Land allocations to root crops

[5] Note that crop yields are exogenously imposed on the model, but land and labor allocations are endogenously determined within the model based on the relatively profitability of different crops and non-farm activities. Crop profitability depends both on commodity prices and demand (subsistence and marketed) and on factor prices and the resource constraints facing different farm households in the typology (as initially captured in UNHS5). Land allocations are exogenously determined for the more investment-intensive crops, such as rice and export crops.

are expected to remain relatively constant despite the overall land expansion of two percent per year. Thus, production grows at about three percent per year for root crops as a whole, which is only slightly faster than cereal production growth.

Table 4. GDP growth rates in the Baseline and CAADP scenarios

	Initial value of GDP (Ugshs bil.)	Percentage share of total (%)		Average annual growth rate (%)	
		Total GDP	Agricultural GDP	Baseline scenario	CAADP scenario
	2005	2005	2005	2005-15	2005-15
Total GDP	14,898	100.0		5.06	6.08
Agriculture	4,659	31.3	100.0	2.72	5.95
Cereals	589	4.0	12.6	2.96	5.44
Maize	255	1.7	5.5	2.44	5.23
Rice	70	0.5	1.5	2.36	5.33
Other cereals	264	1.8	5.7	3.59	5.67
Root crops	976	6.6	20.9	2.88	6.04
Cassava	512	3.4	11.0	2.87	6.03
Irish potatoes	94	0.6	2.0	3.21	5.84
Sweet potatoes	370	2.5	7.9	2.80	6.09
Horticulture	58	0.4	1.2	3.33	6.16
Vegetables	19	0.1	0.4	4.08	6.23
Fruits	38	0.3	0.8	2.92	6.12
Pulses & oil seeds	708	4.8	15.2	2.27	5.64
Oil seed crops	132	0.9	2.8	3.29	6.12
Beans	576	3.9	12.4	2.03	5.53
Matoke	605	4.1	13.0	2.26	6.44
Export-oriented crops	444	3.0	9.5	2.93	7.13
Cotton	26	0.2	0.6	2.75	7.07
Tobacco	127	0.9	2.7	2.66	7.49
Coffee	194	1.3	4.2	3.17	7.96
Tea leaves	65	0.4	1.4	2.70	4.15
Other export crops	33	0.2	0.7	3.04	5.77
Livestock	652	4.4	14.0	2.82	5.45
Cattle	469	3.1	10.1	3.04	5.57
Poultry	72	0.5	1.5	2.61	5.37
Other livestock	112	0.7	2.4	1.96	5.00
Forestry	246	1.6	5.3	3.08	5.35
Fisheries	381	2.6	8.2	2.67	6.04
Industry	3,643	24.5		5.68	5.88
Processing	748	5.0		4.36	5.82
Services	6,596	44.3		6.13	6.28

Source: Own calculations from the new 2005 Ugandan social accounting matrix and results from the Ugandan CGE-microsimulation model.

Table 5. Baseline crop yield, area, production, CAADP targets and growth rates

	Crop yields (exogenous: imposed on the model)				Production quantity (endogenous: results from the model)				Harvested area (endogenous: results from the model)			
	Initial level	Baseline growth rate	CAADP target level	CAADP growth rate	Initial level	Baseline growth rate	CAADP target level	CAADP growth rate	Initial level	Initial share	Baseline share	CAADP share
	mt/ha	%	mt/ha	%	1000 mt	%	1000 mt	%	1000 ha	%	%	%
	2005	2005-15	2015	2005-15	2005	2005-15	2015	2005-15	2005	2004	2015	2015
Cereals												
Maize	1.65	0.92	2.34	3.52	1,185	2.46	1,970	5.22	717	10.76	10.26	10.38
Rice	1.45	0.40	2.00	3.27	129	2.41	217	5.34	89	1.33	1.33	1.33
Other cereals	1.50	0.92	1.96	2.70	1,056	3.60	1,833	5.67	702	10.54	11.23	11.49
Root crops												
Cassava	6.70	0.75	9.99	4.08	2,647	2.87	4,746	6.01	395	5.94	5.99	5.85
Irish potatoes	6.94	0.64	9.95	3.66	554	3.20	973	5.80	80	1.20	1.26	1.20
Sweet potatoes	4.40	0.71	6.53	4.02	2,571	2.80	4,638	6.08	584	8.77	8.83	8.74
Horticulture												
Vegetables	5.99	0.42	9.24	4.44	555	4.09	1,013	6.20	93	1.39	1.64	1.35
Fruits	4.66	0.43	6.78	3.81	669	2.91	1,208	6.09	144	2.16	2.26	2.19
Pulses & oil seeds												
Oil seed crops	0.60	0.69	0.90	4.14	272	3.30	492	6.09	454	6.82	7.22	6.73
Beans	0.73	1.00	1.03	3.53	804	1.98	1,374	5.50	1,104	16.58	14.96	16.40
Matoke	5.76	0.23	9.03	4.60	9,505	2.25	17,700	6.42	1,650	24.78	24.81	24.12
Export crops												
Cotton	0.48	0.27	0.74	4.47	92	2.78	182	7.08	191	2.87	3.02	3.02
Tobacco	0.62	0.24	0.99	4.86	8	2.67	16	7.48	12	0.18	0.19	0.19
Coffee	0.65	0.67	1.09	5.34	166	3.19	358	7.97	256	3.84	4.03	4.03
Tea	9.00	0.21	10.58	1.63	171	2.72	257	4.17	19	0.28	0.30	0.30
Other crops	12.00	0.54	16.46	3.21	2,036	3.05	3,574	5.79	170	2.55	2.67	2.67

Source: Initial yield, area and production estimates from MAAIF (2007) and the Food and Agriculture Organization (FAO, 2007). Crop yield targets based on crop production field trial assessments.

Recent trends indicate that the performance of other food crops has been mixed. Fruits have not performed particularly well, with production growing at only 0.7 percent per year during 1990-2006. In contrast, vegetables have performed much better, with production growing at about three percent per year since 1990. Thus, in the Baseline scenario we assume faster growth in vegetables versus fruits and cereals. Groundnut production has also risen since 2000, and this trend is assumed to continue and be supported by increased land allocations. Accordingly, the production of oil seed crops in the Baseline scenario grows at 3.3 percent per year, which is faster than the average growth rate of the overall agricultural sector.

Export crops play a key role in the agricultural sector, generating 9.5 percent of the sector's GDP and a far larger share of the country's export earnings (see Table 4). These export crops are also likely to have greater growth potential than many staple food crops. However, despite this potential, agricultural exports have performed poorly in recent years, with crop yields falling slightly for crops such as tea and tobacco. In the Baseline scenario, we assume that the performance of these crops will improve slightly. Annual yield growth ranges from 0.21 percent for tea to 0.67 percent for coffee (see Table 5). Coffee is especially important for Uganda, as over a million farm households are engaged in coffee production (see Table 2). Since 2002, there has been a sharp drop in coffee production by about 25 percent. In the Baseline scenario, we assume that this downward trend is halted and that production rises to 227,000 tons by 2015, which is still below the production levels achieved in the late-1990s. The Baseline scenario, therefore, assumes a modest recovery of the coffee sector.

Livestock is an important agricultural sub-sector, generating 14 percent of agricultural GDP in 2005. Recent evidence suggests that Uganda's livestock population has been growing steadily (Kebba and Ofwono, 2007). We assume that these population trends are indicative of changes in livestock GDP, and that this expansion will continue. Cattle GDP in the Baseline scenario grows at 2.8 percent per year during 2005-2015, which is slightly lower than the cattle population's annual growth rate of 3.6 percent during 1998-2006. The poultry population has also grown rapidly since 1998, although there was a sharp decline in 2006. In the Baseline scenario, we assume that the poultry population will return to longer-term trends and the poultry GDP will grow at 2.6 percent per year during 2005-2015. Finally, the populations of other livestock types have not grown as fast as those of either cattle or poultry over the past decade (e.g., the pig population grew at only 1.8 percent per year during 1998-2006). We therefore assume that 'other livestock' GDP grows at about two percent per year in the Baseline scenario.

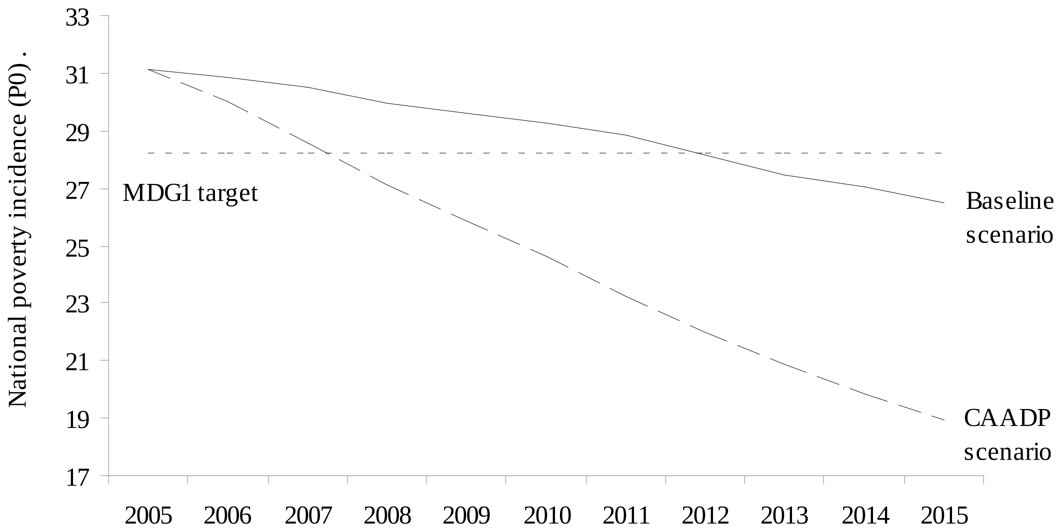
Fisheries and forestry are also important agricultural sub-sectors, together generating 13.5 percent of total agricultural GDP in 2005. The Baseline scenario assumes that fisheries GDP will grow at 2.7 percent per year during 2005-2015. This captures reasonable expectations about Uganda's natural potential for expanding this sector, but also reflects the typical challenges associated with capture fisheries. The Baseline scenario therefore assumes that fish production grows from 416,000 tons in 2005 to 541,000 tons in 2015, which is equivalent to achieving the production targets identified in the government's strategic export plan, but by 2015 as opposed to the 2007 goal stated in the plan (Kebba and Ofwono, 2007). In the forestry sub-sector, recent trends suggest that growth has been driven by charcoal and fuel wood production for household use (Kebba and Ofwono, 2007). Thus, the Baseline scenario assumes forestry GDP will continue to grow roughly proportional to the population, at around 3.1 percent per year during 2005-2015.

Drawing on the above trends, the CGE model simulation results indicate that, with modest growth in the agricultural sector and more rapid growth in the non-agricultural sectors, overall national GDP will grow at an average rate of 5.1 percent during 2005-2015 (see Table 4). This is close to the average GDP growth rate of around 5.5 percent since 2000. With population growth at 3.5 percent per year, per capita GDP grows at 1.6 percent. With rising per capita incomes, the CGE model indicates that poverty will decline modestly, with national poverty falling from 31.1 percent in 2004 to 26.5 percent in 2015 (Figure 2).[6] This is sufficient for Uganda to reach the first Millennium Development Goal (MDG1) of halving the

[6] This is a drop in the national poverty rate by 1.6 percent per year over ten years, with per capita GDP growth of 1.6 percent per year (i.e., a rough average poverty-growth elasticity of -1.00). This is broadly consistent with observed poverty declines

1990 poverty rate by 2015. However, with such modest poverty reduction and an expanding population, the absolute number of poor people in Uganda would increase from 8.46 million in 2005 to 10.15 million by 2015. The model results indicate that urban poverty falls from 13.8 to 11.3 percent by 2015, while rural poverty declines from 34.3 to 29.3 percent during the same period. Thus, although it is on track to meet MDG1, Uganda must still search for new opportunities to accelerate growth and poverty reduction, especially in rural areas.

Figure 2. National poverty rate under alternate agricultural growth scenarios



Source: Results from the Ugandan CGE-microsimulation model.

during the 1992-2005 period, during which time poverty fell by 4.5 percent per year over 13 years with per capita GDP rising by 3.3 percent per year (i.e., an average poverty-growth elasticity of about -1.35). As seen later in this report, part of the reason for the lower poverty growth elasticity in the Baseline scenario can be attributed to the recent slowdown in agricultural growth.

4. ACCELERATING AGRICULTURAL GROWTH AND POVERTY REDUCTION

Reaching the CAADP Agricultural Growth Target

In the previous section, we described the results of the Baseline scenario, which estimated the impact of Uganda's current growth path on poverty reduction. In this section, we examine the potential contribution of different agricultural sub-sectors in helping Uganda achieve the six percent agricultural growth target identified by the CAADP initiative. Accelerated crop production is modeled by increasing yields in order to achieve 'reasonable' yield improvements by 2015. Maximum potential yields are taken from field trial estimates reported by Uganda's National Agricultural Advisory Services (MAAIF, 2006). However, it is not expected that Uganda will achieve and sustain the high yields predicted under the more ideal conditions of controlled field trials, nor is Uganda expected to achieve comprehensive technology adoption rates by 2015.

Taking maize as an example, under the Baseline scenario, we assumed that average yields for the next ten years would remain relatively constant between 1.65 and 1.81 tons per hectare. In this section, we model more ambitious maize yield improvements, with the annual yield growth rate for maize rising from its current 0.9 percent per year to 3.5 percent per year (see Table 5). This implies that national average maize yields will increase consistently over the next ten years to reach 2.34 tons per hectare by 2015. This is well below the maximum potential yields identified by field trials, which range from 1.25 to 4.90 tons per hectare depending on seed types and agro-ecological conditions (see Table 6).

However, while acknowledging the less optimistic estimates of potential maize yields compared to those obtained in field trials, recent trends in maize yields indicate that reaching and sustaining 2.34 tons per hectare by 2015 poses considerable challenges. According to MAAIF statistics, national average maize yields did not exceed 1.8 tons per hectare during 1990-2005. This implies that the government would not only have to improve the distribution of better seed technology, but also improve current farming practices and the distribution of other inputs if it is to help farmers significantly increase maize yields by 2015. For these reasons, 2.34 tons per hectare is considered a challenging maize yield target. Table 6 provides similar comparisons between modeled and field trial yields for other selected crops.[7]

Table 7 shows the ten different scenarios designed for this analysis. In Scenarios 1-9, we target specific groups of crops or agricultural sub-sectors. For instance, in the 'cereal-led growth' scenario, we increase the land productivity of only the three cereal sectors in the model, using them to achieve the yield targets shown in Tables 5 and 6. In the non-crop scenarios, such as 'livestock-led growth,' we increase labor productivity to achieve the targeted increases in GDP growth shown in Table 4. Finally, in Scenario 10, or the 'CAADP scenario,' we combine the yield and productivity improvements of each sub-sector to arrive at an overall growth scenario for the CAADP initiative.

Agriculture's current poor performance means that achieving the CAADP target of six percent agricultural growth will be challenging, as Uganda will have to more than double its existing agricultural growth rate of 2.7 percent per year. However, based on the crop yield and agricultural productivity potentials identified at the sub-sectoral level, the CGE model indicates that it is possible for Uganda to reach an average six percent agricultural growth during 2005-2015 (see Table 4). Since agriculture accounts for nearly one-third of the Ugandan economy, this acceleration of agricultural growth would raise the national GDP growth rate from its current 5.1 percent to 6.1 percent per year during 2005-2015 (see Table 4). Faster agricultural growth will stimulate additional growth in the non-agricultural sectors by raising final demand for non-agricultural goods, lowering input prices, and fostering upstream processing. Under the CAADP growth scenario, the GDP growth rate of the processing sectors would increase from 4.4 percent under the Baseline scenario to 5.8 percent per year. Therefore, achieving the CAADP agricultural growth target would have economy-wide growth-linkage effects for non-agriculture.

[7] Some low-input yields from field trials exceed national yields from official production data. This may be due to differences in measuring production quantities (e.g. dry versus wet weight cassava), inaccurate national production data, or overestimation of low-input yields under more favorable field trial conditions.

Table 6. Comparison of crop yields under model scenarios and research institute field trials

	Modeled crop yields (mt/ha)			Yield ranges from field trials (mt/ha)
	Initial value 2005	Baseline scenario 2015	CAADP scenario 2015	
Cereals				
Maize	1.65	1.81	2.34	1.25 - 4.90
Rice	1.45	1.51	2.00	1.40 - 2.60
Wheat	1.50	1.65	1.96	1.80 - 3.75
Roots				
Cassava	6.70	7.21	9.99	5.00 - 11.50
Irish potatoes	6.94	7.41	9.95	4.50 - 12.50
Sweet potatoes	4.40	4.73	6.53	5.00 - 12.00
Pulses & oil crops	-	-	-	-
Beans	0.73	0.81	1.03	0.45 - 1.20
Groundnuts	0.68	0.73	1.02	0.50 - 1.00
Simsim	0.53	0.57	0.80	0.53 - 0.98
Matoke	5.76	5.89	9.03	5.50 - 11.88
Export crops	-	-	-	-
Cocoa	0.60	0.63	0.82	0.55 - 1.00
Coffee	0.65	0.69	1.09	0.50 - 0.95 (arabica)
				1.00 - 2.50 (robusta)
Cotton	0.48	0.49	0.74	0.28 - 1.00
Sunflower seeds	1.06	1.12	1.45	1.05 - 2.00
Tea	9.00	9.20	10.58	8.50 - 11.50
Tobacco	0.62	0.63	0.99	max 1.00 (fire) 1.20 (air) 1.45 (flue)
Vanilla	0.52	0.55	0.71	0.68 - 1.50

Source: Uganda National Agricultural Advisory Services crop production survey (MAAIF, 2006) and results from the Ugandan CGE-microsimulation model.
Notes: Yield ranges begin with traditional/low-input practices and end with high-input/recommended practices. The 'tobacco' category shows maximum yields under different curing processes.

Table 7. Model growth scenarios

	Cereal-led growth	Root-led growth	Horti-culture-led growth	Pulses-led growth	Matoke-led growth	Export-crop-led growth	Livestock-led growth	Forestry-led growth	Fisheries-led growth	CAADP scenario
	1	2	3	4	5	6	7	8	9	10
Maize	×									×
Rice	×									×
Other cereals	×									×
Cassava		×								×
Irish potatoes		×								×
Sweet potatoes		×								×
Vegetables			×							×
Fruits			×							×
Oil seed crops				×						×
Beans				×						×
Matoke					×					×
Cotton						×				×
Tobacco						×				×
Coffee						×				×
Tea						×				×
Other export crops						×				×
Cattle							×			×
Poultry							×			×
Other livestock							×			×
Forestry								×		×
Fisheries									×	×

Impact on Incomes and Poverty

The acceleration of agricultural growth to six percent per year and the spillover effects into non-agriculture causes poverty to decline by a further 7.6 percentage points, from the Baseline scenario rate of 26.5 percent to 18.9 percent under the CAADP scenario. Thus, taking population growth into account, achieving the CAADP growth target lifts an additional 2.9 million people above the poverty line by 2015, and is sufficient to reverse current trends by reducing the absolute number of poor people in Uganda by 2015.[8]

Faster agricultural growth benefits a majority of households. However, not all households benefit equally from achieving the crop yields and sub-sector growth rates targeted under the CAADP growth scenario. Table 8 shows changes in production, incomes and poverty rates for the different farm types and household groups in the model. Part 1 of the table reports changes in the real value of production for the different farm categories in the typology. Additional growth under the CAADP scenario is partly driven by expanding export crops, where GDP growth rises from 2.9 to 7.1 percent per year (see Table 4). Rural farmers with better market access and more favorable agro-ecological conditions can more readily grow higher-value crops, thereby benefiting the most under the CAADP scenario. As seen in Table 8, the value of total crop production for the high-value producing farm types (types T5-8) increases by as much as 3.8 percentage points (from 2.7 percent per year under the Baseline scenario to 6.5 percent under the CAADP scenario). The importance of higher-value export-oriented crops for certain farm types can be seen in Figure 3, which shows the contribution of growth in different sub-sectors to changes in the value of crop production for different farm types. We see that export crops account for a large share of the additional production for coffee and high-value crop producers.

Despite faster export growth, most farm types benefit fairly equally under the CAADP scenario, largely because reaching the CAADP target requires additional growth in most agricultural sub-sectors. However, Figure 4 indicates that the sources of additional production vary dramatically across farm types. Not surprisingly, farmers that are more dependent on maize and other staple crops tend to benefit more from cereal-, root- and matoke-led growth. There are two forces driving changes in overall production: direct and indirect effects of crop-specific yield improvements. First, increasing yields has a direct effect on farm income, since it increases the quantity of output that a farm household can produce using the same quantity of factor inputs. However, increased production faces demand/market constraints such that prices typically fall following increases in yields. Thus, the direct impact of crop yield improvements for a specific farm household is its net effect on crop production, weighted by the share of the household's land allocated to producing that crop. This *direct* effect assumes that land allocations remain fixed. However, farmers may reallocate land in response to changes in relative prices. Thus, the *indirect* impact of crop yield improvements is the potentially positive impact of reallocating land to other crops. The CGE model captures both the direct and indirect effects crop yield improvements.

Figure 4 shows the importance of taking demand constraints and relative price changes into account. Matoke has relatively weak linkages to upstream food processing, and therefore faces more stringent demand constraints to increasing production. This causes matoke prices to decline significantly under the CAADP scenario. Maize has slightly stronger linkages to the animal feed and food processing sectors, which means that although maize prices decline under the CAADP scenario, they fall by less than matoke prices. Finally, the farm-gate coffee price is influenced by Uganda's real exchange rate, which depreciates under the CAADP scenario. This means that the price received by coffee farmers rises slightly despite quite rapid increases in coffee production. These price changes cause farmers to reallocate land away from crops that become less profitable; therefore, the share of land under maize and matoke declines, while the land allocated to export crops increases (see the last two columns of Table 5).

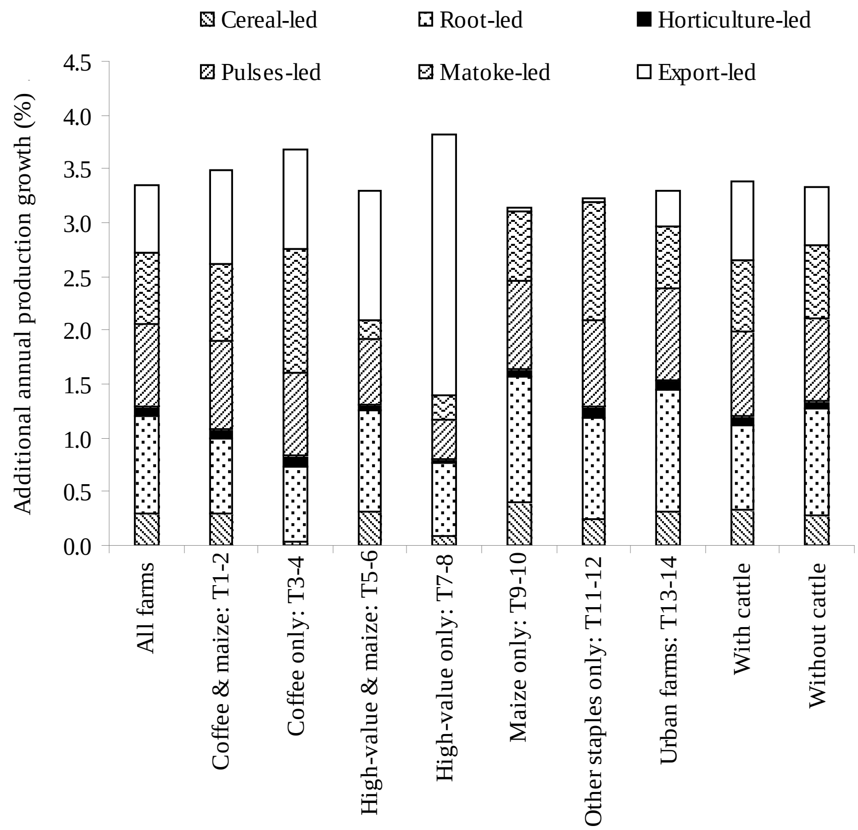
[8] In 2005/06 there were 8.46 million people living below the poverty line. Under the Baseline scenario, this number rises to 10.15 million by 2015, whereas under the CAADP scenario, it falls to 7.25 million.

Table 8. Agricultural production, income growth and poverty reduction in the model

		Initial value 2005	Annual growth under… Baseline 2005-15	CAADP 2005-15	Additional growth rate 2005-15
Part 1: Agricultural production	Real value of production (shillings billion)				
	All farms	4,616	2.68	6.03	3.35
	Rural farms	4,448	2.68	6.03	3.36
	Coffee & maize: T1-2	1,565	2.66	6.16	3.49
	Coffee only: T3-4	334	2.60	6.27	3.68
	High-value & maize: T5-6	592	2.76	6.07	3.30
	High-value only: T7-8	120	2.67	6.48	3.82
	Maize only: T9-10	1,452	2.71	5.85	3.15
	Other staples only: T11-12	386	2.58	5.81	3.23
	Urban farms: T13-14	168	2.72	6.02	3.30
	With cattle (T1,3,5,7,9,11,13)	1,987	2.65	6.03	3.38
	Without cattle (T2,4,6,8,10,12,14)	2,629	2.70	6.04	3.33
Part 2: Incomes	Per capita incomes ($US)				
	National	268	1.25	2.19	0.95
	Urban	484	1.03	1.95	0.91
	Farm: T13-14	224	1.43	2.40	0.98
	Non-farm	544	1.03	1.94	0.90
	Rural	228	1.35	2.32	0.96
	Farm	224	1.43	2.40	0.98
	Coffee & maize: T1-2	247	1.45	2.61	1.15
	Coffee only: T3-4	249	1.25	2.30	1.05
	High-value & maize: T5-6	193	1.51	2.76	1.25
	High-value only: T7-8	200	1.24	2.60	1.36
	Maize only: T9-10	220	1.52	2.33	0.82
	Other staples only: T11-12	205	1.28	2.15	0.87
	Non-farm	261	1.04	1.94	0.90
		Initial poverty rate 2005	Final poverty rate under Baseline 2015	CAADP 2015	Additional poverty reduction 2015
Part 3: Poverty	Poverty incidence (%)				
	National	31.1	26.5	18.9	-7.57
	Urban	13.8	11.3	8.3	-2.95
	Kampala	4.9	2.9	1.0	-1.87
	Urban farms: T13-14	19.7	16.9	12.7	-4.17
	Urban non-farm	16.5	14.0	11.3	-2.72
	Rural	34.3	29.3	20.8	-8.41
	Farm	33.2	27.8	19.0	-8.84
	Coffee & maize: T1-2	23.2	17.0	10.0	-6.93
	Coffee only: T3-4	36.9	33.9	18.4	-15.55
	High-value & maize: T5-6	35.9	30.1	20.7	-9.40
	High-value only: T7-8	27.5	25.0	16.4	-8.53
	Maize only: T9-10	42.1	35.6	25.1	-10.42
	Other staples only: T11-12	43.1	37.0	30.7	-6.30
	Non-farm	42.6	40.7	35.7	-5.01
	With cattle (T1,3,5,7,9,11,13)	26.2	21.6	14.0	-7.51
	Without cattle (T2,4,6,8,10,12,14)	37.1	31.2	21.6	-9.56

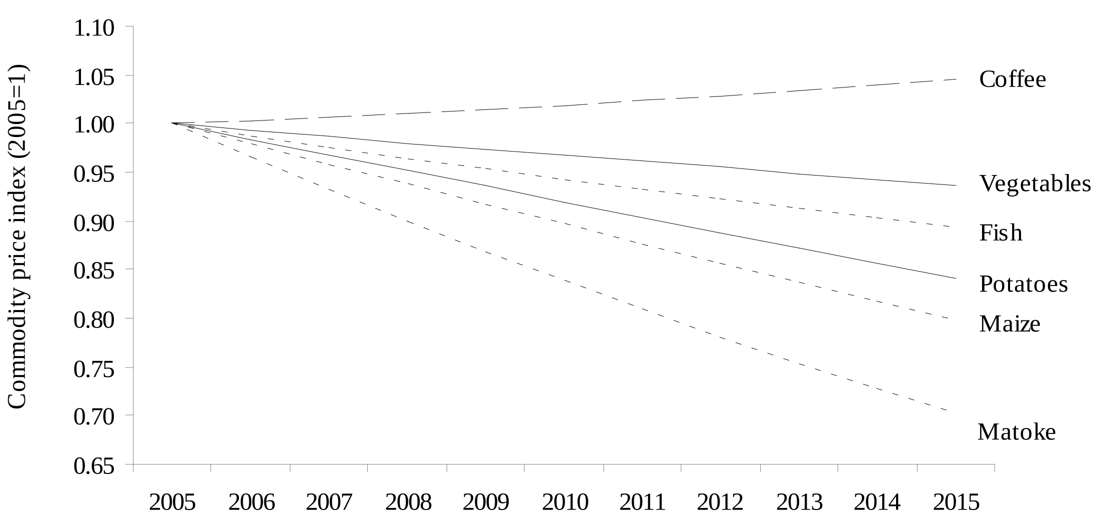
Source: Results from the Ugandan CGE-microsimulation model.

Figure 3. Sources of additional agricultural crop production growth by farm type



Source: Results from the Ugandan CGE-microsimulation model.
Note: Figure shows real production growth over and above that achieved under the Baseline scenario.

Figure 4. Relative producer price changes under the CAADP scenario



Source: Results from the Ugandan CGE-microsimulation model.

The model results also indicate that urban farmers benefit by at least as much as rural farmers under the CAADP growth scenario. This can be seen in Table 8, which shows that per capita household incomes for both rural and urban farm households grow by an additional 0.98 percentage points per year. Since rural poverty is initially much higher than urban poverty, and agriculture is particularly important for poorer rural households, the poverty rate for rural farm households declines by an additional 8.8 percentage points, while urban farm poverty declines by 4.2 percentage points (see Part 3 of Table 8). However, the percentage reduction in the poverty *rates* of the two areas is similar. Therefore, accelerating agricultural growth under the CAADP scenario increases poverty reduction in both urban and rural areas, but does not eliminate the rural bias in Uganda's distribution of poverty.

In summary, the CGE model results indicate that it is possible for Uganda to reach the CAADP target of six percent agricultural growth. However, given the current poor performance of the agricultural sector, achieving the CAADP growth target will require additional growth from most crops and sub-sectors. Uganda, therefore, should not overly rely on specific crops (e.g. coffee) to achieve its aggregate agricultural growth targets. If the crop- and sub-sector-level targets can be achieved, then the resulting broader-based agricultural growth is likely to benefit households in both rural and urban areas. However, the high growth potential of certain export crops and better market conditions in certain parts of the country may cause uneven income growth and poverty reduction. Finally, given the ambitious growth target set by CAADP and the size of fisheries and livestock, these two sub-sectors will also have to contribute to accelerating overall agricultural growth and poverty reduction.

Comparing Sub-Sector Growth in Terms of Growth and Poverty Reduction

The previous section highlighted the potential contributions of various crops and sub-sectors in increasing agricultural growth and poverty reduction. However, the difference in the sizes of these sub-sectors makes it difficult to compare the effectiveness of sectoral growth in reducing poverty. Understanding how growth-poverty linkages vary at the sub-sector and household level is important for designing pro-poor growth strategies, so in this section, we calculate poverty-growth elasticities that allow us to compare the 'pro-poorness' of growth in alternative sub-sectors. These elasticities are endogenous outcomes from the model results. Growth affects individual households differently due to heterogeneity across household groups. The above analysis has shown how, given differences in household and farm characteristics, changes in income across households can differ considerably from average changes at the national level. Thus, to capture growth-poverty linkages, we must understand the changes in income distribution, which are primarily determined by the country's initial conditions. In the previous section, we saw how certain households have better opportunities to produce higher-value crops, and are thus better positioned to benefit from export-led agricultural growth. However, export crop-producing households are typically less poor than other rural households (see Table 2). Thus, agricultural growth driven by export crops may have less of an impact on poverty, especially among the poorest households. In contrast, food crops tend to be a more important source of agricultural incomes for poorer small-scale farm households in more remote areas of the country. Thus, growth in food crops is expected to be more effective at reducing poverty than similar growth in export crops.

The poverty-growth elasticity used in this study measures the responsiveness of the poverty rate to changes in per capita agricultural GDP growth. More specifically, the elasticity measures the percentage change in the poverty rate caused by a one percent increase in agricultural GDP per capita. Table 9 shows the calculated poverty-growth elasticities under the different growth scenarios. The results indicate that horticulture- and root crop-led agricultural growth is more effective at reducing poverty than growth driven by other sub-sectors. For example, a one percent increase in agricultural GDP driven by horticulture causes the national poverty headcount rate (P0) to decline by 1.38 percent, while growth driven by export crops causes the poverty rate to decline by only 0.64 percent. This reflects the importance of root crops for poorer households in Uganda, both as a source of income and as an item in the households' consumption baskets. However, the small initial size of the horticultural sector means that its potential contribution to national-level growth and poverty reduction will remain limited, at least over the short term. Maize and livestock are larger sectors and are also effective at reducing the severity of poverty amongst Uganda's poorest households, as reflected in the higher poverty gap (P1) and squared-gap (P2) elasticities for these sectors. The importance of food crops in reducing urban poverty is also shown in the table. For instance, the national elasticity for fisheries-led growth is higher than the corresponding rural elasticity, meaning that the elasticity is higher in urban than in rural areas. This is because agricultural growth reduces urban poverty by reducing urban food prices, which decline substantially for crops like matoke and maize (see Figure 4). The reverse is true for export crops, which have few and weak consumption-linkages, and are therefore less effective at reducing urban poverty.

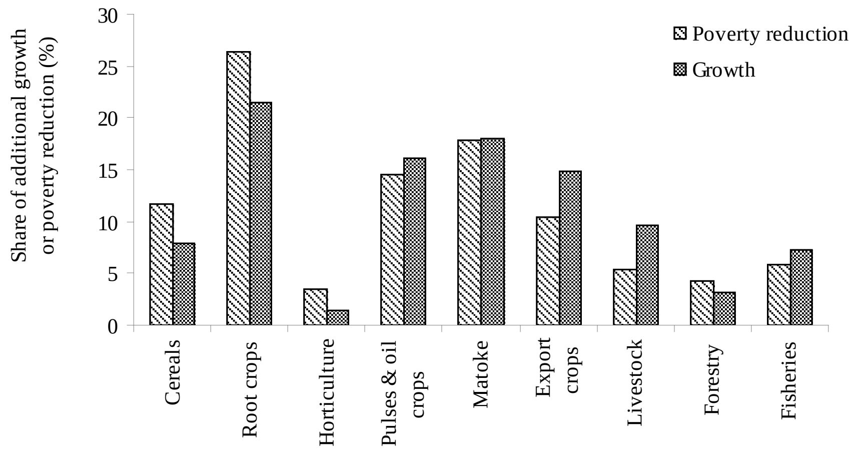
Table 9. Poverty reduction-growth elasticities under alternative agricultural growth scenarios

	Percentage change in poverty rate caused by a one percent growth in agricultural GDP led by the following crops and sub-sectors…					
	National poverty			Rural poverty		
	Incidence P0	Depth P1	Severity P2	Incidence P0	Depth P1	Severity P2
Cereal-led growth	-0.869	-1.337	-1.623	-0.784	-1.306	-1.605
Root-led growth	-1.074	-1.279	-1.420	-1.099	-1.318	-1.464
Horticulture-led growth	-1.383	-1.295	-1.487	-1.363	-1.307	-1.507
Pulse-led growth	-0.766	-0.932	-1.031	-0.796	-0.964	-1.066
Matoke-led growth	-0.801	-1.100	-1.258	-0.785	-1.117	-1.280
Export-crop-led growth	-0.644	-0.626	-0.651	-0.679	-0.654	-0.680
Livestock-led growth	-0.928	-1.351	-1.569	-0.936	-1.345	-1.572
Fisheries-led growth	-0.623	-0.836	-0.986	-0.607	-0.819	-0.975

Source: Results from the Ugandan CGE-microsimulation model.

An alternative representation of poverty-growth linkages is shown in Figure 5, which compares each sectoral scenario's contribution to agricultural growth and poverty reduction. The higher-than-average poverty-growth elasticities of root-led growth can be seen in the fact that this sub-sector contributes more to poverty reduction under the CAADP scenario than it does to growth. However, Uganda should not overly rely on poverty-growth elasticities when designing its growth strategy, since a high elasticity can be meaningless if a sector has poor growth prospects. Thus, even though export crops have a lower poverty-growth elasticity, the rapid growth of these sectors (due to higher growth potential and fewer market constraints) means that they account for a large share of overall poverty reduction under the under the CAADP scenario, compared to horticultural crops. Conversely, a growth strategy should not overly rely on high growth potential sectors without taking into the account their potential contribution to the national economy. For example, the small size of the export crop sector compared to that of pulses and oil crops means that even though the export sector has a substantially higher growth rate, its smaller size limits its ability to substantially raise national agricultural GDP. Even if export crop GDP grows at over seven percent per year, export crops will still contribute only 15 percent to overall additional agricultural growth under the CAADP scenario. Thus, the slower-growing matoke, pulse and root crop sectors will remain important sources of growth during times when other, faster growing and higher-value crops are increasing their relative contributions to the agricultural sector.

Figure 5. Share of additional growth and poverty reduction for CAADP sectoral scenarios



Source: Results from the Ugandan CGE-microsimulation model.

Finally, agriculture's proponents often cite the sector's strong linkages to the rest of the economy as justification for promoting agricultural growth (Diao et al., 2007). Table 10 measures agriculture's growth-linkage effects at the sub-sector level. For example, the cereal-led growth scenario causes agricultural GDP to increase by UGX (Ugandan Shillings) 177 billion (see column five). However, total GDP increases by more than this amount due to backward and forward production and consumption linkages. For example, increasing maize production stimulates growth in food processing within the manufacturing sector, while also reducing food prices and increasing real incomes that are then spent on non-agricultural commodities. Overall, GDP increases by UGX235 billion, which means that for every one shilling increase in agricultural GDP driven by cereal-led growth, we see an additional 0.32 shilling increase in non-agricultural GDP, for a growth-linkage ratio of 1.32. Comparing these ratios across the model scenarios suggests that even through forestry-led growth contributes less to agricultural growth under the CAADP scenario (see Figure 5), it is more effective at stimulating non-agricultural growth compared to export crop-led growth. This is because forestry has upstream links to wood processing and other manufacturing sectors, whereas export crops have weaker economy-wide growth linkages because most export crops are exported directly as raw agricultural materials rather than contributing to upstream production. Furthermore, rapid increases in export earnings from export crops places pressure on the current account balance, which over the medium-term causes a real appreciation of the exchange rate. This reduces the competiveness of non-agricultural exports, whose sectors contract as a result. The appreciation also increases competition from manufactured imports, which can hurt domestic manufacturing. Thus, it is important to note that while domestic-market-oriented crops face constraints in local markets, growth in export crops have exchange rate implications for other non-agricultural export sectors.

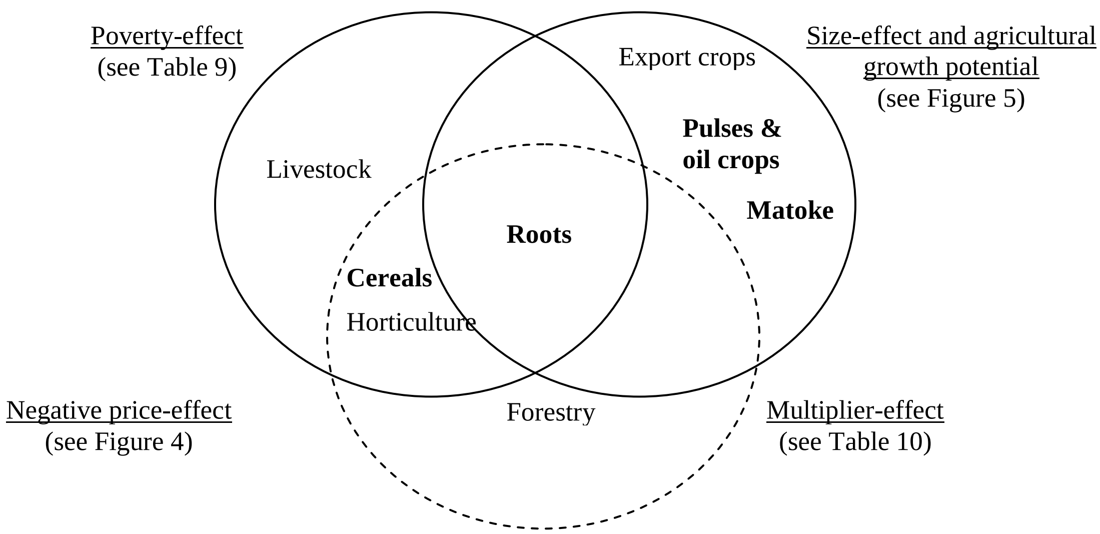
In this section, we have considered four dimensions that help us understand the potential contribution of individual crops toward accelerating growth and poverty reduction: (i) the effectiveness of sub-sector-driven growth in reducing poverty (i.e., the poverty-growth elasticity); (ii) the effect of a sub-sector's size and growth potential in determining its potential contribution to overall growth and poverty reduction (i.e., the size-effect); (iii) the implications of sub-sector-driven growth for growth in other non-agricultural sectors (i.e., the multiplier-effect); and (iv) the market constraints facing different crops (i.e., the price-effect). Based on these considerations, it is possible to rank the sub-sectors relative to one another. In Figure 6, we identify the top four sub-sectors under each of the three considerations listed above.

Table 10. Agriculture's economy-wide growth-linkage effect

	Sector's initial value-added	Sectoral growth rates (%)		Additional GDP relative to baseline (UGX 2005 bil.)		Economy-wide growth-linkage ratio
		Baseline scenario	Sector scenario	Total GDP	Agricultural GDP	
	2005	2005-15	2005-15	2015	2015	
				(1)	(2)	(1) / (2)
Cereal-led	589	2.99	5.08	235	177	1.32
Root-led	976	2.87	6.01	619	480	1.29
Horticulture-led	58	3.33	6.03	49	36	1.39
Pulse-led	708	2.24	5.86	386	360	1.07
Matoke-led	605	2.25	6.47	517	401	1.29
Export-crop-led	444	2.94	7.41	205	331	0.62
Livestock-led	652	2.83	5.03	267	216	1.24
Forestry-led	246	3.09	5.05	95	70	1.36
Fisheries-led	381	2.68	6.01	116	162	0.72

Source: Results from the Ugandan CGE-microsimulation modes.

Figure 6. Comparing crops across different effects



	Simple ranking of sub-sectors			
	Poverty-effect	Size-effect	Multiplier effect	Price-effect
Cereal-led	4	6	3	6
Root-led	2	1	4	8
Horticulture-led	1	9	1	4
Pulses-led	6	3	7	6
Matoke-led	5	2	5	9
Export-crop-led	7	4	9	1
Livestock-led	3	5	6	5
Forestry-led	-	8	2	3
Fisheries-led	8	7	8	2

Source: Results from the Ugandan CGE-microsimulation model.
Notes: The four commodities in bold letters are the ones facing the worst market constraints.

The four sub-sectors with the highest poverty-growth elasticities are horticulture, roots, cereals and livestock. These are placed inside the circle labeled 'poverty-effect' in Figure 6. Similarly, the four sectors that contribute the most to overall agricultural growth are roots, matoke, pulses and oil crops, and export crops. This ranking of 'size-effects' is contingent on the appropriateness of the target crop yields shown in Table 6. Based on their growth-potentials, these four sub-sectors are placed inside the 'size-effect' circle in Figure 6. Since the root sector is among the top four sub-sectors under both criteria, it falls into the intersection of the 'poverty-effect' and 'size-effect' circles. We also consider the sub-sectors' multiplier effects. Here we identified horticulture, forestry, cereals and roots (note that the multiplier of roots is only slightly higher than that of matoke). However, we place greater emphasis on the first two criteria, since this report focuses on the contribution of different sub-sectors to agricultural growth and poverty reduction, rather than broader economy-wide growth. Finally, we consider market constraints and price-effects. While cereals, root crops and matoke have been identified as having growth potential and strong size-effects, they also face considerable market constraints, leading to large price declines when production increases. From this, it is clear that in order to realize the growth and poverty-reducing potentials of the prioritized food crops, it will be necessary to improve market conditions by reducing transaction costs, supporting market development and expanding upstream agro-processing. A complete ranking of commodities is shown in the accompanying table in Figure 6.

The previous section concluded that in order to substantially increase agricultural growth and reach the CAADP growth target, it will be necessary to encourage growth in a number of agricultural sub-sectors in Uganda. However, the poverty-growth elasticities, sectoral growth potentials, and size- and linkage-effects presented in this section suggest that high priority should be given to improving yields for maize, roots and matoke, while also encouraging the longer-term expansion of *smallholder* export crops, where the growth potential is higher than that for most staple food crops. However, this ranking of sub-sectors should be treated with some caution; the results indicate that sub-sectors affect different households differently, and as such, broad-based reduction will require an encompassing agricultural growth strategy. For example, livestock and fisheries should also be accorded an important role, especially if agricultural diversification is a longer-term objective. In the next section, we examine the level of aggregate public investment required to increase agricultural growth.

5. AGRICULTURAL SPENDING REQUIRED TO REACH THE CAADP GROWTH AND POVERTY TARGETS

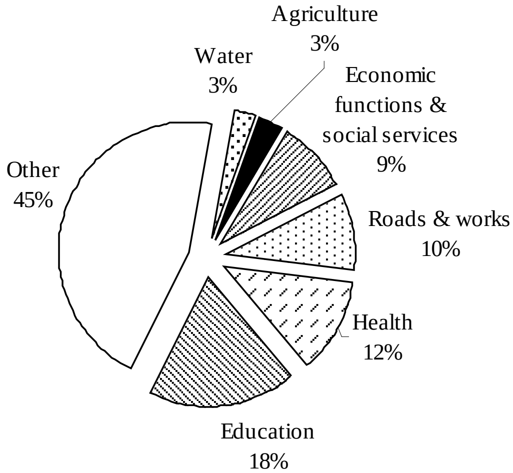
Achieving the CAADP agricultural growth target will be a challenge for Uganda. In addition to an improved policy environment, public investment will be instrumental in improving public services and attracting private investment and inputs. This raises a number of key questions for the government such as: What kinds of public investments will be needed to achieve Uganda's stated growth and poverty reduction objectives? How should public investment resources be allocated among different types of public goods and services (e.g. agriculture research and extension, irrigation, roads, and education and health) and across geographical areas (i.e., high-potential versus lagging regions) to improve the outcomes and impacts? And finally, how can the investments be financed? In this section, we consider the public agricultural expenditure (PAE) required to achieve the growth targets described in the previous sections.

Our CGE modeling indicates that Uganda's agricultural sector could grow at six percent per year over the next decade if certain crop- and other sub-sector-level growth targets within agriculture can be achieved. To promote agricultural growth and poverty reduction in Uganda in general, beginning in 2000 the Government of Uganda and its development partners began implementing the Plan for Modernization of Agriculture (PMA), which is a major driver in the Poverty Eradication Action Plan (PEAP). The resources allocated to the agriculture sector are expected to remain at four percent of the total budgetary resources for the PEAP until 2013/14 (see Figure 7). In an effort to achieve faster poverty reduction, the government has recently undertaken additional actions, including the Rural Development Strategy (RDS) and Prosperity for All (PFA). Key components of the PMA and RDS are the National Agriculture Advisory Services (NAADS) and the Integrated Support to Farmers Groups (ISFG), respectively. NAADS is an innovative public-private extension service delivery approach that targets the development and use of farmer institutions, thereby empowering farmers to procure and manage delivery of advisory services. First implemented in six districts beginning in 2001, NAADS has expanded rapidly and is expected to cover the entire country by the end of financial year 2007/08. The ISFG, which started in 2005, is designed to complement and strengthen NAADS activities by allowing farmer groups to access grants for technology inputs and investment in individual or group enterprises. In 2005/06, for example, about UGX8 billion of the over UGX20 billion budgeted for the RDS were allocated to NAADS for implementation of the ISFG (MAAIF, 2005).

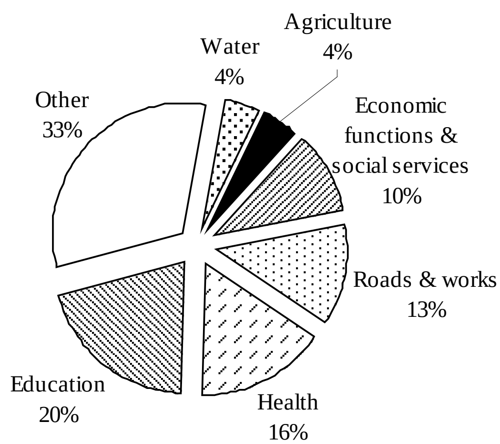
While these interventions and investments will provide a better foundation for achieving higher agricultural growth, the question remains as to whether the planned investments are sufficient to meet the desired growth and poverty-reduction targets. Detailed knowledge of the rates of return to such different types of public investment is needed to answer this question. In the following, the results from previous studies on Uganda and elsewhere are used to assess the aggregate PAE that will be required to reach the CAADP growth target. First, we examine recent trends in PAE to establish a Baseline scenario for the required spending.

Figure 7. Expected allocation of public resources under Uganda's PEAP

Budget allocation in 2003/04 (UGX3144 billion)



Budget allocation in 2013/14 (UGX7287 billion)



Source: MFPED (2004).

Trends in Public Agricultural Expenditure

Government financial statistics obtained from the International Monetary Fund (IMF, 2007) show that the share of public resources allocated to the agricultural sector has been declining steadily, reaching about five percent in 2004, having reached a low level of 1.7 in the mid-1990s (see Table 11). This is consistent with the results of the recent public agricultural expenditure review (OPM, 2007), which found that the agriculture sector has not received more than three percent of the GOU (Government of Uganda)-financed budget in any year since 1991/92, and that in some years the share has been below two percent. Although combining the GOU-financed budget with donor financing raises total public agricultural expenditure substantially, it has yet to exceed five percent of agricultural GDP in any given year. The data show that since 1999, non-agricultural and total spending grew at about 11.8 and 12.6 percent per year in real terms, respectively, while PAE grew by about 19.4 percent. Detailed information on spending on specific sub-sectors (crops, livestock, fishery, forestry) or function (research, extension, irrigation, input support, etc.) was not available.

Table 11. Government spending on agriculture and non-agriculture sectors in Uganda, 1975-2004

	1975	1980	1985	1990	1995	2000	2001	2002	2003	2004
Expenditure (Billion 2004 UGX)										
Total	--	--	681.3	649.8	785.4	2169.7	2948.0	3405.6	3334.3	3170.0
Agriculture	--	--	44.6	25.4	13.6	86.7	118.4	142.0	139.0	159.3
Non-agriculture	--	--	636.7	624.4	771.8	2083.0	2829.6	3263.6	3195.3	3010.7
Expenditure shares (%)										
Agricultural expenditure in total expenditure	10.46	32.55	6.55	3.91	1.73	4.00	4.02	4.17	4.17	5.03
Agricultural expenditure in agricultural GDP	2.32	2.80	0.02	0.86	0.00	2.38	3.15	4.18	3.72	4.08
Non-agricultural expenditure in non-agricultural GDP	47.76	14.74	28.41	24.06	18.10	29.49	37.87	38.21	36.44	32.41
Total expenditure in total GDP	15.67	6.17	15.70	11.70	10.08	20.28	26.26	28.52	26.67	24.03

Sources: Government Finance Statistics (IMF, 2007).
Notes: Deflator was not available to calculate real values for 1975-1981.

Estimated Spending Required for Agricultural Growth

To determine the aggregate PAE required to achieve the CAADP growth target, we need to know the annual growth rate in agricultural expenditure ($\dot{E}_{agexp}$) required to achieve a particular growth rate in agriculture (θ_{ag}), which can be expressed as:[9]

$$\dot{E}_{ag\exp} = \frac{\theta_{ag} - (\varepsilon_{nag\exp} * \dot{E}_{nag\exp} * s_{nag})}{[\varepsilon_{ag\exp} + (\varepsilon_{nag\exp} * \phi_{nag,ag})] * s_{ag}} \quad (1)$$

where ε_{agexp} and ε_{nagexp} are the 'agricultural growth-agricultural expenditure elasticity' and 'agricultural growth-non-agricultural expenditure elasticity,' respectively; $\dot{E}_{nagexp}$ is the annual growth rate in non-agricultural expenditure; $\phi_{nag,ag}$ is the multiplier effect or linkage (i.e. trade-offs and complementarities) between agricultural and non-agricultural expenditures; and s_{ag} and s_{nag} are the shares of agriculture and non-agriculture in GDP, respectively. These parameters (i.e. ε_{agexp}, ε_{nagexp}, and $\phi_{nag,ag}$) can be estimated econometrically using historical data on different types of public investment, private investment, and agricultural production (for example, see Fan, Hazell and Thorat 2000; and Fan, Zhang and Rao 2004). The main concept underlying such econometric estimation is that public and private capital complement one another such that an increase in the public capital stock increases the productivity of all (private) factors used in agricultural production. By raising the productivity of all factors of production, public investment also attracts (or crowds in) private capital investment for agricultural development, non-farm rural development (e.g., food processing and marketing, transportation and trade, restaurant services, electronic repairs shops, etc.), urban industrial development, and service development. The development of the non-farm rural sector can have multiplier effects if it in turn expands the market opportunities for farmers and creates off-farm employment opportunities. The latter is particularly important for absorbing the excess labor and other factors of production that arise as a result of increased agricultural productivity. In addition to their agricultural productivity impacts, public investments in rural areas directly create non-farm rural employment opportunities, thereby improving rural wages and incomes, and reducing rural poverty.

We use the results from prior studies on Uganda and elsewhere to obtain estimates of these elasticities. The agricultural growth-expenditure elasticity comprises two parts, namely the growth-capital and capital-expenditure elasticities. For the agricultural growth-capital elasticity, we use the results of Fan, Zhang and Rao (2004) on Uganda, where they estimated the elasticities for different types of public capital stock and inputs including land (0.13), fertilizer (0.16), agricultural extension (0.19), feeder roads (0.14), education (0.33) and health (0.46). Due to limited historical data on public capital and expenditure, the authors of the prior paper did not estimate the capital-expenditure elasticities. Several studies in other countries show that these elasticities typically lie in the lower range of zero to one. We therefore assume an elasticity of 0.35 across the board (see Appendix 3 for detailed examples).

We combine this information to obtain estimated agricultural-growth-expenditure elasticities for different types of public expenditures in Uganda (see Table 12).[10] For example, the estimated elasticity is 0.17, which means that every one percent increase in PAE generates 0.17 percent growth in agricultural GDP. This compares favorably with elasticities for the sector in other countries, including the elasticity with respect to agricultural development expenditure in Rwanda (0.17) (Diao et al., 2007) and agricultural research and extension in the US (0.11–0.19) (Huffman and Evenson, 2006). However, the elasticity estimated here is lower than some of those estimated in other studies, including, for example, the elasticity with respect to agricultural research in India (0.25) (Fan, Hazell and Thorat 2000) and agricultural development expenditure in Africa (0.36) (Fan and Rao, 2003). Thus, our estimated agricultural growth-expenditure elasticity of 0.17 appears to reflect a low spending efficiency. We

[9] See Appendix B and Fan et al. (2008) for details.

[10] The agricultural growth-agricultural expenditure elasticity is given by the sum of the agricultural growth-capital elasticities in land, fertilizer and extension multiplied by the assumed capital-expenditure elasticity, which is (0.13+0.16+0.19)*0.35=0.17.

therefore use not only the estimated elasticity of 0.17 in the simulations, but also run the simulations with the 0.30 elasticity estimated by Fan and Rao (2003), in order to obtain a more optimistic spending efficiency scenario.

Table 12. Effect of public expenditure on agricultural productivity in Uganda

Sectoral expenditure	Elasticity
Agriculture	0.167
Feeder roads	0.049
Education	0.116
Health	0.163

Source: Authors' estimates based on Fan, Zhang and Rao (2004) and other studies. See Appendix 3 for details.

Regarding the multiplier effect or linkage (i.e. trade-offs and complementarities) between agricultural and non-agricultural expenditure (i.e. $\phi_{nag,ag}$), we were unable to obtain any reliable estimates. For simplicity, we assume that it is zero, noting that both positive and negative values are possible, where a positive sign indicates complementarity and a negative sign indicates trade-offs. Non-agricultural expenditure is treated as exogenous, and historical data from 1982 are used to calculate the annual growth rate (i.e. $\dot{E}_{nagexp}$), which is about 11.8 percent per year. Similarly, historical data on GDP are used to calculate the shares of agriculture and non-agriculture in GDP, which are 0.35 and 0.65, respectively.

It is also important to recognize that the elasticities may shift over time, depending on whether the returns to public investments are increasing or declining. Rosegrant and Evenson (1995), for example, found that while the return to public investments in extension and research in India's agriculture sector was declining over time, the return to public investments in irrigation was increasing, due primarily to increased private investment in irrigation. They also found that the returns to education were greater in the post-Green Revolution period than before or during this period. These authors used data over a 30-year period. In this report, however, we are examining a shorter period of time (ten years from 2005 to 2015), and therefore assume that the above parameters remain unchanged over the simulation period.

Scenarios

To estimate the aggregate PAE requirements, we simulate four scenarios. The first is the Baseline scenario, where we assume that PAE and non-agricultural spending continue to grow according to recent trends, at 19.4 and 11.8 percent per year, respectively, during 2004-2015. The simulation results show that the share of agricultural spending in total expenditure will rise from five percent in 2004 to 7.3 percent in 2010 and 9.8 percent in 2015 (see Table 13 and Figure 8), since PAE grows more rapidly than total spending.

Under the CAADP scenario, agricultural growth accelerates from 2.7 to six percent per year during 2004-2015, while non-agricultural GDP growth increases marginally from 4.2 to 4.6 percent per year, and total GDP growth increases from 5.1 to 6.1 percent per year. To estimate the aggregate PAE required to support the acceleration in agricultural growth, we perform three simulations: (i) we assume that agricultural growth will be supported solely by an increase in PAE, without taking into account the effect of non-agricultural expenditure on agricultural growth, which continues to grow at the Baseline rate of 11.8 percent per year; (ii) we relax the latter assumption and take the effect of non-agricultural expenditure on agricultural growth into account, but still assume that it continues to grow at the Baseline rate; and (iii) we simulate an increase in non-agricultural expenditure growth proportionate to the growth in this sector's GDP.

Under the first scenario, the accelerated growth in agricultural GDP requires an associated growth in PAE from the Baseline value of 19.4 to 30.2 percent per year under the high elasticity scenario and

38.3 percent under the low elasticity scenario (see Table 13 and Figure 8). The total government budget is estimated to grow at 13.9 percent per year under the high elasticity scenario and at 16.2 percent under the low elasticity scenario (see Table 13 and Figure 9). Again, with agricultural spending growing more rapidly than total spending, the share of agricultural spending will rise from the Baseline value of five percent to 11.7-16.3 percent in 2010 and 22.0-36.4 percent in 2015 (the lower bound numbers correspond to the high elasticity and vice versa, here and below) (see Table 13 and Figure 10). These increases translate into additional spending on the sector of UGX5901-14525 billion over 2004-2015, or UGX492-1210 billion per year.

In the second scenario, we take the effect of non-agricultural expenditure on agricultural growth into account. In this case, PAE is expected to grow at 25.6 percent per year under the high elasticity scenario and 30.7 percent under the low elasticity scenario (see Table 13 and Figure 8). The proportion of the accelerated growth (i.e. from the Baseline value of 2.7 to six percent per year during 2004-2015) to be driven by growth in PAE was determined using the shares of the growth-expenditure elasticities for the two sectors as weights. Under these conditions, the total government budget is projected to grow at 13.1 percent per year under the high elasticity scenario and at 14.0 percent under the low elasticity scenario (see Table 13 and Figure 9). Again, with agricultural spending growing more rapidly than total spending, the share of agricultural spending in total expenditure will be 9.6-11.9 percent in 2010 and 16.1-22.8 percent in 2015 (see Table 13 and Figure 10). These increases translate into additional spending on the sector in a total amount of UGX 2,927–6,275 billion over 2004-2015, or UGX 244–523 billion per year.

In the third scenario, we assume that non-agricultural expenditure grows at 12.8 percent per year. As in the second scenario, PAE is expected to grow at 25.3 percent per year under the high elasticity scenario and 30.0 percent under the low elasticity scenario (see Table 13 and Figure 8). However, in this case the total government budget is projected to grow at 13.9 percent per year under the high elasticity scenario and at 14.7 percent under the low elasticity scenario (see Table 13 and Figure 9), while the share of agricultural spending in total expenditure will be 9-11 percent in 2010 and 14.3-20.0 percent in 2015 (see Table 14 and Figure 10). These also translate into additional spending on the sector of UGX 2,711–5,747 billion over 2004-2015, or UGX226-479 billion per year.

These results confirm the importance of Uganda meeting the Maputo declaration by allocating at least ten percent of the government's total budget to agriculture. In fact, the results suggest that even under a more efficient spending scenario (i.e., high elasticity), the government will need to allocate at least 14 percent of its total budget to agriculture by 2015 in order to achieve the CAADP growth target of six percent growth in the agricultural sector per year. Figures 7 to 9 show that the allocation of resources to the agricultural sector proposed under the PEAP (i.e. less than five percent per year) will be insufficient to meet this goal.

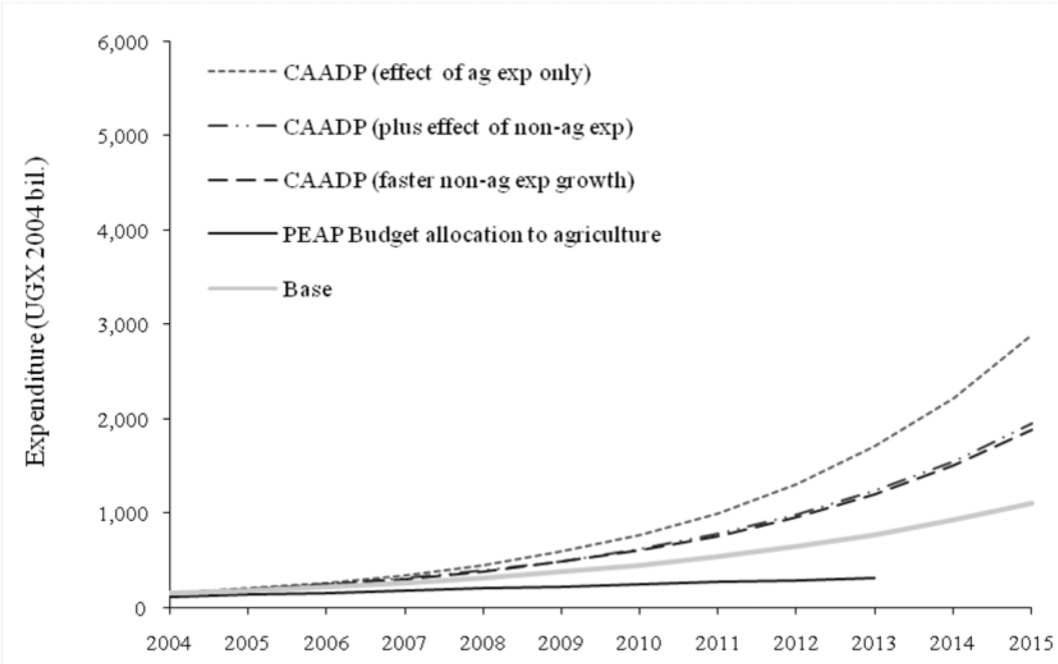
Table 13. Estimated Resource Allocation

	Baseline	Agricultural growth due to agricultural expenditure growth only		Accounting for effect of non-agricultural expenditure on agricultural growth		Accounting for effect of non-agricultural expenditure and allowing for faster non-agricultural expenditure growth	
		CAADP		CAADP		CAADP	
		Low	High	Low	High	Low	High
Average annual growth rates (%)							
Total government expenditure	12.3	16.2	13.9	14.0	13.1	14.7	13.9
Agricultural	19.4	38.8	30.2	30.7	25.6	30.0	25.3
Non-agricultural	11.8	11.8	11.8	11.8	11.8	12.8	12.8
Government expenditure shares (%)							
Agriculture in total expenditure							
2004	5.0						
2010	7.3	16.3	11.7	11.9	9.6	11.0	9.0
2015	9.8	36.4	22.0	22.8	16.1	20.0	14.3
Agriculture in agricultural GDP							
2004	4.1						
2010	10.1	20.6	14.0	14.4	11.4	13.9	11.1
2015	21.3	79.7	39.3	40.9	26.6	38.6	25.7
Non-agriculture in non-agricultural GDP							
2004	32.4						
2010	49.3	48.3	48.3	48.3	48.3	51.1	51.1
2015	70.0	67.2	67.2	67.2	67.2	74.7	74.7
Total expenditure in total GDP	24.0						
2004							
2010	38.4	39.6	37.6	37.7	36.7	39.5	38.6
2015	57.2	71.3	58.1	58.7	54.0	63.0	58.8
Agricultural expenditure required (UGX 2004 bil.)							
2004	159						
2010	461	1139	775	792	627	768	615
2015	1118	5871	2895	3017	1961	2845	1896
Annual average (2004-2015)	505	1716	997	1028	749	984	731

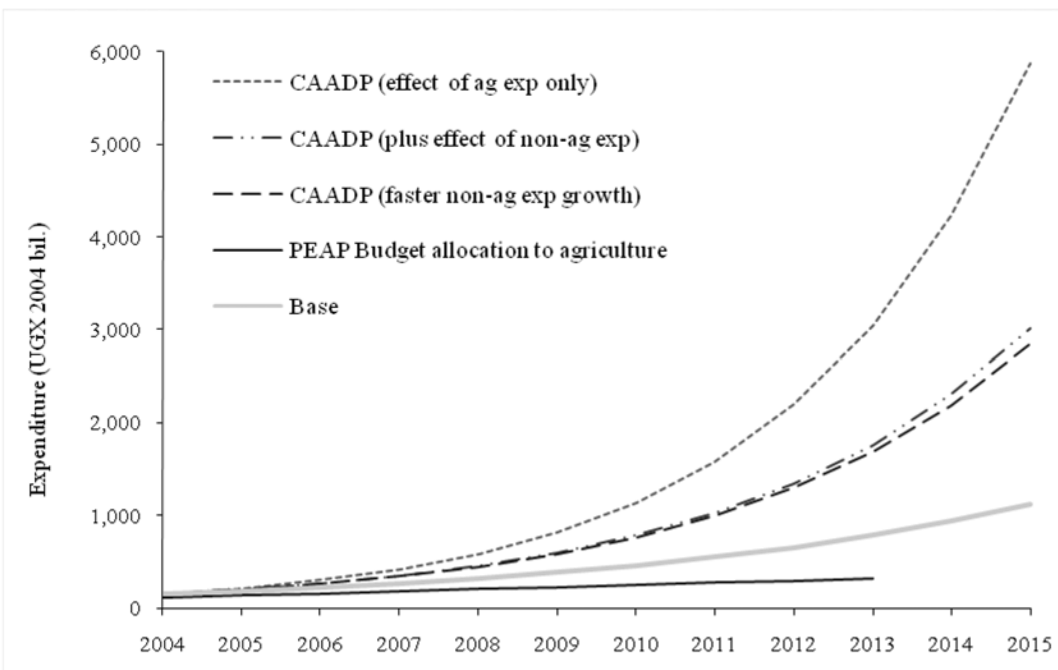
Source: Authors' estimates.
Notes: Low and High refer to low elasticity and high elasticity, respectively.

Figure 8. Value of agricultural expenditure required under alternate growth scenarios

More efficient expenditure scenario (high growth-expenditure elasticity)



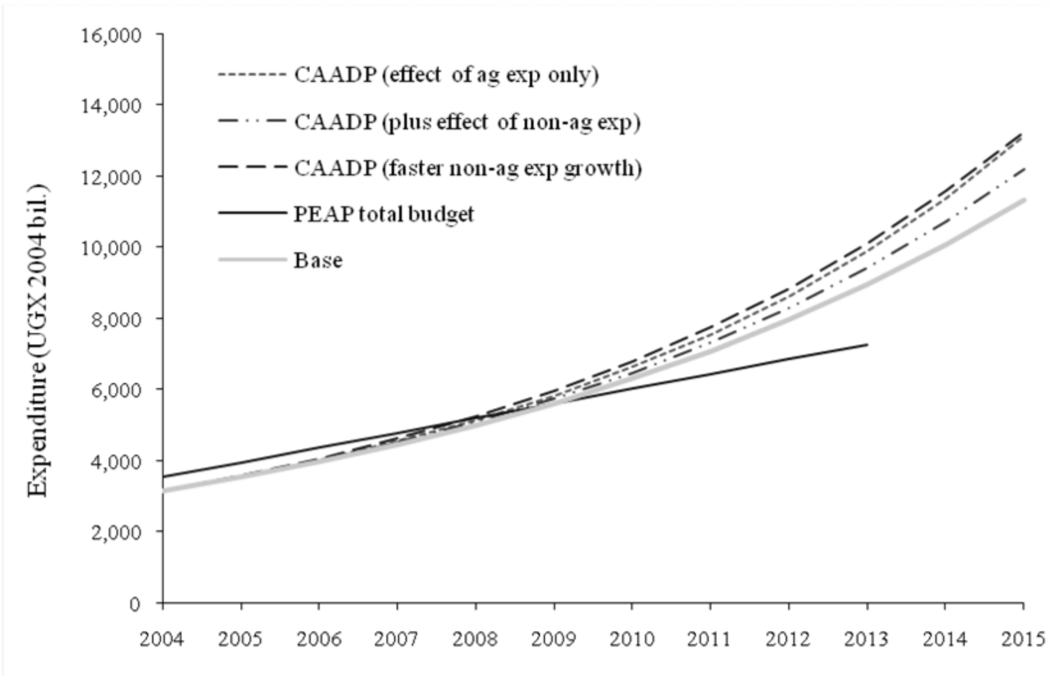
Less efficient expenditure scenario (low growth-expenditure elasticity)



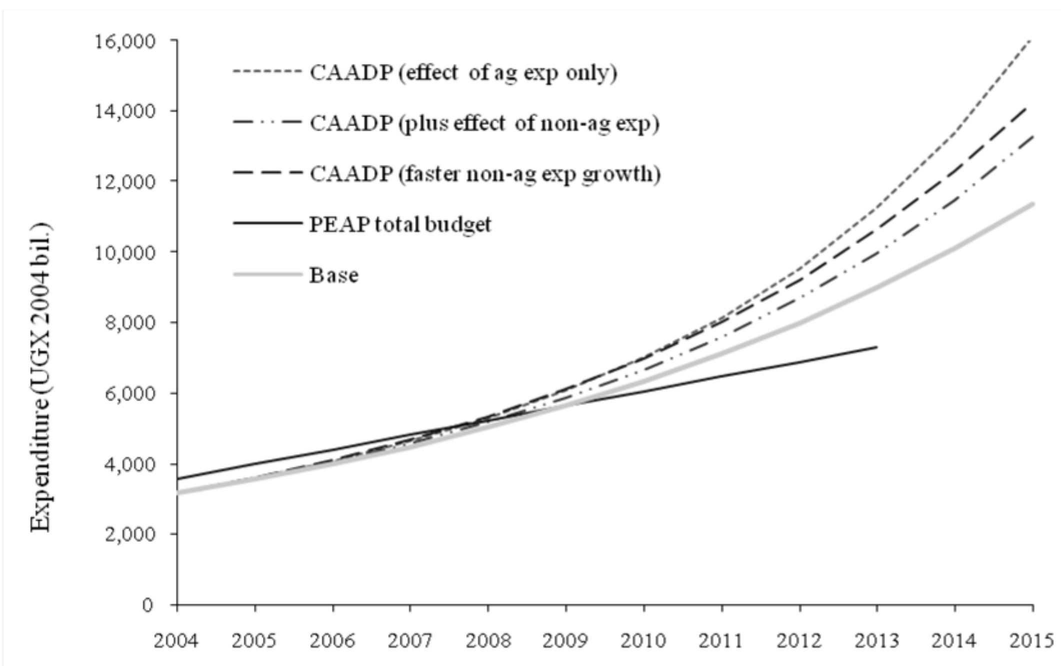
Source: Own calculations using results from the Ugandan CGE-microsimulation model, plus prior public expenditure regressions (Fan, Zhang and Rao, 2004)

Figure 9. Value of total expenditure required under alternative growth scenarios

More efficient expenditure scenario (high-growth expenditure elasticity)



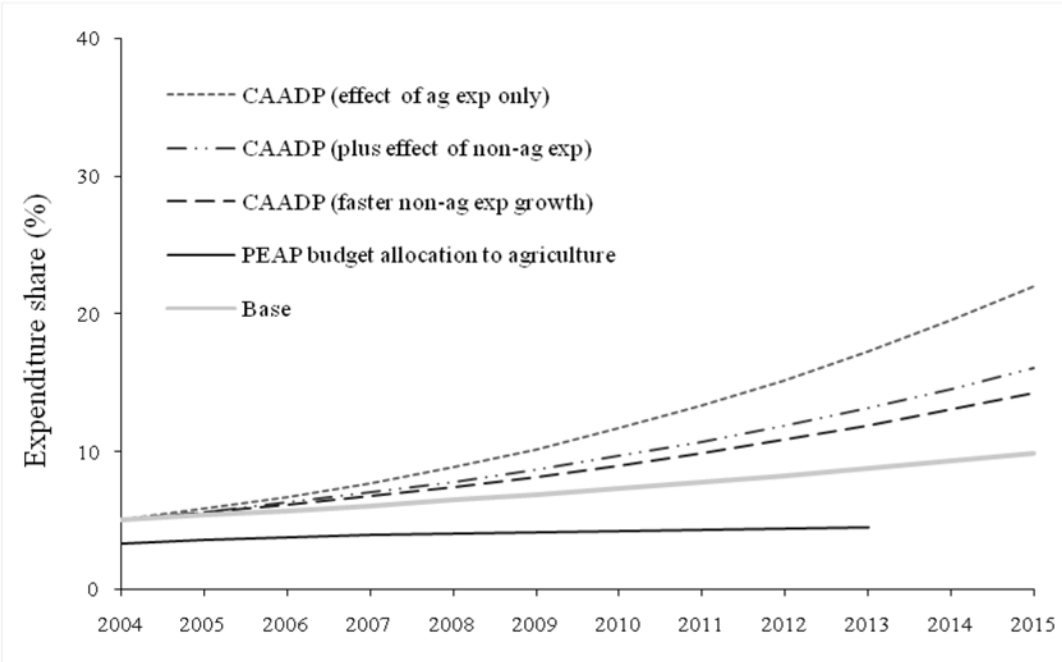
Less efficient expenditure scenario (low growth-expenditure elasticity)



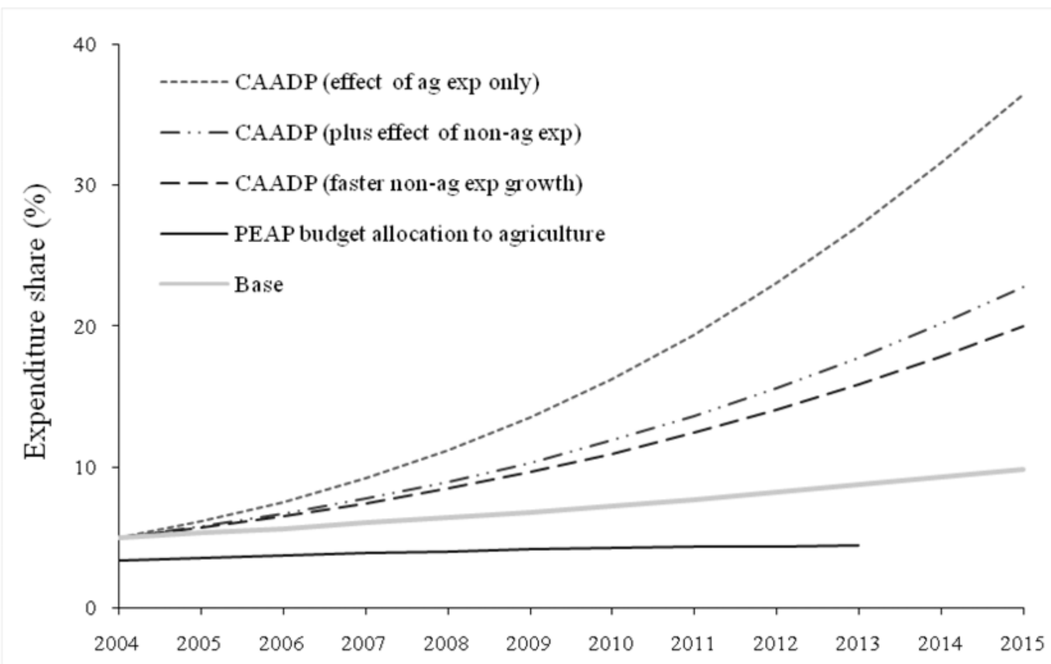
Source: Own calculations using results from the Ugandan CGE-microsimulation model, plus prior public expenditure regressions (Fan, Zhang and Rao, 2004)

Figure 10. Share of agricultural spending in total expenditure under alternative growth scenarios

<u>More efficient expenditure scenario (high growth-expenditure elasticity)</u>



<u>Less efficient expenditure scenario (low growth-expenditure elasticity)</u>



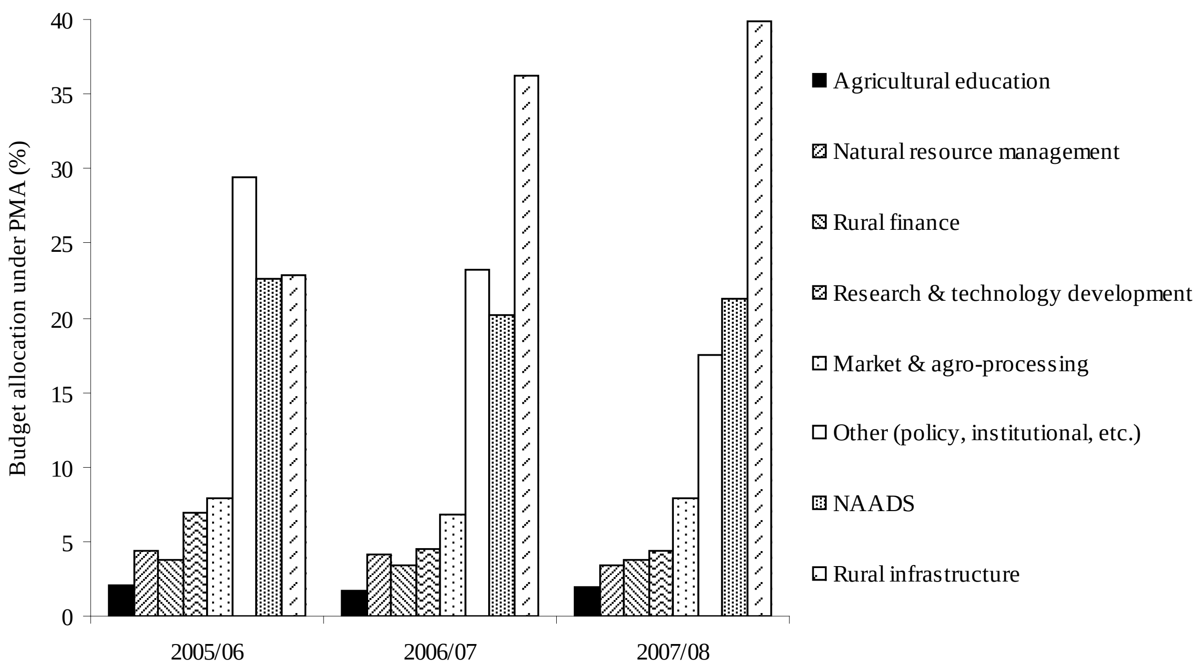
Source: Own calculations using results from the Ugandan CGE-microsimulation model, plus prior public expenditure regressions (Fan, Zhang and Rao, 2004).

Identifying Investment Priorities

It is important to be able to estimate the total public resources needed to reach particular agricultural growth targets, but prioritizing investments is equally important. Due to a lack of long-term historical data on PAE for specific investment programs in Uganda, and related data on program outputs and outcomes, we are unable to analyze specific investment priorities based on their potential returns on agricultural growth. The priorities associated with the CGE analysis were based on the sub-sector and commodity growth-poverty relationships, but we do not have sufficient data to examine prioritization of decisions on where to invest (research, extension, irrigation, farm input support, marketing information, storage and processing infrastructure, etc.) to achieve those sub-sector and commodity specific growths and how much to invest in each of these areas. However, using the results of Fan, Zhang and Rao (2004) and others, as well as recent data on different types of PAE, we herein attempt to offer an indicative guide to key investments that could help promote agricultural growth and rural poverty reduction.

It is generally agreed that in order to increase agricultural production, reduce costs of production and protect the environment for sustainable agricultural production, farmers need improved technologies. These technologies should be profitable under local farming and market conditions, while helping the farmers increase yields, manage water, and use natural resources in a more sustainable manner. Therefore, a key investment area to support technology generation and dissemination is agricultural research and development (R&D) and extension. The research by Fan, Zhang and Rao (2004) on Uganda confirms that investment in agricultural R&D and extension offers the greatest potential for enhancing productivity and reducing poverty. Similarly, Thirtle et al. (2003) showed that for every one percent increase in yields brought about by investments in agricultural R&D, two million Africans can be lifted out of poverty. However, agricultural R&D spending in Uganda is low compared expenditures on the provision of other public agricultural goods and services (see Figure 11).

Figure 11. Spending on agricultural R&D and other public goods and services in Uganda

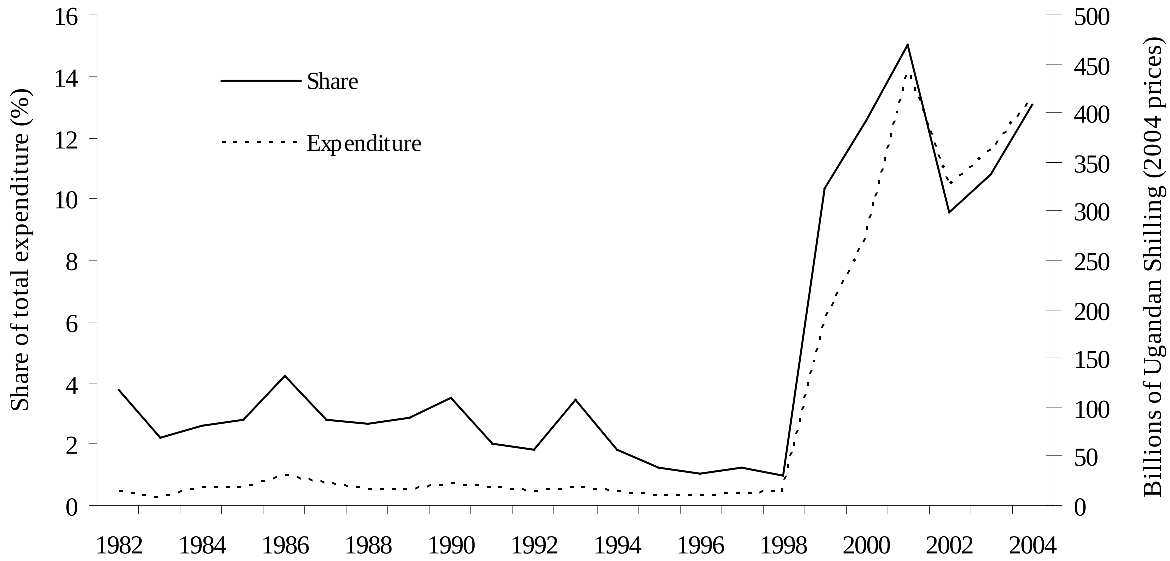


Source: ROU (2007).

Figure 11 shows that NAADS is one of the favored strategies, which is justified by several favorable evaluations (see OPM, 2005; Scanagri, 2005; Benin et al., 2007). The study by Benin et al. (2007), for example, shows that the NAADS program has positively impacted the availability and quality of advisory services provided to farmers, the adoption of new crop and livestock enterprises, and the use of modern agricultural production technologies and practices. Furthermore, NAADS also appears to have promoted the use of post-harvest technologies and improved the commercial marketing of commodities, consistent with its mission to promote more commercially-oriented agriculture. However, the program's success in promoting the adoption of improved varieties of crops and some other yield-enhancing technologies has not been matched by the increased application of improved soil fertility management. This raises concern about the sustainability of productivity increases, which are likely to result in more rapid soil nutrient mining in the absence of improved soil fertility management. These findings suggest the potential need for increased public investment in applied agronomic research that seeks to identify more effective ways to profitably combine inorganic and organic soil fertility measures in different crop systems, and looks to improve the market environment and promote adoption of more remunerative crop enterprises. At present, the International Food Policy Research Institute (IFPRI) is undertaking the end-of-Phase 1 evaluation of the NAADS program, seeking to assess the outcomes and impacts of NAADS and its contribution to food security, poverty reduction and environmental degradation. The findings from this evaluation should help guide future resource allocation and may suggest ways to better support the farmers' groups in acquiring inputs and production assets.

The report by Fan, Zhang and Rao (2004) shows that investment in rural road infrastructure in Uganda, particularly feeder roads, has a high return and can have large effects on growth and poverty reduction. The marginal returns to public spending on feeder roads on agriculture output and poverty reduction is three to four times larger than the returns to public spending on murram and tarmac roads. This positive effect of public infrastructure spending on agricultural growth is consistent with the results of several other studies on the effect of infrastructure development on economic growth (see review by Guild 2000). In fact, investment in infrastructure, especially road development, is often ranked among the top two public spending sources of overall growth and poverty reduction (see Fan, Hazell and Thorat, 2000; Fan and Zhang, 2004; Mogues et al., 2007). IFPRI studies in other countries, including Ethiopia, Ghana and Zambia, emphasize the importance of rural roads for increasing smallholder access to agricultural inputs and product markets. Roads enable farmers to participate in higher value-added market chains, thereby contributing significantly to poverty reduction (Thurlow and Wobst, 2004; Diao and Nin-Pratt, 2005). With its current road density standing at about 350 kilometers per 1000 square kilometers, Uganda is ranked 7th in Sub-Saharan Africa (IRF, 2007). Figure 12 shows how the Government of Uganda has dramatically increased its spending on transport and communications in recent years, reflecting the importance of these types of investments.

Figure 12. Government spending on transport and communications in Uganda



Source: Government Finance Statistics (IMF, 2007)

6. SUMMARY OF MAJOR FINDINGS

A dynamic CGE model is herein developed and used to examine how accelerating growth in various agricultural crops and sub-sectors could help Uganda achieve the CAADP target of six percent agricultural growth, especially when supported by raising agricultural expenditure to at least ten percent of the government's total budgetary resources. The impacts of agricultural growth at the macro- and microeconomic levels, as well as the effects on poverty, are also estimated. The major conclusions of this study are summarized below.

Six Percent Agricultural Growth is Achievable but Will be Challenging

The CGE model results indicate that Uganda is on track to achieve the MDG1 target of halving poverty by 2015. This is projected to take place around 2012, but is vulnerable to changes in world markets and other potential shocks. If Uganda can achieve reasonably ambitious improvements in crop yields and sub-sector growth, then it will be possible for the country to achieve the CAADP target of six percent agricultural growth and secure its achievement of MDG1. Agricultural growth at six percent per year would increase overall GDP growth from 5.1 to 6.1 percent per year. This higher growth rate would reduce national poverty to 18.9 percent by 2015, which is lower than the 26.5 percent poverty rate that would be achieved without the additional agricultural growth. This means that the higher growth under the CAADP scenario would lift an additional 2.9 million Ugandans above the poverty line by 2015.

Farmers Will Benefit Fairly Equally under the CAADP Growth Scenario

Most households are expected to benefit from faster agricultural growth, and the distribution of additional incomes under the CAADP scenario is relatively even. However, farm households growing higher-value export-oriented crops stand to gain more than households that rely more on food crops or livestock. Furthermore, rural households will benefit more than urban households, because rural households are more dependent on agricultural incomes. Urban households also benefit because urban agriculturalists comprise a significant share of agricultural producers in Uganda, and because agricultural commodities are an important part of the consumption baskets of both urban and rural households. As such, while rural poverty falls by an additional 8.4 percentage points, urban poverty falls by three percentage points.

The Composition of Agricultural Growth Matters

Comparing the effectiveness of different sub-sectors in reducing poverty and stimulating broader-based growth, we see that a one percent growth driven by either horticulture or root crops has considerably larger impacts on poverty reduction than a similar growth in export-oriented crops. This is because yield improvements in these crops not only directly benefit households by increasing incomes from horticulture and root crop production, but also by allowing farmers to diversify their land allocation towards other higher-value crops. Cereals and fisheries also have stronger growth-linkages to non-agriculture, thereby stimulating broader economy-wide growth and poverty reduction. However, the high growth potential of export crops relative to that of the food crops means that export-led growth will still account for a significant share of overall growth and poverty reduction under the CAADP scenario. The small initial size of horticulture means that its potential contribution to national-level growth and poverty reduction is limited, at least over the shorter term. Taken together, our findings highlight the importance of broader-based agricultural growth, but accord a high priority to roots, matoke and smallholder export crops.

Agricultural Spending Needs to Increase Substantially

Increasing agricultural growth to meet the CAADP growth target will require additional investment in the sector as well as improvements in the efficiency of public spending. Our investment analysis indicates that government spending on agriculture would have to grow by 25.3 percent per year in order to achieve and sustain the targeted six percent agricultural growth. This implies that the government will need to allocate at least 14 percent of its total budgetary resources to agriculture by 2015. However, this spending scenario assumes that the government is able to invest more efficiently and is able to realize about 0.3 percent increase in agricultural GDP for every one percent increase in its total agricultural spending. If this is not the case, and the government can only achieve a more modest return on its spending, say 0.17 percent increase in agricultural GDP for every one percent increase in its total agricultural spending, then public spending on agriculture in Uganda would have to grow at 30 percent per year in order to reach the CAADP six percent growth target during 2005-2015. This would mean that the government would have to allocate about a fifth of its total budget to the agricultural sector. Thus, it is important that the government not only meet and exceed the CAADP agricultural spending target, but also greatly improve the efficiency of its agricultural investments. Doing so will assist the country in achieving the CAADP target, which will substantially reduce the number of poor people living below the poverty line by 2015 and significantly improve the well-being of both rural and urban households.

APPENDIX A. SPECIFICATION OF THE CGE AND MICROSIMULATION MODELS

A computable general equilibrium (CGE) model is developed herein to assess sector-specific growth options and their poverty impacts. The model is calibrated to a 2005 social accounting matrix (SAM) that provides information on demand and production for 50 detailed sectors (see Table 1). Based on the SAM, the production technologies across all sectors are calibrated to their current situation, including each sector's use of primary inputs, such as land, labor and capital, and intermediate inputs. To capture existing differences in labor markets, the model classifies employed labor into different sub-categories, including self-employed agricultural workers, unskilled workers laboring in both agriculture and non-agriculture, and skilled non-agricultural workers. Information on employment and wages by sector and region is taken from the 2005/06 Uganda National Household Survey (UNHS5).

Workers in the model can migrate between sectors, although agricultural family laborers remain on their farms (i.e., the various family labor types correspond to a farm household typology and are specific to these households). By assuming that the self-employed agricultural labor force grows more slowly than the rest of the work force, the model accounts for the movement of rural laborers from working on a smallholder farmers' own land to finding employment opportunities through the labor market. Capital moves freely within the broad agricultural and non-agriculture sectors, and capital is accumulated through investment financed by domestic savings and foreign inflow. Increased capital is allocated across sectors according to their relative profitability. Incomes from employment accrue to different households according to employment and wage data from UNHS5. This detailed specification of production and factor markets in the model allows it to capture the changing scale and technology of production across sectors, thereby reflecting how changes in Uganda's structure of growth influences its distribution of incomes.

The growth-poverty relationship is examined by combining the CGE model with a microsimulation model. An important factor determining the contribution of agriculture to overall economic growth is its linkages with the rest of the economy. Agriculture's proponents argue that agriculture has strong growth-linkages. The model captures production linkages by explicitly defining a set of nested constant elasticity of substitution (CES) production functions, and allowing producers to generate demand for both factors and intermediates. The CGE model also captures forward and backward production linkages between sectors. Import competition and export opportunities are modeled by allowing producers and consumers to shift between domestic and foreign markets depending on changes in the relative prices of imports, exports and domestic goods. More specifically, the decision of producers to supply domestic or foreign markets is governed by a constant elasticity of transformation (CET) function, while substitution possibilities exist between imports and domestically supplied goods under a CES Armington specification. In this way, the model captures how import competition and the changing export opportunities of agriculture and industry can strengthen or weaken the linkages between growth and poverty.

Incomes from production, trade and employment accrue to different households according to the employment and wage data from UNHS5. As with production, households are defined according to the farm typology described in Section 2 and further separated into rural and urban areas. Kampala is treated as a separate group given its unique role as the national economic hub. Income and expenditure patterns vary considerably across these household groups. These differences are important for distributional change, since incomes generated by agricultural growth accrue to different households depending on their location and factor endowments. Each representative household in the model is an aggregation of a group of households in UNHS5. Households in the model receive income through the employment of their factors in both agricultural and non-agricultural production, and they pay taxes, save and make transfers to other households. The disposable income of a representative household is allocated to the commodity consumption derived from a Stone-Geary utility function (i.e., a linear expenditure system of demand). In order to retain as much information as possible on households' incomes and expenditure patterns, the CGE model is linked to a microsimulation module based on UNHS5. Endogenous changes in commodity consumption for each aggregate household in the CGE model are used to adjust the level of commodity expenditure for the corresponding households in the survey. Real consumption levels are then recalculated in the survey and standard poverty measures are estimated using this updated expenditure measure.

The model makes a number of assumptions about how the economy maintains macroeconomic balance. These 'closure rules' concern the foreign or current account, the government or public sector account, and the savings-investment account. For the current account, a flexible exchange rate maintains a fixed level of foreign savings. This assumption implies that the government cannot increase foreign debt and that Uganda has to generate export earnings in order to pay for imported goods and services. While this assumption realistically limits the degree of import competition in the domestic market, it also underlines the importance of the agricultural and industrial export sectors. For the government account, tax rates and real consumption expenditures are exogenously determined, leaving the fiscal deficit to adjust to ensure that public expenditures equal receipts. For the savings-investment account, real investment adjusts to changes in savings (i.e., savings-driven investment). These two assumptions allow the models to capture the effects of growth on the level of public investment and the crowding-out effect from changes in government revenues.

Finally, the CGE model is recursive dynamic, which means that some exogenous stock variables in the models are updated each period based on inter-temporal behavior and the results from previous periods. The model is run over the period 2005-2015, with each equilibrium period representing a single year. The model also exogenously captures demographic and technological change, including population, labor supply, human capital and factor-specific productivity. Capital accumulation occurs through endogenous linkages with previous-period investment. Although the allocation of newly invested capital is influenced by each sector's initial share of the gross operating surplus, the final allocation depends on depreciation and sector profit-rate differentials. Sectors with above-average returns in the previous period receive a larger share of the new capital stock in the current period.

In summary, the CGE model incorporates distributional change by (i) disaggregating growth across sectors; (ii) capturing income-effects through factor markets and price-effects through commodity markets; and (iii) translating these two effects onto each household in the survey according to its unique factor endowment and income and expenditure patterns. The structure of the growth-poverty relationship is therefore defined explicitly ex ante based on observed country-specific structures and behavior. This allows the models to capture the poverty and distributional changes associated with agricultural growth.

Table A.1. CGE model sets, parameters, and variables

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CMN(\subset C)$	Commodities not in *CM*
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CT(\subset C)$	Transaction service commodities
$c \in C$	Commodities	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$f \in F$	Factors
$c \in CDN(\subset C)$	Commodities not in *CD*	$i \in INS$	Institutions (domestic and rest of world)
$c \in CE(\subset C)$	Exported commodities	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CEN(\subset C)$	Commodities not in *CE*	$i \in INSDNG(\subset INSD)$	Domestic non-government institutions
$c \in CM(\subset C)$	Aggregate imported commodities	$h \in H(\subset INSDNG)$	Households
Parameters			
$cwts_c$	Weight of commodity c in the CPI	$qdst_c$	Quantity of stock change
$dwts_c$	Weight of commodity c in the producer price index	$\overline{qg}_c$	Base-year quantity of government demand
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$\overline{qinv}_c$	Base-year quantity of private investment demand
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$shif_{if}$	Share for domestic institution i in income of factor f
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$shii_{ii'}$	Share of net income of i' to i (i' ∈ INSDNG'; i ∈ INSDNG)
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps}_i$	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tq_c	Rate of sales tax
pwe_c	Export price (foreign currency)	$trnsfr_{i\,f}$	Transfer from factor f to institution i
pwm_c	Import price (foreign currency)		

Table A.1 Continued

Symbol	Explanation	Symbol	Explanation
Greek Symbols			
α_a^a	Efficiency parameter in the CES activity function	δ_{cr}^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
β^a	Capital sectoral mobility factor	ρ_a^{va}	CES value-added function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^{ac}	Domestic commodity aggregation function exponent
δ_a^a	CES activity function share parameter	ρ_c^q	Armington function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^t	CET function exponent
δ_{cr}^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
υ_f	Capital depreciation rate		
Exogenous Variables			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment factor	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
$\overline{IADJ}$	Investment adjustment factor		
Endogenous Variables			
AWF_{ft}^a	Average capital rental rate in time period t	QG_c	Government consumption demand for commodity
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QH_{ch}	Quantity consumed of commodity c by household h
DPI	Producer price index for domestically marketed output	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EG	Government expenditures	$QINTA_a$	Quantity of aggregate intermediate input
EH_h	Consumption spending for household	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
EXR	Exchange rate (LCU per unit of FCU)	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_{cr}	Quantity of imports of commodity c
QF_{fa}	Quantity demanded of factor f from activity a		

Table A.1 Continued

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PA_a	Activity price (unit gross revenue)	QT_c	Quantity of commodity demanded as trade input
PDD_c	Demand price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PDS_c	Supply price for commodity produced and sold domestically	QX_c	Aggregated quantity of domestic output of commodity
PE_{cr}	Export price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
$PINTA_a$	Aggregate intermediate input price for activity a	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_{cr}	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution i (i $\in$ INSDNG)
PQ_c	Composite commodity price	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PVA_a	Value-added price (factor income per unit of activity)	WF_f	Average price of factor
PX_c	Aggregate producer price for commodity	YF_f	Income of factor f
$PXAC_{ac}$	Producer price of commodity c for activity a	YG	Government revenue
QA_a	Quantity (level) of activity	YI_i	Income of domestic non-government institution
QD_c	Quantity sold domestically of domestic output	YIF_{if}	Income to domestic institution i from factor f
QE_{cr}	Quantity of exports	ΔK^{a}_{fat}	Quantity of new capital by activity a for time period t

Table A.2. CGE model equations

Production and Price Equations

$$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a \tag{1}$$

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \tag{2}$$

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \tag{3}$$

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}-1} \tag{4}$$

$$QF_{f\,a} = \alpha_{f\,a}^{van} \cdot \left(\sum_{f' \in F} \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}^{\;-\rho_{f\,a}^{van}} \right)^{-\frac{1}{\rho_{f\,a}^{van}}} \tag{5}$$

$$W_{f'} \cdot WFDIST_{f'\,a} = W_f \cdot WFDIST_{f\,a} \cdot QF_{f\,a} \cdot \left(\sum_{f'' \in F} \delta_{f\,f''\,a}^{van} \cdot QF_{f''\,a}^{\;-\rho_{f\,a}^{van}} \right)^{-1} \cdot \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}^{\;-\rho_{f\,a}^{van}-1} \tag{6}$$

$$QVA_a = iva_a \cdot QA_a \tag{7}$$

$$QINTA_a = inta_a \cdot QA_a \tag{8}$$

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \tag{9}$$

$$QXAC_{a\,c} = \theta_{a\,c} \cdot QA_a \tag{10}$$

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \tag{11}$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{\;-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}} \tag{12}$$

$$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1} \tag{13}$$

$$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c} \tag{14}$$

$$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \tag{15}$$

$$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \tag{16}$$

Table A.2. Continued

$QX_c = QD_c + \sum_r QE_{cr}$	(17)
$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr}$	(18)
$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$	(19)
$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c}$	(20)
$QQ_c = \alpha_c^q \cdot \left(\sum_r \delta_{cr}^q \cdot QM_{cr}^{-\rho_c^q} + (1 - \sum_r \delta_{cr}^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}}$	(21)
$\frac{QM_{cr}}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \sum_r \delta_{cr}^q} \right)^{\frac{1}{1+\rho_c^q}}$	(22)
$QQ_c = QD_c + \sum_r QM_{cr}$	(23)
$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr}$	(24)
$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'} \right)$	(25)
$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c$	(26)
$DPI = \sum_{c \in C} PDS_c \cdot dwts_c$	(27)
Institutional Incomes and Domestic Demand Equations	
$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa}$	(28)
$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{ro\,wf} \cdot EXR \right]$	(29)
$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$	(30)
$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'}$	(31)
$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h$	(32)
$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right)$	(33)
$QINV_c = IADJ \cdot \overline{qinv}_c$	(34)
$QG_c = \overline{GADJ} \cdot \overline{qg}_c$	(35)

Table A.2. Continued

$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$	(36)
System Constraints and Macroeconomic Closures	
$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR$	(37)
$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c$	(38)
$\sum_{a \in A} QF_{f\,a} = QFS_f$	(39)
$YG = EG + GSAV$	(40)
$\sum_{r\ c \in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f \in F} trnsfr_{row\,f} = \sum_{r\ c \in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i \in INSD} trnsfr_{i\,row} + FSAV$	(41)
$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$	(42)
$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right)$	(43)
Capital Accumulation and Allocation Equations	
$AWF_{f\,t}^{a} = \sum_{a} \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right]$	(44)
$\eta_{f\,a\,t}^{a} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^{a} \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF_{f\,t}^{a}} - 1 \right) + 1 \right)$	(45)
$\Delta K_{f\,a\,t}^{a} = \eta_{f\,a\,t}^{a} \cdot \left(\frac{\sum_{c} PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right)$	(46)
$PK_{f\,t} = \sum_{c} PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}}$	(47)
$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K_{f\,a\,t}^{a}}{QF_{f\,a\,t}} - \upsilon_f \right)$	(48)
$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_{a} \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f \right)$	(49)

APPENDIX B. ESTIMATING AGRICULTURAL SPENDING REQUIRED FOR AGRICULTURAL GROWTH

Estimates of the growth in agricultural spending required to achieve a particular agricultural growth rate can be derived by decomposing agricultural growth (θ_{ag}) into effects associated with both agricultural and non-agricultural expenditure growth, taking their interactions (i.e. any trade-offs and complementarities) into account (see Fan et al. 2008 for details):

$$\theta_{ag} \equiv (\varepsilon_{ag\exp} * \dot{E}_{ag\exp} * s_{ag}) + (\varepsilon_{nag\exp} * \dot{E}_{nag\exp} * s_{nag}) + (\varepsilon_{nag\exp} * \phi_{nag,ag} * \dot{E}_{nag\exp} * s_{nag}). \quad \ldots 1$$

where $\dot{E}_{agexp}$ is the annual growth rate in agricultural expenditure; $\dot{E}_{nagexp}$ is the annual growth rate in non-agricultural expenditure; ε_{agexp} and ε_{nagexp} are elasticities of agricultural growth with respect to agricultural and non-agricultural expenditure, respectively; $\phi_{nag,ag}$ is the multiplier effect or linkage (i.e. trade-offs and complementarities) between agricultural and non-agricultural expenditure; and s_{ag} and s_{nag} are shares of agriculture and non-agriculture in total GDP, respectively. Given *a priori* information or assumptions about the parameters, equation 1 can now be solved to obtain the agricultural spending required to achieve a particular growth rate in agriculture ($\overline{\theta}_{ag}$).

$$\dot{E}_{ag\exp} = \frac{\overline{\theta}_{ag} - (\varepsilon_{nag\exp} * \dot{E}_{nag\exp} * s_{nag})}{[\varepsilon_{ag\exp} + (\varepsilon_{nag\exp} * \phi_{nag,ag})] * s_{ag}} \quad \ldots 2$$

Assuming no trade-offs or complementarities between agricultural and non-agricultural expenditure, i.e. $\phi_{nag,ag}=0$, as used in this paper due to lack of information, equation 2 simplifies to:

$$\dot{E}_{ag\exp} = \frac{\overline{\theta}_{ag} - (\varepsilon_{nag\exp} * \dot{E}_{nag\exp} * s_{nag})}{\varepsilon_{ag\exp} * s_{ag}} \quad \ldots 3$$

APPENDIX C. EXAMPLES OF ESTIMATED ELASTICITIES ASSOCIATED WITH PUBLIC INVESTMENT

Table C.1. Marginal effect of public expenditure on capital stock (capital-expenditure elasticities)

Public expenditure in:	Effect on indicator of public capital	Elasticity	Time lag (years)	Remarks (country, source)
Irrigation	Crop area irrigated (%)	0.87	8	Rural India (Fan, Hazell and Thorat, 2000)
Roads	Road density (km/1000Km^2)	0.23	7	
Education	Illiteracy rate (%)	0.07	11	
Electrification	Villages electrified (%)	0.07	7	
Irrigation	Crop area irrigated (%)	0.25	14	Rural China (Fan and Zhang, 2004)
Roads	Road density (km/1000Km^2)	0.47	17	
Telecommunications	Number of telephones per 1000 residents	0.30		
Education	Average years of schooling of adults 15 years or older	0.34	16	
Electrification	Electricity consumption per capita	0.25	12	
Roads	Road density (km/1000 persons)	1.74	0	Ethiopia (Mogues et al., 2007)
Education	Primary enrollment rate (%)	0.24	0	
Health	Distance to nearest health facility (km)	–0.12	0	

Notes: Elasticity is the percentage change in public capital due to a one percent change in public expenditure.

Table C.2. Marginal effect of public expenditure or capital on agricultural productivity ('growth-capital' and 'growth-expenditure' elasticities)

Indicator of public capital	Elasticity	Time lag (years)	Notes
Agricultural extension (staff per 1000 farms)	0.063; 0.059; 0.041	3	India (Rosegrant and Evenson, 1995); estimates for the periods 1956-66, 1967-77 and 1978-87, respectively
Agricultural research (number of scientists per ha of arable land)	0.027	0	*LDCs (Johnson and Evenson, 2000)
Road density (km/1000km^2)	0.042	3	India (Zhang and Fan, 2004)
Road density (km/1000km^2)	0.242	8	India (Fan, Hazell and Thorat, 2000)
Public expenditure			
Agricultural research (expenditure)	0.131–0.189	35	USA (Huffman and Evenson, 2006).
Agricultural extension (expenditure)	0.110–0.156	4	
Agricultural research (expenditure)	0.066; 0.053; 0.049	27	India (Rosegrant and Evenson, 1995); estimates for the periods 1956-66, 1967-77 and 1978-87, respectively
Agricultural research and development (expenditure)	0.255	13	India (Fan, Hazell and Thorat, 2000)
Soil and water conservation (expenditures)	0.013	3	

Notes: Elasticity is the percentage change in agricultural productivity due to a one percent change in public expenditure or capital. *LDCs mean least developed countries.

REFERENCES

Benin, S., Nkonya, N., Okecho, G., Pender, J., Nahdy, S., Mugarura, S., Kato, E. and Kayobyo, G. 2007. Assessing the impact of the national agricultural advisory services in the Uganda rural livelihoods. International Food Policy Research Institute (IFPRI) Discussion Paper 724, IFPRI, Washington D.C.

Diao, X., Hazell, P., Resnick, D. and Thurlow, J. 2007. *The Role of Agriculture in Pro-Poor Growth in Sub-Saharan Africa*. Research report 144, IFPRI, Washington D.C.

Diao, X., and Nin-Pratt, A. 2005. Growth options and poverty reduction in Ethiopia: A spatial, economywide model analysis for 2004–2015. Development Strategy and Governance Division Discussion Paper 20, IFPRI, Washington D.C.

Fan, S., Hazell, P. and Thorat, S. 2000. Government spending, agricultural growth and poverty in rural India. *American Journal of Agricultural Economics* 82(4):1038-51.

Fan, S., Johnson, M., Saurkar, A. and Makombe, T. 2008. Investing in African Agriculture to Halve Poverty by 2015. IFPRI Discussion Paper 751, IFPRI, Washington D.C.

Fan, S. and X. Zhang. 2004. Investment, Reforms and Poverty in Rural China. *Economic Development and Cultural Change* 52(2):395-422.

Fan, S., Zhang, X. and Rao, N. 2004. Public expenditure, growth, and poverty reduction in rural Uganda. Development Strategy and Governance Division Discussion Paper 4, IFPRI, Washington D.C.

Fan, S. and Rao, N. 2003. Public spending in developing countries: trend, determination and impact. Environment and Production Technology Division Discussion Paper 99, IFPRI, Washington, D.C., USA.

FAO (Food and Agriculture Organization of the United Nations). 2007. FAOSTAT database. <http://faostat.fao.org/> last accessed in October 2007.

Guild, R.L. 2000. Infrastructure investment and interregional development: theory, evidence, and implications for planning. *Public Works Management and Policy* 4(4):274-285.

Huffman, W.E. and Evenson, R.E. 2006. Do formula or competitive grant funds have greater impact on state agricultural productivity? *American Journal of Agricultural Economics* 88(4):783-798.

IMF (International Monetary Fund). 2007. *Government finance statistics*. IMF, Washington D.C.

IRF (International Road Federation). 2007. *World road statistics*. IRF, Switzerland.

Johnson, D.K.N. and Evenson, R.E. 2000. How far away is Africa? Technological spillovers to agriculture and productivity. *American Journal of Agricultural Economics* 82:743-749.

Kebba, A. and Ofwono, N. 2007. COMESA-CAADP Uganda Stocktaking Report. Ministry of Agriculture, Animal Industries and Fisheries, Uganda.

MAAIF (Ministry of Agriculture, Animal Industry and Fisheries). 2005. Integrated support to farmers' groups (ISFG) component of the rural development strategy: implementation plan. MAAIF, Entebbe, Uganda

MAAIF (Ministry of Agriculture, Animal Industry and Fisheries). 2006. *Crop Production Surveys*. MAAIF, Entebbe, Uganda

MAAIF (Ministry of Agriculture, Animal Industry and Fisheries). 2007. National Agricultural Production Data. MAAIF, Entebbe, Uganda

MFPED (Ministry of Finance, Planning and Economic Development). 2004. Poverty Eradication Action Plan, 2004/05-2007/08. MFPED, Kampala, Uganda.

Mogues, T., Ayele, G., and Paulos, Z. 2007. The bang for the Birr: public expenditures and rural welfare in Ethiopia. IFPRI Discussion Paper 702. IFPRI, Washington D.C.

OPM (Oxford Policy Management). 2007. Uganda agriculture sector public expenditure review. OPM, Oxford, UK.

OPM (Oxford Policy Management). 2005. Evaluation report: the plan for modernization of agriculture. OPM, Oxford, UK.

ROU (Republic of Uganda). 2007. Analysis of PMA related medium term expenditure framework (MTEF) budget framework papers (BFP). ROU, Kampala, Uganda.

Rosegrant, M.W. and Evenson, R.E. 1995. Total factor productivity and sources of long-term growth in Indian agriculture. Environment and Production Technology Discussion Paper 7, IFPRI, Washington D.C.

Scanagri Consulting Company. 2005. Midterm evaluation of Uganda's National Agricultural Advisory Services (NAADS) program. Draft Consultancy report submitted to the Government of Uganda. NAADS, Kampala, Uganda.

Thirtle, C., Lin, L. and Piesse, J. 2003. The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America. *World Development* 31(12): 1959-75.

Thurlow, J. 2004. A recursive dynamic computable general equilibrium model of South Africa, Trade and Industrial Policy Strategies, Johannesburg, South Africa.

Thurlow, J. and Wobst, P. 2004. The road to pro-poor growth in Zambia: past lessons and future challenges. Development Strategy and Governance Division Discussion Paper 16, IFPRI, Washington, D.C., USA.

UBOS (Uganda Bureau of Statistics). 2006. *Uganda National Household Survey 2005/2006*. UBOS, Entebbe Uganda.

UBOS (Uganda Bureau of Statistics). 2007. *Uganda Statistical Abstract 2007*. UBOS, Entebbe Uganda.

UBOS (Uganda Bureau of Statistics). 2008. *Uganda Supply-Use Tables, 2002/03 (preliminary release)*. UBOS, Entebbe Uganda.

Zhang, X. and Fan, S. 2004. How productive is infrastructure? A new approach and evidence from rural India. *American Journal of Agricultural Economics* 86(2):492-501.

RECENT IFPRI DISCUSSION PAPERS

For earlier discussion papers, please go to www.ifpri.org/pubs/pubs.htm#dp.
All discussion papers can be downloaded free of charge.

789. *Agricultural public spending in Nigeria*. Tewodaj Mogues, Michael Morris, Lev Freinkman, Abimbola Adubi, and Simeon Ehui; *with* Chinedum Nwoko, Olufemi Taiwo, Caroline Nege, Patrick Okonji, and Louis Chete, 2008.

788. *Choosing sensitive agricultural products in trade negotiations*. Sébastien Jean**,** David Laborde, and Will Martin, 2008.

787. *An Updated Look at the Recovery of Agricultural Productivity in Sub-Saharan Africa*. Alejandro Nin Pratt and Bingxin Yu. 2008

786. *Migration, Poverty, and Inequality: Evidence from Burkina Faso*. F.S. Wouterse. 2008

785. *Insecticide use on vegetables in Ghana: Would GM seed benefit farmers?* Daniela Horna, Melinda Smale, Ramatu Al-Hassan, José Falck-Zepeda, and Samuel E. Timpo, 2008.

784. *Agriculture for development in Ghana: New opportunities and challenges*. Clemens Breisinger, Xinshen Diao, James Thurlow, and Ramatu M. Al-Hassan, 2008.

783. *Understanding the investment and abandonment behavior of poor households: An empirical investigation*. Ruth Vargas Hill, 2008.

782. *Access to irrigation and the escape from poverty: Evidence from Northern Mali*. Andrew Dillon, 2008.

781. *Structural changes in the Philippine pig industry and their environmental implications.* Maria Angeles O. Catelo, Clare A. Narrod, and Marites M. Tiongco, 2008.

780. *Evaluating alternative policy responses to higher world food prices: The case of increasing rice prices in Madagascar*. David Coady, Paul Dorosh, and Bart Minten,, 2008.

779. *Contract farming of swine in Southeast Asia as a response to changing market demand for quality and safety in pork.* Marites Tiongco, Maria Angeles Catelo, and Ma. Lucila Lapar, 2008.

778. *On-site and off-site long-term economic impacts of soil fertility management practices: The case of maize-based cropping systems in Kenya.* Ephraim Nkonya, Patrick Gicheru, Johannes Woelcke, Barrack Okoba, Daniel Kilambya, and Louis N. Gachimbi, 2008

777. *Development under conditions of inequality and distrust: Social cohesion in Latin America*. Marco Ferroni, Mercedes Mateo, Mark Payne, 2008.

776. *Exploring strategic priorities for regional agricultural R&D investments in East and Central Africa.* Liangzhi You and Michael Johnson, 2008.

775. *Reforming the agricultural extension system in India: What do we know about what works where and why?* Katharina Raabe, 2008.

774. *An experimental inquiry into the effect of yardstick competition on corruption*. Angelino Viceisza, 2008.

773. *Alianzas para la innovación agroalimentaria en Bolivia: Lecciones para la formulación de políticas.* Frank Hartwich, Luis Ampuero, Tito Arispe, Vicente EguezJaime Mendoza, y Nancy Alexaki, 2008.

772. *Tracing power and influence in networks: Net-Map as a tool for research and strategic network planning*. Eva Schiffer and Douglas Waale, 2008.

771. *Estimating household income to monitor and evaluate public investment programs in Sub-Saharan Africa.* Samuel Benin and Josee Randriamamonjy, 2008.

770. *Does Africa trade less than it should, and if so, why? The role of market access and domestic factors.* Antoine Bouet, Santosh Mishra, and Devesh Roy, 2008.

769. *Impacts of the Hutan Kamasyarakatan social forestry program in the Sumberjaya Watershed, West Lampung District of Sumatra, Indonesia.* John Pender, Suyanto, John Kerr, and Edward Kato, 2008.

768. *Finance and cluster-based industrial development in China*. Jianqing Ruan and Xiaobo Zhang, 2008.

767. *Introducing a genetically modified banana in Uganda: Social benefits, costs, and consumer perceptions*. José Falck-Zepeda, Enoch Kikulwe, and Justus Wesseler, 2008.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

www.ifpri.org

IFPRI HEADQUARTERS

2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI

CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
Email: ifpri-newdelhi@cgiar.org