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Agricultural Growth and Investment Options for Poverty Reduction in Zambia

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agriculture, GDP, poverty, public investment, MDG

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Abstract

Zambia has experienced strong economic performance since 1999. However, agriculture has not performed as well as the rest of the economy, and although the incidence of poverty has declined, it still remains high. The Zambian government, within the framework of the Fifth National Development Plan (FNDP), 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 Zambia's FNDP, in alignment with the principles and objectives of the CAADP, which include the achievement of six percent agricultural growth and allocation of at least ten percent of budgetary resources to the sector.

Computable general equilibrium (CGE) model results indicate that it is possible for Zambia to reach the CAADP target of six percent agricultural growth, but this will require additional growth in all crops and sub-sectors. Zambia cannot rely on only maize or higher-value export crops to achieve this growth target; broader-based agricultural growth, including increases in fisheries and livestock, will be important. So, too, is meeting the Maputo declaration of spending at least ten percent of the government's total budget on agriculture. In order to meet the CAADP target, the Government of Zambia must increase its spending on agriculture in real value terms by about 17–27 percent per year between 2006 and 2015, and spend about 8–18 percent of its total expenditure on the sector by 2015.

Although agriculture has strong linkages to the rest of the economy and its growth will result in substantial overall growth in the economy and the household incomes of rural and urban populations, achieving the CAADP target of six percent agricultural growth will not be sufficient to meet the first Millennium Development Goal (MDG1) of halving poverty by 2015. To achieve this more ambitious target, both agricultural and non-agricultural sectors would need an average annual growth rate of around ten percent per year. These growth requirements are substantial, as are the associated resource requirements. Thus, while the MDG1 target appears to be beyond reach for Zambia, achieving the CAADP target should remain a priority, as its more reasonable growth and expenditure scenarios will still 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.

Introduction

Zambia has experienced strong economic performance since 1999. However, agriculture has not performed as well as the rest of the economy, and while the incidence of poverty has declined, it still remains high. To accelerate growth and poverty reduction, Zambia's government recently launched the Fifth National Development Plan (FNDP), which emphasizes the revitalization of agriculture as an engine of growth and development for the national economy. This is not surprising, since agriculture is an important mainstay of a large proportion of the population, contributing about 20 percent of GDP and foreign exchange earnings, and employing two-thirds of the population. In association with the New Partnership for Africa's Development (NEPAD), the Government of Zambia 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 (AU 2006).

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 demand in both domestic and export markets, and demand, in turn, depends on income growth both in agriculture and in the broader economy. Although agriculture is a dominant economic activity in Zambia and the majority of the population lives in rural areas, both rural and urban sectors need to be included in this framework in order for us to understand the economy-wide impact of agricultural growth.

This study analyzes the agricultural growth and investment options that can support the development of a more comprehensive rural development component under Zambia's FNDP, 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 Zambia's agricultural sector and rural economy within the FNDP. For these purposes, and to assist policymakers and other stakeholders in making informed long-term decisions, we herein develop an economy-wide, computable general equilibrium (CGE) model for Zambia and use it to analyze the linkages and trade-offs between economic growth and poverty reduction at both the macro- and microeconomic levels. In addition, the study assesses the aggregate public resources required by the agricultural sector for achieving the development goals committed to by the government.

II. Modeling agricultural growth and poverty reduction

The computable general equilibrium (CGE) and microsimulation model

A new CGE model for Zambia was developed to capture trade-offs and synergies from accelerating growth in various agricultural sub-sectors, as well as the economic inter-linkages between agriculture and the rest of the economy.[2] Although this study focuses on the agricultural sector, the CGE model also contains information on the non-agricultural sectors; the model examines 34 sub-sectors in total, half of which are in agriculture. The examined agricultural crops fall into four broad groups: (i) cereal crops, which are separated into maize, sorghum and millet, and other cereals, such as rice, wheat and barley; (ii) root crops, such as cassava, Irish potatoes, and sweet potatoes; (iii) other food crops, which are separated into pulses and oil crops, groundnuts, vegetables, and fruits; and (iv) higher-value export-oriented crops, which are separated into cotton, sugar, tobacco, and other export crops, such as sunflower seeds and paprika. 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. Most of the agricultural commodities

[2] A detailed description of the model is provided in the appendix. See also Lofgren et al. (2002) and Thurlow (2003).

listed above are not only exported or consumed by households in Zambia, but are also used as inputs into various processing activities in the manufacturing sector. The three agricultural processing activities identified in the model include food and tobacco processing, textile manufacturing, and wood processing. The agricultural sub-sectors themselves also use inputs from other non-agricultural sectors, such as fertilizer from the chemical sector and marketing services from the trade and transport sectors. A complete list of the sectors identified in the model is provided in Table 1.

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

	Agricultural sub-sectors
	Cereals
1	Maize
2	Sorghum & millet
3	Other cereals (incl. wheat, rice, barley)
4	Root crops (incl. cassava, sweet potatoes, Irish potatoes)
	Other food crops
5	Pulses & oils (incl. mixed beans, soybeans)
6	Groundnuts
7	Vegetables
8	Fruits
	High-value export-oriented crops
9	Cotton
10	Sugarcane
11	Tobacco
12	Other crops (incl. sunflower seeds, paprika, spices, floriculture)
	Livestock
13	Cattle
14	Poultry
15	Other livestock (incl. goats, sheep and pigs)
16	Fisheries
17	Forestry
	Industrial sub-sectors
18	Mining
19	Food processing, beverages & tobacco
20	Textiles & clothing
21	Wood & paper products
22	Chemicals & rubber products
23	Machinery & equipment (incl. vehicles)
24	Other manufacturing (incl. furniture)
25	Electricity & water
26	Construction
	Service sub-sectors
27	Trade services
28	Hotels & catering
29	Transport & communication services
30	Financial, business & real estate services
31	Government administration
32	Education services

33	Health services
34	Community & other services

The CGE model also captures regional heterogeneity. Rural agricultural production is disaggregated across Zambia's four main agro-ecological regions, which are shown in Figure 1. Furthermore, to capture the importance and unique circumstances of urban agriculture, agricultural production is disaggregated between the main metropolitan centers and other urban areas.[3] This means that there are six sub-national regions identified in the model, four rural and two urban. Finally, crop production is further disaggregated across small and large-scale producers (this is discussed in detail below).

Figure 1. Agro-ecological zones in the CGE model

Note: The zones shown in the figure are agro-ecological zones, whereas the zones in the model are based on administrative districts mapped according to which zone contained a majority of the districts' land. Although the survey is not strictly representative at the zonal level, it is representative at the provincial level, and these provinces largely correspond with the more aggregate agro-ecological zones.

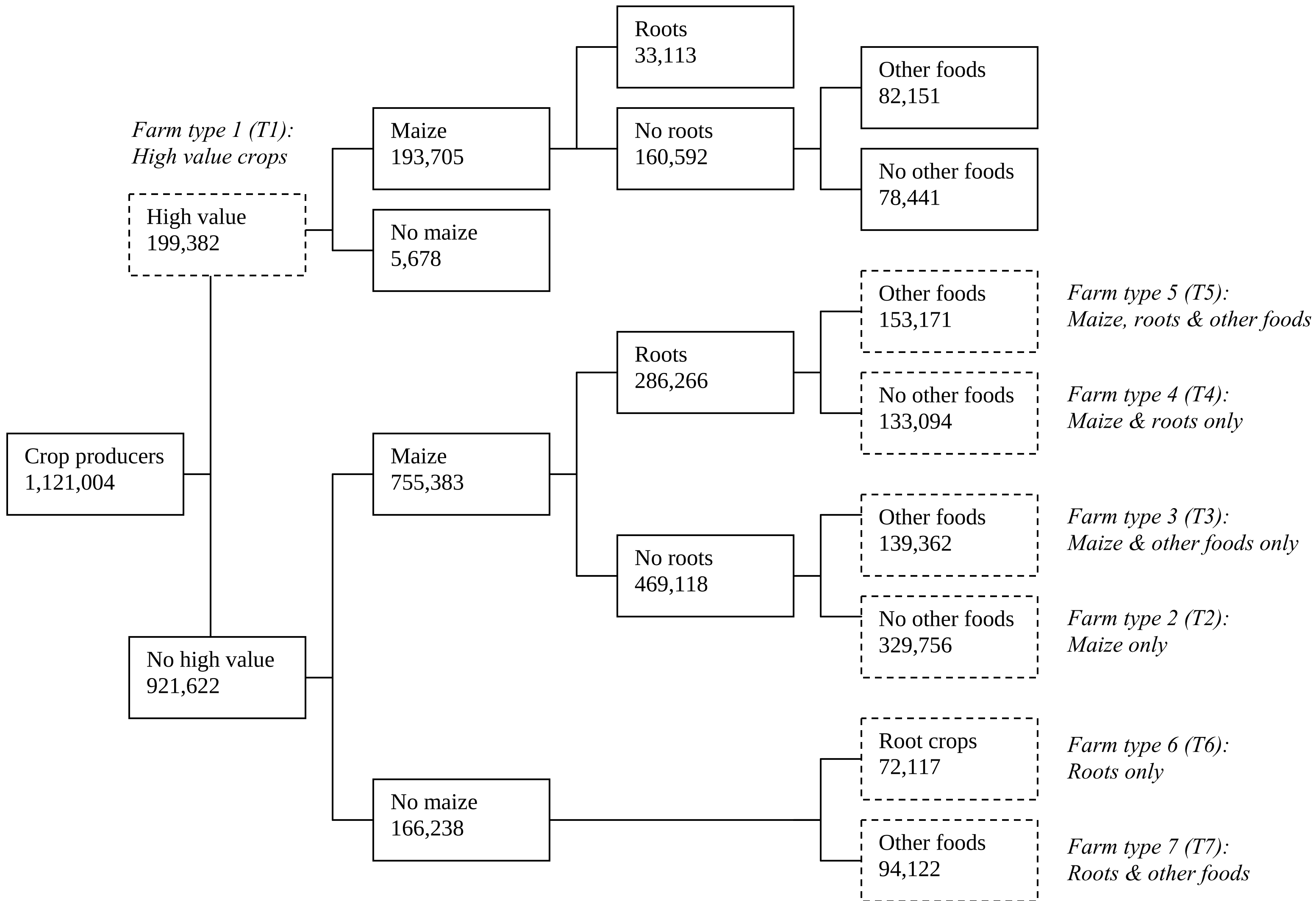
[3] Metropolitan centers are defined as urban areas in the following districts: Kabwe in Central Province; Chingola, Chililabombwe, Kitwe, Kalulushi, Lufwanyama, Mufulira and Ndola in Copperbelt Province; Lusaka in Lusaka Province; and Livingstone in Southern Province.

The model captures differences in cropping patterns across farmers *within* each of the four rural agro-ecological zones. Information on crop production within each zone was drawn from the 2004 Living Conditions Monitoring Survey (LCMS4), in which households were asked whether they engaged in crop production and how much of their agricultural land was devoted to producing different crops. The objective of the farm typology is to group farmers into major categories based on the crops they produced, which is assumed to reflect agro-ecological, technological and marketing constraints and opportunities.

According to LCMS4, 1.12 million rural households reported agricultural crop incomes in 2004. This is shown in the left-hand box in Figure 2, which gives the general structure of the farm typology for all rural households in Zambia engaged in crop production (excludes urban and non-farm households, which are discussed later). We first separate out farm households that reported producing 'high-value' crops, such as cotton, tobacco, sunflower seeds and flowers. In 2004, 199,382 farm households produced these more export-oriented crops (i.e., about one out of every six rural farm households). From the figure, we can see that most households producing high-value crops also grew maize, but very few of them engaged in root crop production. Since maize and roots are the more widespread crops in Zambia and most farm households growing high-value crops have broadly similar cropping patterns, we group all households growing high-value crops into a single group or farm type, namely 'farm type 1: high value crops' (T1). As shown in the fourth column of Table 2, farm households growing high-value crops tend to harvest larger land areas (2.62 hectares compared to a national average of 1.47 hectares). Despite the importance of higher-value crops in generating agricultural incomes, these farm households devote a greater share of their land to food crops. They also have higher-than-average maize yields (1.29 tons per hectare) and plant a larger share of their maize land with hybrid seeds (39.6 percent). The sharp distinction between the cropping patterns and yields of this farm-type versus the others supports its choice as a separate farm group within the model.

As shown in Figure 2, there is more diversity in cropping patterns among the 921,622 rural farm households that do *not* grow high-value crops. Most of these households grow either maize or root crops. According to LCMS4, almost one third of rural farm households grow maize only, and do not grow other kinds of crops. We choose this large group as the second group of farm households in the typology (see ‘farm type 2: maize only’ (T2), shown on the right-hand side of Figure 2). Far fewer households produce only root crops (see ‘farm type 6: roots only’ (T6)).

Figure 2. Farm typology structure for rural agricultural household



Source: Own calculations using the 2004 Living Conditions Monitoring Survey.

Table 2. Land and population distribution across farm household types

	National	Urban		Rural									
		Farm	Non-farm	Farm							Non-farm	Small-scale (<5ha)	Larger-scale (>5ha)
				High value	Maize only	Maize & other foods	Maize & roots only	Maize, roots & other foods	Roots only	Roots & other foods			
		T8		T1	T2	T3	T4	T5	T6	T7			T9
Population (1000)	10,989	1,220	3,077	1,170	1,664	776	700	870	322	466	724	5,633	336
Number of households	2,109	196	626	199	330	139	133	153	72	94	172	1,074	40
Household size	5.21	6.21	4.91	6.06	5.05	5.58	5.26	5.68	4.46	4.94	4.22	5.24	8.33
Total area harvested (1000 ha)	1,927	212	-	506	360	246	166	299	39	99	-	1,299	416
Average area harvested per farm household (ha)	1.47	1.08	-	2.62	1.09	1.77	1.25	1.95	0.54	1.05	-	1.21	10.32
Cereals	0.92	0.82	-	1.24	1.09	1.23	0.76	0.94	-	0.23	-	0.73	6.19
Root crops	0.20	0.08	-	0.07	-	-	0.49	0.61	0.54	0.42	-	0.21	0.71
Other food crops	0.20	0.15	-	0.27	-	0.53	-	0.41	-	0.40	-	0.14	1.76
High-value crops	0.16	0.03	-	1.03	-	-	-	-	-	-	-	0.12	1.66
Share of maize land using hybrid seeds (%)	38.7	41.1	-	39.6	41.8	41.7	24.6	32.4	-	-	-	30.2	62.5
Selected food crop yields (mt/ha)													
Maize	1.10	1.19	-	1.29	0.90	1.29	0.88	1.12	-	-	-	0.99	1.35
Local seeds	0.90	1.01	-	1.12	0.71	0.97	0.79	0.95	-	-	-	0.86	1.03
Hybrid seeds	1.40	1.45	-	1.55	1.16	1.74	1.13	1.47	-	-	-	1.28	1.55
Millet	0.87	1.06	-	0.79	-	0.74	-	0.88	-	0.96	-	0.88	0.74
Sorghum	0.57	0.67	-	0.46	-	0.67	-	0.67	-	0.38	-	0.57	0.44
Cassava	1.75	1.83	-	1.88	-		1.65	1.65	1.76	2.06	-	1.82	1.13

Source: Own calculations using the 2004 Living Conditions Monitoring Survey.
Note: 'Small-scale' farm households have less than five hectares of land, whereas 'larger-scale' farm households have more than five hectares. 'High-value crops' include cotton, sugar, tobacco, sunflower seeds, paprika and floriculture. 'Maize' includes local and hybrid varieties. 'Roots' include cassava, sweet potatoes, and Irish potatoes. 'Other foods' include millet, sorghum, rice, beans, mixed beans, soybeans, and groundnuts.

As shown in Table 2, the ‘maize only’ and ‘root only’ farm groups (i.e. T2 and T6) engage in a narrower range of cropping activities and tend to have relatively small landholdings (1.09 and 0.54 hectares on average, respectively). Furthermore, while the ‘maize only’ group plants a higher-than-average share of their land under hybrid seeds, their maize yields are far below the national average. Again, the differences between these and other groups confirm their separation in the typology.

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 can be seen in Table 2.[4] According to the table, urban agriculturalists are an important part of the agricultural sector, comprising about 196,300 households and 1.22 million individuals, which corresponds to 11.1 percent of Zambia’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, at 1.08 hectares. Urban crop yields are consistently higher than average, and a larger share of urban maize land is planted using hybrid seeds (41.1 percent). Very little urban agricultural land is devoted to high-value crops (about three percent), with almost all land allocated to either cereals (76 percent, mostly maize) or other food crops (14 percent).

The typology also distinguishes between small- and larger-scale farm households. This is shown in the final two columns of Table 2. Consistent with Zambia’s official reports, we define small-scale farmers as those harvesting less than 5 hectares of land, while larger-scale farmers are those harvesting more than 5 hectares.[5] Average smallholder plots measure 1.21 hectares, while the average plot for larger-scale farmers is substantially higher at 10.32 hectares. Although the roughly 40,000 larger-scale rural farmers captured in LCMS4 amount to only 3.5 percent of farm households in Zambia, they account for a quarter of rural agricultural land and more than a third of rural land allocated to higher-value export-oriented crops. Larger-scale farmers also have high maize yields due, at least in part, to their greater adoption of hybrid seeds.[6]

[4] The numbers in Figure 2 are the summation of the seven rural household types shown in Table 2, Columns 5-10.
[5] The term ‘larger-scale’ is used rather than ‘large-scale’ since this category in the CGE model includes both ‘medium-scale’ and ‘large-scale’ as defined in the stratification of LCMS4.
[6] Larger-scale farmers’ maize yields when using local seeds is similar to the national average.

As mentioned earlier, the model captures the heterogeneity in agricultural production across sub-national regions. The importance of the different farm types in each of these regions is shown in Table 3, in which the third column gives the number of farm households corresponding to those reported in Figure 2. As shown in the table, most of the rural farm households fall into Zones 2a and 3 (see Figure 1). Export crop production is highly concentrated in Zambia, with more than 88.5 percent of households in the high-value group (T1) situated in central Zone 2a. Root crops are less important outside of the northern Zone 3. However, roots are the dominant food crop within Zone 3, which is home to around 80 percent of all households fall into the 'roots only' and 'roots and other food crop' groups (T6 and T7). Maize is an especially important crop for urban and Zone 1 farm households, with 59.3 percent of Zone 1 households growing only maize. Table 3 also shows the greater importance of higher-value export-oriented crops for larger-scale farmers compared to small-scale farmers. These regional concentrations of production underline the importance of taking spatial differences into account within the model.

The CGE model captures the initial cropping patterns of each farm type in each of the six sub-national regions. Each group of farmers (represented by the various farm types) responds to changes in production technology and 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 larger-scale 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 the data on the different agents 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 single sector but more detailed farm models. The new CGE model for Zambia is therefore an ideal tool for capturing the growth linkages and income-and price-effects resulting from growth acceleration in different agricultural sectors.

Table 3. Number of households in each farming type across different regions in the model

		National	Urban	Rural							
				All zones	Zone 1	Zone 2			Zone 3	Small-scale	Larger-scale
						Both	Zone 2a	Zone 2b			
Number of households of each farming type across regions											
	All farm households	1,315,005	194,002	1,121,004	94,621	551,939	463,696	88,243	474,444	1,080,509	40,545
1	High-value	208,820	9,437	199,382	6,958	184,774	183,266	1,508	7,650	182,018	17,414
2	Maize only	438,590	108,834	329,756	56,124	192,635	156,713	35,922	80,997	323,319	6,437
3	Maize & other foods	175,787	36,426	139,362	16,346	69,793	60,628	9,165	53,222	133,906	5,455
4	Maize & roots only	145,356	12,262	133,094	4,591	51,570	26,379	25,191	76,934	131,208	1,886
5	Maize, roots, & food	165,433	12,262	153,171	3,978	38,546	30,483	8,064	110,647	144,655	8,516
6	Roots only	78,318	6,201	72,117	1,626	7,920	1,400	6,520	62,570	72,117	92
7	Roots & other foods	102,701	8,580	94,122	4,997	6,701	4,829	1,872	82,424	93,285	745
Share of households of each farming type within each region											
	All farm households	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1	High-value	15.9	4.9	17.8	7.4	33.5	39.5	1.7	1.6	16.8	42.9
2	Maize only	33.4	56.1	29.4	59.3	34.9	33.8	40.7	17.1	29.9	15.9
3	Maize & other foods	13.4	18.8	12.4	17.3	12.6	13.1	10.4	11.2	12.4	13.5
4	Maize & roots only	11.1	6.3	11.9	4.9	9.3	5.7	28.5	16.2	12.1	4.7
5	Maize, roots, & food	12.6	6.3	13.7	4.2	7.0	6.6	9.1	23.3	13.4	21.0
6	Roots only	6.0	3.2	6.4	1.7	1.4	0.3	7.4	13.2	6.7	0.2
7	Roots & other foods	7.8	4.4	8.4	5.3	1.2	1.0	2.1	17.4	8.6	1.8
Share of households in each region by farming type											
	All farm households	100.0	14.8	85.2	7.2	42.0	35.3	6.7	36.1	82.2	3.1
1	High-value	100.0	4.5	95.5	3.3	88.5	87.8	0.7	3.7	87.2	8.3
2	Maize only	100.0	24.8	75.2	12.8	43.9	35.7	8.2	18.5	73.7	1.5
3	Maize & other foods	100.0	20.7	79.3	9.3	39.7	34.5	5.2	30.3	76.2	3.1
4	Maize & roots only	100.0	8.4	91.6	3.2	35.5	18.1	17.3	52.9	90.3	1.3
5	Maize, roots, & food	100.0	7.4	92.6	2.4	23.3	18.4	4.9	66.9	87.4	5.1
6	Roots only	100.0	7.9	92.1	2.1	10.1	1.8	8.3	79.9	92.1	0.1
7	Roots & other foods	100.0	8.4	91.6	4.9	6.5	4.7	1.8	80.3	90.8	0.7

Source: Own calculations using the 2004 Living Conditions Monitoring Survey.

Note: Rural and urban non-farm households are not shown in the table. ‘Small-scale’ farm households have less than five hectares of land, whereas ‘larger-scale’ farm households have more than five hectares. ‘High-value crops’ include cotton, sugar, tobacco, sunflower seeds, paprika and floriculture. ‘Maize’ includes local and hybrid varieties. ‘Roots’ include cassava, sweet potatoes, and Irish potatoes. ‘Other foods’ include millet, sorghum, rice, beans, mixed beans, soybeans, and groundnuts.

Finally, the CGE model endogenously estimates the impact of alternative growth paths on the incomes of various household groups. These household groups include both farm and non-farm households, and are disaggregated across nine geographic regions (one metropolitan region, plus rural and urban areas in each of the four agro-ecological zones). Rural farm households are further separated by land size into small-scale and larger-scale households. Each of the households included in the 2004 LCMS4 are linked directly to their corresponding representative household in the CGE model. This is the microsimulation component of the new Zambian 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 measures are consistent with official poverty estimates, and changes in poverty draw on the consumption patterns, income distribution and poverty rates captured in the 2004 LCMS.

Data

The data used to calibrate the base year of the model are drawn from a variety of data sources. The core dataset underlying the CGE model is a new 2004 social accounting matrix (SAM) constructed using information from national accounts, trade data from the Central Statistical Office (CSO), and balances of payment from the Bank of Zambia (BOZ). District-level agricultural production, agricultural area data, and market-level price data were provided by the Ministry of Agriculture and Cooperatives (MACO, 2007). Whenever production information was unavailable for certain crops (e.g., horticulture), information was taken from the Food and Agriculture Organization (FAO) of the United Nations (FAO, 2007). Agricultural production was first disaggregated across regions by mapping districts to the four agro-ecological regions. Production was then disaggregated across farm types using information from the 2004 LCMS4. The CGE model is therefore consistent with official agricultural production levels and yields at the zonal level, while retaining the within-region distribution of production captured in the survey. Non-agricultural production and employment data were compiled from LCMS4, national accounts, and the World Bank's World Development Indicators (World Bank, 2007). On the demand side, information on industrial technologies (e.g., intermediate and factor demand) was taken from an earlier SAM for Zambia (Thurlow and Wobst, 2006), while the income and expenditure patterns for the various household groups were taken from 2004 LCMS4. The CGE model is therefore based on the most recent available data for Zambia.

III. Poverty reduction under Zambia's current growth path

In this section, we use the Zambian CGE and microsimulation model to examine the impact of Zambia'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. Zambia as a whole performed well during 2000-2005, with national GDP growing at 4.8 percent (CSO, 2007a). However, during this same period, the agricultural sector experienced a far more modest growth of only 1.5 percent per year. Furthermore, agricultural growth was erratic, with agricultural GDP declining during 2000-2002 and rising during 2003-2005. In the Baseline scenario, we assume that agricultural GDP will maintain its current slightly stronger performance and grow at an average of 2.5 percent per year during 2005-2015. Moreover, two-thirds of agricultural growth since 2001 has been due to area expansion, with only one third driven by yield improvements. In the Baseline scenario, we assume that land expansion will continue but at a more modest pace, with only one-third of production increases driven by area expansion. This is equivalent to a 1.2 percent increase per year in harvested land during 2005-2015, and is lower than the rural population growth rate of two percent. As shown in Table 4, the non-agricultural sectors are projected to maintain their strong performances over the coming decade. While the mining sector grows especially fast at 6.4 percent per year, the manufacturing and service sectors also grow strongly, at 3.9 and 4.7 percent, respectively.

The overall 2.5 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 regarding each sub-sector's yield growth. We initially adopt a more modest maize yield than was actually observed in 2004, and then assume that maize yields grow at 0.67 percent during 2005-2015, such that Zambia achieves a sustained maize yield of 1.52 tons per hectare by 2015.

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

	Initial value of GDP (Kw bil.)	Percentage share of total (%)		Average annual growth rate (%)	
		Total GDP	Agricultural GDP	Baseline scenario	CAADP scenario
	2004	2004	2004	2005-15	2005-15
Total GDP	23,699	100.0		4.56	5.34
Agriculture	4,859	20.5	100.0	2.53	6.09
Cereals	1,307	5.5	26.9	1.78	4.92
Maize	1,143	4.8	23.5	2.13	4.84
Sorghum & millet	53	0.2	1.1	2.61	4.69
Other cereals	111	0.5	2.3	-3.51	5.84
Root crops	444	1.9	9.1	2.08	5.54
Other food crops	895	3.8	18.4	0.84	4.80
Pulses & oil crops	100	0.4	2.1	-4.28	2.97
Groundnuts	344	1.5	7.1	2.54	5.35
Vegetables	283	1.2	5.8	0.79	5.24
Fruits	168	0.7	3.4	-0.62	3.78
High-value crops	818	3.5	16.8	3.20	9.13
Cotton	312	1.3	6.4	3.37	9.37
Sugar	337	1.4	6.9	3.22	9.00
Tobacco	109	0.5	2.2	2.93	9.43
Other export crops	61	0.3	1.3	2.65	7.97
Livestock	740	3.1	15.2	4.26	6.05
Cattle	237	1.0	4.9	4.57	6.68
Poultry	236	1.0	4.8	4.60	6.70
Other livestock	268	1.1	5.5	3.65	4.80
Other agriculture	656	2.8	13.5	3.31	5.99
Forestry	374	1.6	7.7	3.46	6.93
Fisheries	282	1.2	5.8	3.12	4.62
Mining	2,556	10.8		6.36	6.19
Manufacturing	3,084	13.0		3.90	4.66
Processing	2,722	11.5		3.90	4.84
Other industry	1,818	7.7		5.38	5.61
Services	6,520	27.5		4.66	4.70

Source: Own calculations from the new 2004 Zambia social accounting matrix and our results from the Zambian CGE-microsimulation model.

While this is below the yields that have been achieved since 2004, it is consistent with Zambia's long term trend of 1.55 tons per hectare since 1990, and thus takes into account past fluctuations in the performance of the maize sector. Similarly, for sorghum and millet, we assume that initial yields are closer to the longer-term trends at 0.67 tons per hectare and rise modestly to 0.69 tons per hectare by 2015.

Table 5. Baseline crop yield, area and production and CAADP targets and growth rates (national level)

	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	%	%	%
	2004	2005-15	2015	2005-15	2004	2005-15	2015	2005-15	2004	2004	2015	2015
Cereal crops												
Maize	1.42	0.67	2.00	3.47	763	2.84	1,226	4.86	536	46.1	49.6	45.8
Sorghum & millet	0.67	0.19	1.00	4.01	50	3.17	80	4.86	74	6.4	7.4	6.0
Other cereal crops	1.19	0.85	1.74	3.92	121	-3.28	207	5.55	102	8.7	5.0	8.9
Root crops	5.99	0.66	8.98	4.13	957	2.47	1,646	5.57	160	13.7	14.3	13.7
Other food crops												
Pulses & oil crops	0.60	2.04	0.77	2.57	31	-4.25	40	2.67	52	4.4	2.0	3.9
Groundnuts	0.44	0.40	0.64	3.83	36	3.21	62	5.45	82	7.1	8.1	7.2
Vegetables	6.27	1.61	8.57	3.18	199	1.16	331	5.24	32	2.7	2.3	2.9
Fruits	6.35	1.84	7.83	2.12	84	-0.27	123	3.93	13	1.1	0.8	1.2
High-value crops												
Cotton	0.52	1.65	1.09	7.74	41	3.90	108	10.11	80	6.9	7.4	7.4
Sugarcane	60.55	1.36	119.67	7.05	1,453	3.59	3,571	9.41	24	2.1	2.2	2.2
Tobacco	1.08	0.95	2.21	7.42	5	3.17	11	9.78	4	0.4	0.4	0.4
Other crops	2.77	0.76	4.86	5.76	14	2.98	29	8.09	5	0.4	0.5	0.5

Source: Initial yield, area and production estimates are from MACO (2007) and the Food and Agriculture Organization (FAO, 2007). Crop yield targets are based on crop production field trial assessments from the Zambia Agricultural Research Institute (ZARI, 2007).

Since population growth is projected to exceed cereal yield growth, there will be increasing demand for these food crops, encouraging a slightly larger allocation of land towards maize, sorghum and millet. Thus, even though total agricultural grows at 1.2 percent per year, a larger share of land is allocated to cereal crops by 2015.[7] Together, yield increases and land area expansion causes production of these cereal crops to grow at around 2.8 percent per year during 2005-2015.

In contrast, production of other cereals, such as wheat and barley, decline despite stronger yield improvements. This is because the rapid expansion of the mining sector causes a real appreciation of the real exchange rate, which undermines production of these more import-competing cereal crops. Falling import prices for wheat and barley reduces the land allocated to these crops, such that production decreases by 3.3 percent per year. However, the smaller contribution of these crops to agricultural GDP means that their weaker performance has a relatively small effect on overall cereal crop GDP, which grows at an average of 1.8 percent per year in the Baseline scenario (see Table 4). Although cereal production growth is slightly below population growth, net cereal imports rise due to the appreciation of the Kwacha (Kw), which reduces the cost of food imports. Consequently, annual average per capita consumption of cereals increases from 70.9 to 81.2 kilograms by 2015 under the Baseline scenario, despite relatively stagnant per capita production. Zambia will therefore become more reliant on imported cereals under its current growth path.

Although root crops are aggregated in the model, initial yields are based on long-term trends for individual root crops.[8] Based on the recent performance of root crops, we assume that these crop yields will grow as fast as maize yields over the coming decade. Root crop yields in the Baseline scenario grow at 0.66 percent per year (see Table 5). As with maize, sorghum and millet, population growth exceeds the yield growth in root crops, and rising excess demand pressure

[7] Note that crop yields are exogenously imposed on the model, but land and labor allocation are endogenously determined within the model based on the relative 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 each typology (as initially captured in LCMS4).

[8] Initial national average yields are 5.17 tons per hectare for cassava (dry-weight), 9.18 tons per hectare for Irish potatoes, and 14.18 tons per hectare for sweet potatoes. Since these crops are aggregated into a single category in the model, we effectively assume that each individual crop's yield and land area change proportionately.

causes a slight increase in the share of land allocated to root crops, from 13.7 to 14.3 percent.[9] Root crop production is therefore expected to grow at a rate similar to that of cereal crops.

In recent years, the performance of other food crops in Zambia has been mixed. Fruits, pulses and basic oil crops have not performed well in recent years. For example, the production of soybean oil has fallen by an average 14.5 percent per year since 2000, while the production of pulses has grown modestly, at around 0.6 percent per year, and still lies well below its historical production highs of the mid-1990s. Today, around two-thirds of domestic demand for these crops is supplied by imports, and domestic producers will continue to face import competition caused by an appreciated Kwacha. The Baseline scenario reflects the difficulties experienced by these sectors, with production levels declining despite strong yield growth. In contrast, groundnut production has risen since 2000 and this trend is expected to continue under the Baseline scenario, driven primarily by area expansion. Accordingly, the production of groundnuts in the Baseline scenario grows at 3.2 percent per year. Zambia's export crops have performed particularly well since the market reforms of the early 1990s, and more recent trends are equally promising. Cotton production has doubled since 1998, and sugarcane production rose from 1.6 to 2.7 million tons during 2000-2005. The Baseline scenario assumes that export-oriented crops will continue to have higher growth potential than food crops. Cotton is a particularly important agricultural sub-sector for Zambia; it accounts for seven percent of the country's total export earnings and is the largest export earner after copper. Cotton production is expected to grow faster than agriculture as a whole, at 3.9 percent per year (see Table 4). This is still slower than what has been experienced since 2000, but better reflects the reduced export competitiveness caused by the stronger Kwacha, which started to appreciate in 2004-05 and is projected to remain strong due to expanded mining production (Breisinger and Thurlow, 2007).

Livestock is an important agricultural sub-sector, generating 15.2 percent of agricultural GDP in 2004. Although it is difficult to compile reliable time-series data, recent evidence suggests that Zambia's livestock population expanded substantially between 1999/2000 and 2003/04 (Kalinda and Kalinda, 2007). The Baseline scenario assumes that these population trends are indicative of

[9] Although the share of land allocated to root crops increases only slightly, the absolute amount of land allocated to these crops rises from 160,000 to 190,000 hectares in the Baseline scenario, due to total land expansion of 1.2 percent per year.

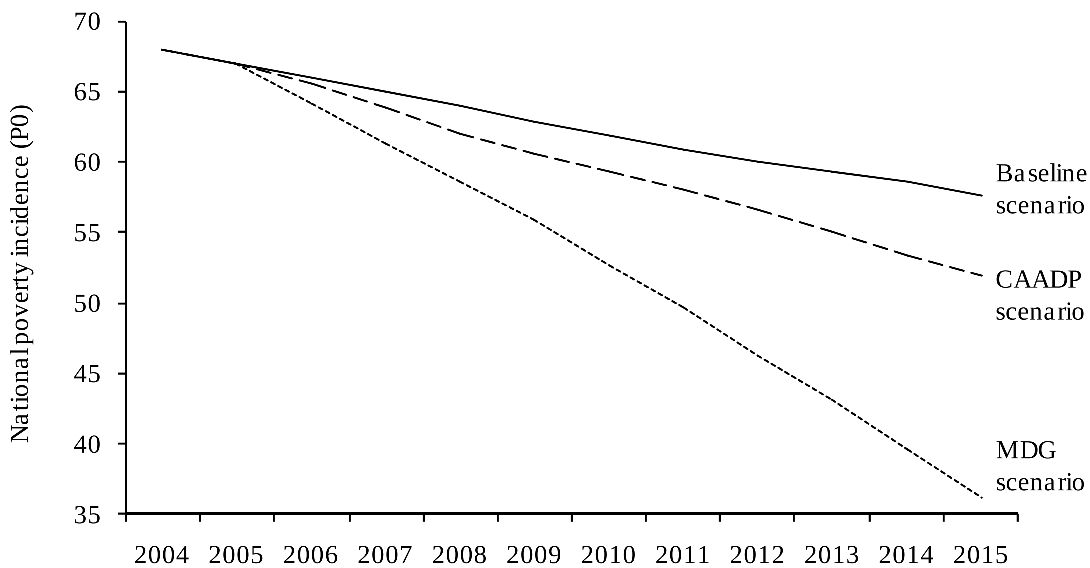
changes in livestock GDP, and will continue. Cattle GDP in the Baseline scenario grows at 4.6 percent per year during 2005-2015, which is higher than the cattle population's annual growth rate of 2.8 percent during 1999/2000-2003/04. The Baseline scenario also assumes faster growth in poultry production than that suggested by recent trends, due to rising urban incomes and the higher income elasticity of poultry. This is supported by observed increases in national poultry consumption from 18,900 tons in 1990 to 36,500 tons in 2002, which implies an annual growth rate of 5.6 percent per year (FAO estimates cited in Kalinda and Kalinda, 2007).

Fisheries and forestry are also important agricultural sub-sectors, together generating 13.5 percent of total agricultural GDP in 2004. The Baseline scenario assumes that fisheries GDP will grow at 3.1 percent per year during 2005-2015. This captures reasonable expectations about Zambia's high potential for aquaculture, which accounts for about 15 percent of fish production, and the offsetting resource constraints facing capture fisheries (Kalinda and Kalinda, 2007). For the forestry sub-sector, the Baseline scenario assumes that value-added in this sub-sector will continue to grow at 3.5 percent per year, which is a relatively modest projection compared to its recent high growth period of 2002-06, when growth rates exceeded 4.5 percent per year (see Table 4).

Drawing on the above trends, the CGE simulation results indicate modest growth in the agricultural sector and more rapid growth in the non-agricultural sectors, and overall national GDP will grow at an average rate of 4.6 percent during 2005-2015. This closely matches the average GDP growth rate of 4.8 percent experienced since 2000. With population growth at two percent per year, per capita GDP grows at 2.6 percent. With rising per capita incomes, the CGE model indicates that poverty will decline modestly from 67.9 percent in 2004 to 57.7 percent in 2015 (Figure 3). This 10.2 percentage point drop in the national poverty rate over 11 years (or 0.72 percentage points per year) is consistent with poverty declines observed during the 1998-2004 period, when poverty fell by around five percentage points over seven years (or 0.71 percentage points per year) under similar GDP growth rates. With such modest poverty reduction and an expanding population, the absolute number of poor people in Zambia would increase from 7.43 million in 2004 to 7.85 million by 2015. Furthermore, stronger growth in the non-agricultural sectors means that national income growth is biased towards urban households.

Accordingly, while urban poverty falls from 52.8 to 36.2 percent by 2015, rural poverty declines from 77.6 to 71.5 percent during the same period under the Baseline scenario. Thus, Zambia must accelerate growth and poverty reduction, especially in rural areas, if the country is to come close to achieving the MDG1 of halving poverty by 2015.

Figure 3. National poverty rate under alternative agricultural growth scenarios



Source: Results from the Zambian CGE-microsimulation model.

IV. 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 Zambia's current growth path on poverty reduction. In this section, we examine the potential contribution of different agricultural sub-sectors in helping Zambia 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 for different parts of the country are taken from field trial estimates made by Zambia's Agricultural Research Institute (ZARI, 2007). However, it is not expected that Zambia will achieve and sustain the highest yields predicted under the more ideal conditions of controlled field trials, nor is Zambia expected to achieve comprehensive improved seed and 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 1.42 and 1.52 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 0.7 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 two tons per hectare by 2015. This is well below the maximum potential yields identified by field trials, which range from three to ten tons per hectare depending on the hybrid seed type and agro-ecological conditions (see Table 6).

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

	Modeled crop yields (mt/ha)				Maximum potential yield ranges from research field trials (mt/ha)
	Initial value 2004	Baseline scenario 2015	CAADP scenario 2015	MDG1 scenario 2015	
Maize					
National	1.42	1.52	2.00	2.57	
Agro-ecological zone 1	1.27	1.32	1.83	2.35	3.0 - 4.5
Agro-ecological zone 2	1.34	1.44	1.86	2.41	3.0 - 10.0
Agro-ecological zone 3	1.47	1.56	2.12	2.72	7.5 - 10.0
Sorghum					
National	0.67	0.69	1.00	1.22	
Agro-ecological zone 1	0.42	0.42	0.63	0.77	2.0 - 10.0
Agro-ecological zone 2	0.58	0.60	0.83	1.03	2.0 - 10.0
Agro-ecological zone 3	0.81	0.83	1.21	1.47	2.0 - 10.0
Rice					
National	1.07	1.16	1.57	1.96	4.0
Groundnuts					
National	0.44	0.46	0.64	0.82	
Agro-ecological zone 1	0.35	0.36	0.52	0.67	0.5 - 1.0
Agro-ecological zone 2	0.46	0.48	0.67	0.86	0.8 - 2.5
Agro-ecological zone 3	0.41	0.43	0.61	0.78	1.0 - 2.5
Cassava					
National	5.17	5.52	7.75	9.87	7.0 - 10.0 (dry weight)
Sweet potato					
National	14.18	15.15	21.25	27.07	27.5 - 37.0

Source: Zambia Agricultural Research Institute (ZARI, 2007) and results from the Zambian CGE-microsimulation model.
Note: National yields include urban agriculture and are therefore not averages of rural zonal yields. Maximum potential yields vary according to improved seed types and agro-ecological zones.

However, although the estimates of the LCMS4 are admittedly conservative, they indicate that it could be difficult for Zambia to achieve a maize yield of two tons per hectare by 2015. The lower-bound estimates of LCMS4 indicate that national hybrid maize yields are only 1.40 tons; this suggests that the government would not only have to improve the distribution of hybrid seeds, but also dramatically improve current farming practices and the distribution of other inputs if it is to help farmers achieve average maize yields of two tons per hectare. Nonetheless, we consider two tons per hectare a reasonable, albeit challenging, maize yield target for 2015. Table 6 provides similar comparisons between modeled and field trial yields for other selected crops. Table 7 shows the eight different scenarios designed for this analysis. In Scenarios 1-7, we target specific groups of crops or agricultural sub-sectors. For instance, in the 'cereal-led growth' scenario, we increase land productivity for the three cereal sectors in the model so as 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. In Scenario 8, 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.

Table 7. Model growth scenarios

	Cereal-led growth 1	Root-led growth 2	Other-food-led growth 3	High-value-led growth 4	Livestock-led growth 5	Fisheries-led growth 6	Forestry-led growth 7	CAADP growth scenario 8
Maize	×							×
Sorghum & millet	×							×
Other cereals	×							×
Root crops		×						×
Pulses & oils			×					×
Groundnuts			×					×
Vegetables			×					×
Fruits			×					×
Cotton				×				×
Sugarcane				×				×
Tobacco				×				×
Other crops				×				×
Cattle					×			×
Poultry					×			×
Other livestock					×			×
Fisheries						×		×
Forestry							×	×

Agriculture's current poor performance means that achieving the CAADP target of six percent agricultural growth poses a substantial challenge. Zambia will need to more than double its existing agricultural growth rate of 2.5 percent per year. However, based on the crop yield and agricultural productivity potentials identified at the sub-sectoral level, the CGE model indicates that Zambia would be able to reach an average 6.09 percent agricultural growth during 2005-2015, thereby meeting the CAADP target (see Table 4). Since agriculture accounts for about one-fifth of the Zambian economy, this acceleration of agricultural growth would raise the national GDP growth rate from its current 4.6 percent to 5.3 percent per year during 2005-2015 (see Table 4). Faster agricultural growth will also stimulate additional growth in the non-agricultural sectors, by raising final demand for non-agricultural goods, lowering input prices, and fostering upstream processing. For instance, under the CAADP growth scenario, the GDP growth rate of the processing sectors would increase from 3.9 percent under the Baseline scenario to 4.8 percent per year. Increased agriculture will also generate additional demand for chemicals and transport services, which further stimulates growth in the rest of the manufacturing and service sectors. Achieving the CAADP agricultural growth target will therefore have strong economy-wide growth-linkage effects for non-agriculture.

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 5.75 percentage points. This is shown in Figure 3, which indicates that the share of Zambia's population under the poverty line is 51.9 percent by 2015 under the CAADP scenario compared to 57.7 percent under the Baseline scenario. Thus, taking population growth into account, achieving the CAADP growth target will lift an additional 780,000 people above the poverty line by 2015, and would be sufficient to reverse current trends by reducing the absolute number of poor people in Zambia by 2015. Food security would also improve, with annual average per capita cereal consumption rising from 81.2 kilograms under the Baseline scenario to 93.1 kilograms by 2015 under the CAADP scenario. Furthermore, while Zambia's dependence on imported cereals will not be eliminated, accelerated growth under the CAADP scenario will substantially reduce the country's trade deficit for food crops.

Table 8. Income growth and poverty reduction in the model

		Initial value	Annual growth under…		Additional growth rate
			Baseline scenario	CAADP scenario	
		2004	2005-15	2005-15	2005-15
Part 1: Production	Real value of production (Kw billion)				
	National	5,979	2.27	6.01	3.73
	Rural	5,617	2.31	6.10	3.79
	Small-scale farms	3,977	2.09	6.00	3.91
	T1: High-value crops	1,606	2.58	7.35	4.77
	T2: Maize only	693	1.61	4.62	3.00
	T3: Maize & other foods	614	1.85	4.88	3.03
	T4: Maize & roots only	172	1.79	5.23	3.44
	T5: Maize, roots & other foods	594	1.68	5.23	3.55
	T6: Roots only	97	1.86	5.36	3.50
	T7: Roots & other foods	201	1.90	5.43	3.54
	T9: Larger-scale farms	1,639	2.84	6.34	3.49
	T8: Urban farms	362	1.65	4.47	2.82
Part 2: Incomes	Per capita incomes (Kw thousand)				
	National	1,860	1.90	3.92	2.02
	Urban	3,445	2.12	4.08	1.95
	Farm	2,788	1.53	3.58	2.05
	Non-farm	3,703	2.29	4.22	1.93
	Rural	832	1.28	3.48	2.20
	Zone1	1,128	1.21	3.77	2.56
	Zone2a	754	1.02	3.78	2.75
	Zone2b	634	1.11	3.19	2.08
	Zone3	652	1.32	2.82	1.50
	Non-farm	1,626	1.71	3.75	2.04
		Initial poverty rate	Final poverty rate under…		Additional poverty reduction
			Baseline scenario	CAADP scenario	
		2004	2015	2015	2015
Part 3: Poverty	Poverty incidence (%)				
	National	67.92	57.67	51.92	-5.75
	Urban	52.83	36.24	31.46	-4.79
	Farm	64.83	51.51	45.19	-6.32
	Non-farm	48.26	30.42	26.22	-4.20
	Rural	77.63	71.47	65.09	-6.38
	Zone1	76.84	69.08	64.01	-5.07
	Zone2a	77.31	71.85	63.80	-8.05
	Zone2b	85.14	82.26	76.40	-5.86
	Zone3	77.65	71.59	66.04	-5.55
	Non-farm	74.74	65.03	60.51	-4.52

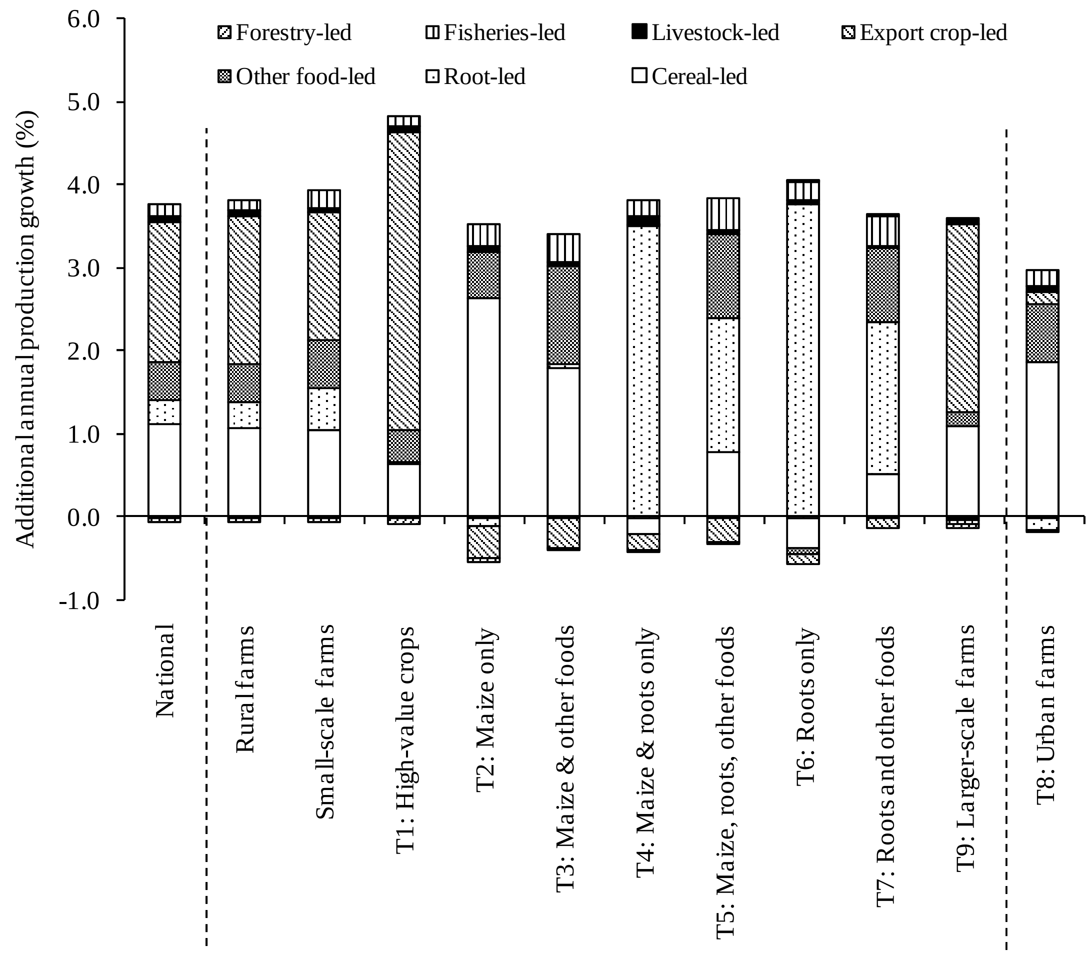
Source: Results from the Zambian CGE-microsimulation model. 'T' refers to farm type (see Figure 2 and Table 2).

Faster agricultural growth benefits a majority of households. However, not all households will 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 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 the expansion of export crops, whose GDP growth rises from 3.2 to 9.1 percent per year (see Table 4). Since rural farmers with better market access and more favorable agro-ecological conditions can more readily grow higher-value crops, this group will benefit the most under the CAADP scenario. As seen in Table 8, the value of total farm production for ' high-value crops' (T1) increases by 4.8 percentage points (from 2.6 percent per year under the Baseline scenario to 7.4 percent under the CAADP scenario).

As indicated in Tables 2 and 3, higher-value crops are typically grown on larger-scale farms and maize is a particularly important crop for urban households. As such, larger-scale and urban farms benefit more from additional maize and high-value crop production under the CAADP scenario. This can be seen in Figure 4, which shows the contribution of growth in different sub-sectors to changes in the value of production for different farm types. The figure also highlights the importance of export crop-led growth in determining production growth for certain farm types. Export crops generate one-third of additional production at the national level and most of the production growth for farmers growing high-value crops (i.e., T1 and T9).

With the exception of export crop producers, most small-scale farms benefit equally under the CAADP scenario. However, despite this even distribution of benefits, Figure 4 indicates that the sources of additional production vary dramatically across farm types. Not surprisingly, households that are more dependent on maize and root crops tend to benefit more from cereal- and root crop-led growth, respectively. However, there are two forces driving changes in overall production: *direct* and *indirect* effects of sub-sector-specific yield improvements. First, increasing yield has a direct effect on farm incomes, 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 therefore assumes that land allocations remain fixed. However, farmers may reallocate land in response to changes in relative prices, meaning that the *indirect* impact of crop yield improvement is the potentially positive impact of reallocating land to other crops. The CGE model captures both the direct and the indirect effects.

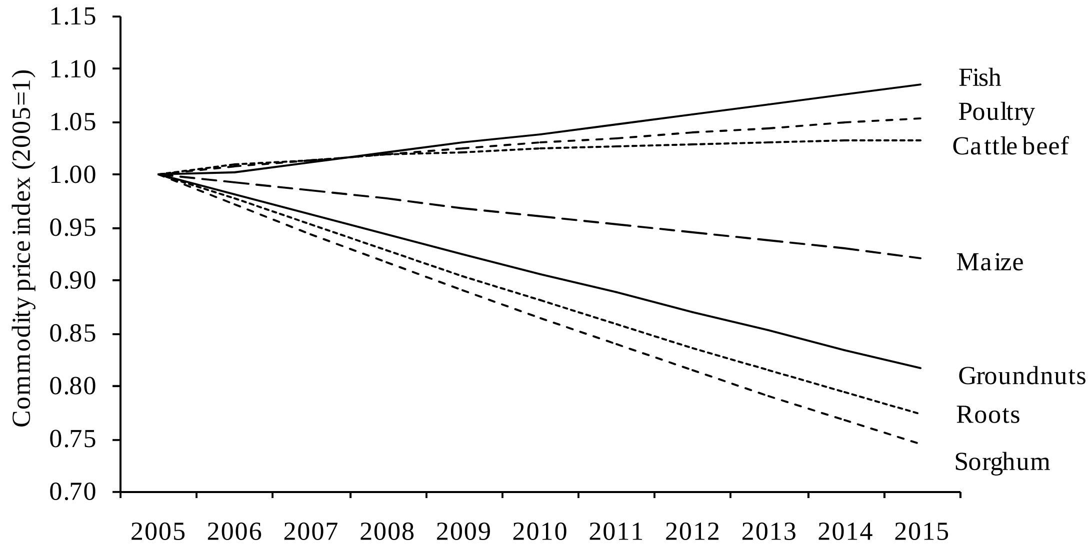
Figure 4. Sources of additional production growth by farm type



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

Figure 5 shows the importance of accounting for demand constraints and relative price changes. Root crops and sorghum/millet have lower income elasticities (0.6 and 0.4, respectively) and relatively weak linkages to upstream food processing. As such, these crops face more stringent demand constraints to increasing their production, and this causes their prices to decline the most under the CAADP scenario. Maize's slightly higher income elasticity (0.8) and its stronger linkages to the animal feed and food processing sectors means that, while maize prices do decline under the CAADP scenario, they fall by less than for root crops and sorghum/millet. Finally, the higher income elasticity of livestock and poultry (1.3), and also of fish, means that demand for these commodities grows more rapidly than do incomes, thereby preventing prices from falling under the CAADP scenario.

Figure 5. Relative producer price changes under the CAADP scenario



Source: Results from the Zambian CGE-microsimulation model.

For the crop sectors, relative price changes cause the different representative farmer types in the model to reallocate their land in order to maximize farm incomes. This can be seen in Table 9, which shows the percentage change in land allocated to different crops for selected farm types. While all food crop prices fall under the CAADP scenario, they do not fall to the same extent. The larger price declines for roots and sorghum/millet cause farmers to reduce the land allocated to these crops and increase land allocated to maize, which does not show as sharp a price decline. For example, farmers falling in the 'maize, roots and other foods' group (T5) decrease the amount of land allocated to sorghum and millet by 14.1 percent in the CAADP scenario, while increasing the amount of land allocated to maize by 15.1 percent. Therefore, the benefits of increased root crop yields are not only increased root crop production (a direct effect), but also the reallocation of crop land to maize and horticulture (an indirect effect). Thus, it is important to note that while Figure 4 indicates the importance of root-crop-led growth in raising farm incomes for small-scale farmers, some of the gains under this growth scenario are derived from diversification into other higher-value crops that face better demand conditions.

Table 9. Changes in producer prices and land allocations for selected farm types

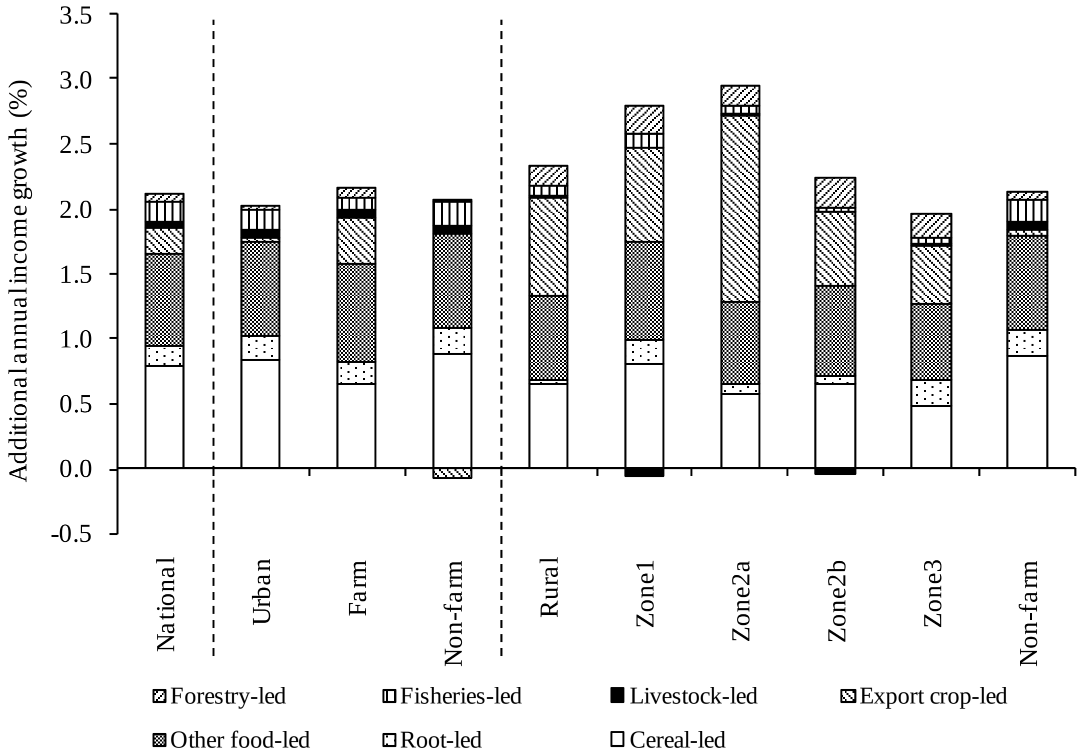
	Relative producer price index in 2015	Percentage change in land allocated to crops under CAADP scenario (%)			
		High value crops T1	Maize & other foods T3	Maize, roots, other foods T5	Roots & other foods T7
Maize	0.92	1.6	0.6	15.1	
Sorghum & millet	0.74	-28.3	-30.9	-14.1	-7.0
Other cereals	0.89		127.3	175.8	113.3
Root crops	0.77	-21.1		-6.0	-1.4
Pulses & oil crops	0.98	140.1	121.5	174.1	
Groundnuts	0.82	-15.8	-17.8	-3.1	-0.1
Fruits & vegetables	0.95	36.7	31.6	53.3	

Note: Relative producer price index is final price in 2015 under CAADP scenario divided by final price in 2015 under Baseline scenario.

Finally, the CGE model takes into account potential competition over limited agricultural resources. For example, a number of small-scale farm types appear to be hurt by export crop-led growth (see Figure 4), which reflects a shift in resources towards the production of export crops. The CGE model captures how the increased growth potential for higher-value crops causes farm labor and capital to shift towards the production of these crops, causing their production by other farm types to decline. However, these resource reallocations or indirect effects from export crop-led growth are relatively small and the model results indicate that rural and small-scale farms still stand to benefit greatly from increasing agricultural growth to the six percent CAADP target.

The model results also indicate that small-scale rural farmers benefit by at least as much as urban households under the CAADP growth scenario. This can be seen in Table 8, which shows that per capita household incomes for rural households grow by an additional 2.2 percentage points per year compared to 1.95 percentage points for urban households. This is reflected in changes in poverty; rural poverty declines by an additional 6.4 percent, while urban poverty declines by 4.8 percentage points (see Part 3 of Table 8). Therefore, accelerating agricultural growth under the CAADP scenario not only increases poverty reduction in both urban and rural areas, it also helps correct some of the urban bias in Zambia’s current growth path. However, this is driven by strong rural income growth in certain parts of the country. Household incomes in Zones 1 and 2a grow by an additional 2.6 and 2.8 percentage points, compared to 2.1 and 1.5 percentage points for households in Zones 2b and 3. These differences in household outcomes can be explained by considering the sources of income growth across the household groups.

Figure 6. Sources of additional per capita income growth by household group



Source: Results from the Zambian CGE-microsimulation model.
Note: Figure shows income growth over and above that achieved under the Baseline scenario. Since population growth remains unchanged in the CAADP scenario, it does not influence relative gains across household groups.

Figure 6 shows that additional household incomes in Zones 1 and 2a are driven by growth in export-oriented crops. This is especially true for households in Zone 2a, where more than half of the additional incomes come from export crop-led growth. This is because households in Zones 1 and 2a have better access to markets, major transport routes and urban centers, and are thus better positioned to benefit from export-led growth. In contrast, households in the northern Zone 3 benefit more from growth in root crops. This is not surprising given the importance of these crops for farmers in this region (see Tables 2 and 3).

In summary, the CGE model results indicate that it is possible for Zambia 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 in all crops and sub-sectors; Zambia cannot rely on only maize or higher-value export crops to achieve the aggregate agricultural growth targets. If the above-described 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 specific export crops and better market conditions in certain parts of the country may cause uneven income growth and poverty reduction. Finally, the fisheries and livestock sub-sectors will need to contribute significantly 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 different crops and sub-sectors in increasing agricultural growth and poverty reduction. However, the different sizes of these sub-sectors make it difficult for us 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. In this section, we calculate poverty-growth elasticities that allow us to compare the 'pro-poorness' of growth in the various 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, due to differences in household and farm characteristics, changes in income and consumption across households can differ considerably from average changes at the national level. Thus, in order to capture growth-poverty linkages, we need to understand the changes in income distributions, which are primarily determined by a country's initial conditions. In the previous section, we saw that households in Zone 2a have better opportunities to produce higher-value export commodities, and are thus better positioned to benefit from export agriculture. However, per capita incomes are low for households in this agro-ecological zone (see Table 8) and export crop-producing households are typically less poor than other rural households. Thus, agricultural growth driven by export crops may have less of an impact on poverty, especially amongst the poorest households. In contrast, food crops tend to be a more important source of agricultural incomes for poorer 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 10 shows the calculated poverty-growth elasticities under the different growth scenarios. The results indicate that agricultural growth driven by growth in root crops or cereals is more effective at reducing poverty than growth in other sub-sectors. For example, a one percent increase in maize GDP causes the national poverty headcount rate (P0) to decline by 0.27 percent, while growth in other cereals, such as wheat and barley, causes the poverty rate to decline by 0.18 percent. This emphasizes the importance of maize for poorer households in Zambia, both as a source of income and as an item in their consumption baskets. Root crops are particularly effective at reducing the severity of poverty amongst Zambia's poorest households, as reflected in the higher poverty gap (P1) and squared-gap (P2) elasticities. The importance of the food crops in reducing urban poverty is also shown in the table. For instance, the national elasticity for maize-led growth is higher than the rural elasticity, meaning that the elasticity is higher in urban than in rural areas. This is because maize growth reduces urban poverty by reducing urban food prices. The reverse is true for export crops, which are less effective at reducing urban poverty since they lack the linkage to consumption.

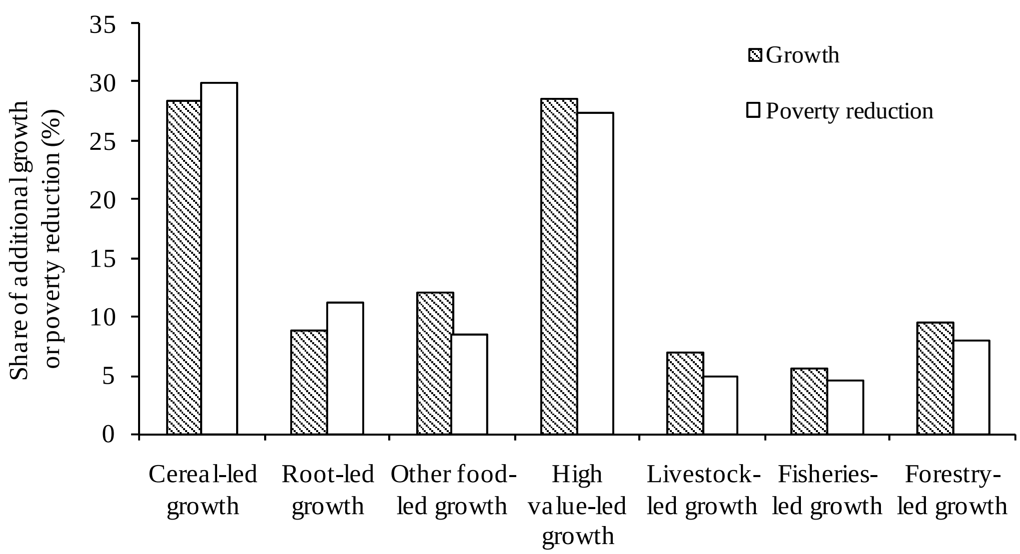
An alternative representation of poverty-growth linkages is shown in Figure 7, which compares each sectoral-based scenario's contribution to agricultural growth and poverty reduction. The higher-than-average poverty-growth elasticities of maize- and root-led growth can be seen in the fact that these sectors contribute more to poverty reduction than agricultural growth under the CAADP scenario. However, Zambia should not overly rely on poverty-growth elasticities when designing its growth strategy, since having a high elasticity can be meaningless if a sector has poor growth prospects. Thus, even though export crops have lower poverty-growth elasticities, the rapid growth of these sectors means that they account for a large share of overall poverty reduction under the CAADP scenario. 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, even though the root crop sector has a higher growth rate and poverty-growth elasticity than cereals, the small size of the root crop sector limits its ability to substantially raise national agricultural GDP.

Table 10. Poverty-reduction-growth elasticities under the various agricultural growth scenarios

	Percentage change in poverty rate caused by 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
CAADP growth scenario	-0.288	-0.444	-0.536	-0.258	-0.443	-0.540
Cereal-led growth	-0.271	-0.378	-0.451	-0.180	-0.332	-0.416
Root-led growth	-0.332	-0.540	-0.653	-0.261	-0.512	-0.638
Other food-led growth	-0.184	-0.307	-0.376	-0.154	-0.296	-0.372
High-value-led growth	-0.247	-0.473	-0.601	-0.287	-0.547	-0.674
Livestock-led growth	-0.185	-0.201	-0.214	-0.076	-0.106	-0.130
Fisheries-led growth	-0.213	-0.286	-0.320	-0.128	-0.205	-0.253
Forestry-led growth	-0.217	-0.332	-0.414	-0.210	-0.347	-0.432

Source: Results from the Zambian CGE-microsimulation model.

Figure 7. Share of additional growth and poverty reduction for CAADP scenarios by sector



Source: Results from the Zambian CGE-microsimulation model.

Finally, proponents of agriculture often cite the sector's strong linkages to the rest of the economy as justification for promoting agricultural growth (Diao et al., 2007). Table 11 measures agriculture's growth-linkage effects at the sub-sector level. For example, the cereal-led growth scenario causes agricultural GDP to increase by Kw746 billion. However, total GDP increases by more than this amount due to backward and forward production and consumption linkages. 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 Kw1217 billion, which means that for every one Kwacha increase in agricultural GDP driven by cereal-led growth, there is an additional 0.63 Kwacha increase in non-agricultural GDP (a growth-linkage ratio of 1.63). Comparing these ratios across model scenarios suggests that even through fisheries-led growth contributes less to agricultural growth under the CAADP scenario (see Figure 7), it is more effective at stimulating non-agricultural growth compared to export crop-led growth. The latter has poor growth-linkages because most export crops are exported directly as raw agricultural materials rather than contributing to upstream production. Furthermore, by rapidly increasing export growth, the export crops also increase the appreciation of the real exchange rate, which reduces non-agricultural exports. Thus, the linkage ratio for export crops is less than one and its overall impact on national GDP is similar to that of fisheries.

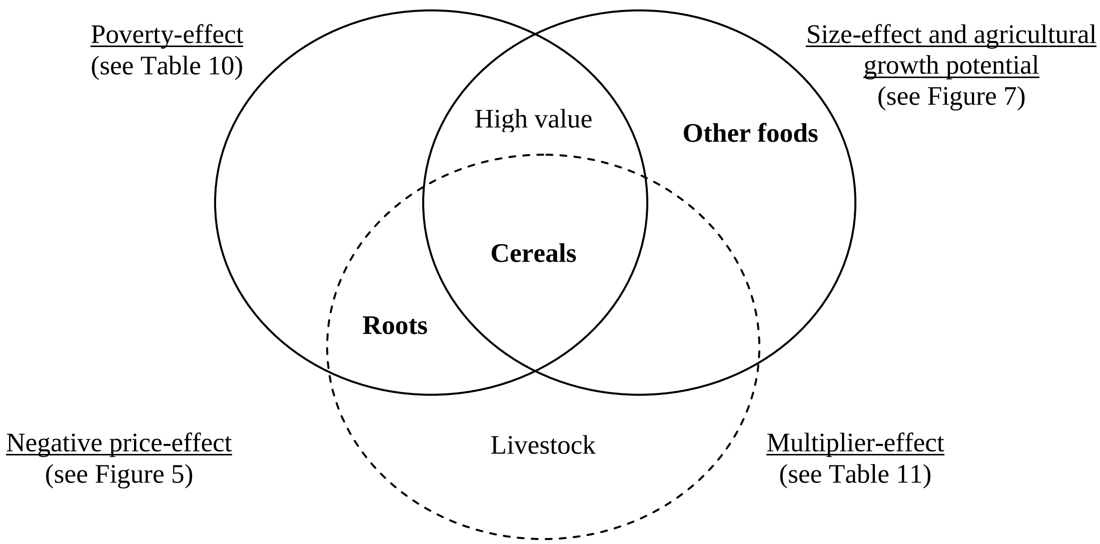
Table 11. Agriculture's economy-wide growth-linkage effect

	Sector's initial value-added	Sectoral growth rates (%)		Additional GDP relative to baseline (Kw 2004 bil)		Economy-wide growth-linkage ratio
		Baseline scenario	Sector scenario	Total GDP	Agricultural GDP	
	2004	2005-15	2005-15	2015	2015	
				(1)	(2)	(1) / (2)
Cereal-led	1,307	1.78	4.46	1,217	746	1.63
Root-led	444	2.08	4.30	419	223	1.88
Other food-led	895	0.84	3.01	397	306	1.30
Export crop-led	818	3.20	8.86	223	751	0.30
Livestock-led	740	4.26	5.39	308	176	1.75
Fisheries-led	282	3.12	3.95	227	141	1.62
Forestry-led	374	3.46	7.56	146	241	0.61

Source: Results from the Zambian CGE-microsimulation model.

In this section, we have considered four dimensions to understanding the potential contribution of individual crops in 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., price-effect). Based on these considerations, it is possible to rank the sub-sectors. In Figure 8 we identify the top three sub-sectors under each of the four considerations listed above.

Figure 8. Comparing crops across different effects



	Simple ranking of sub-sectors			
	Poverty-effect	Size-effect	Multiplier effect	Price-effect
Cereal-led	2	2	3	6
Root-led	1	5	1	7
Other food-led	7	3	5	5
High-value-led	3	1	7	1
Livestock-led	6	6	2	2
Fisheries-led	5	7	4	3
Forestry-led	4	4	6	4

Source: Results from the Zambian CGE-microsimulation model. The items in bold letters are the ones facing market constraints.

The three sub-sectors with the highest poverty-growth elasticities are cereals, roots and high-value export-oriented crops. These are placed inside the circle labeled 'poverty-effect' in Figure 8. Similarly, the three sectors that contribute the most to overall agricultural growth are cereals, high-value crops, and other food crops. The ranking of size-effects is contingent on the appropriateness of the target crop yields shown in Table 6. Based on their growth potentials, the three sub-sectors are placed inside the 'size-effect' circle in Figure 8. Since cereals and high-value crops are in the top three sub-sectors under both criteria, they fall into the intersection of the 'poverty-effect' and 'size-effect' circles. We also consider each sub-sector's multiplier effects, and identify cereals, livestock and roots as being pertinent to this effect. 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 are identified as having growth potential and strong size-effects, these crops also face considerable market constraints, leading to large price declines in the face of production increases. In Figure 8, we highlight in bold the three commodities facing the largest market constraints. This clearly shows that in order to realize the growth and poverty-reducing potential of the prioritized food crops, it would be necessary to improve market conditions, for example 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 8.

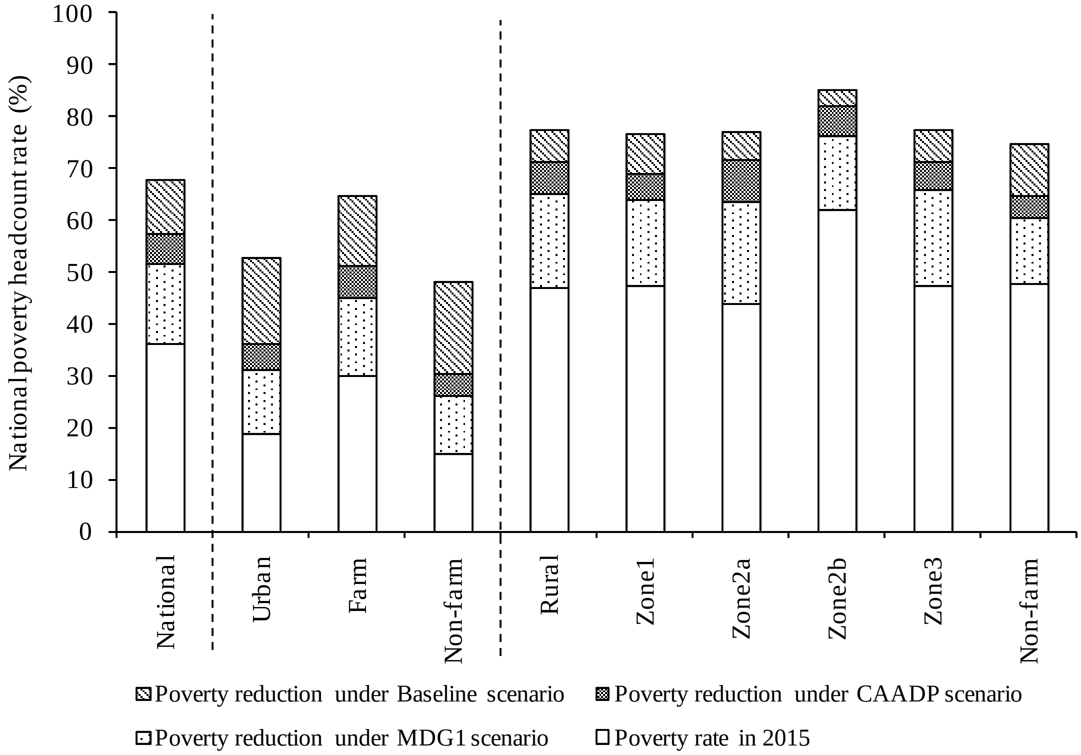
The previous section concluded that in order to substantially increase agricultural growth and reach the CAADP growth target, Zambia will have to encourage growth in most of its agricultural sub-sectors. However, the poverty-growth elasticities, sectoral growth potentials, and size- and linkage-effects presented in this section suggest that high priority should be given to improving cereal yields and encouraging higher-value export-oriented crops. Later in this study, we will examine the level of public investments required to increase agricultural growth.

V. Meeting the first Millennium Development Goal

Although achieving six percent agricultural growth under the CAADP initiative will significantly reduce poverty, the projected reductions will fall far short of the first Millennium Development Goal (MDG1) of halving the national poverty rate by 2015. Targeted growth in some agricultural sub-sectors and modest growth in others will not generate sufficient poverty reduction. While the CAADP growth scenario is already ambitious, Table 6 indicates that crop yields will remain below the maximum potential yields identified by research field trials. Furthermore, we have so far assumed that additional growth in Zambia will be targeted through the agricultural sector, without explicitly modeling accelerated growth in the non-agricultural sectors. In this section, we model a more ambitious growth scenario in which the agricultural sector comes closer to achieving its maximum yield targets, accompanied by far more rapid growth in the non-agricultural sectors. The modeled crop yield targets for the MDG1 scenario are shown in the fourth column of Table 6. For many crops, such as cassava, sweet potatoes and groundnuts, the MDG1 scenario is equivalent to meeting maximum potentials. While maize yields remain below the high potentials identified by ZARI, the MDG1 scenario is still equivalent to matching South Africa's dry-land maize yields of 2.8 tons per hectare. Finally, sorghum and rice yields remain below both Zambia's yield potentials and South Africa's current yields. Thus, the MDG1 scenario is ambitious, not only because of the necessary target yields, but also because there is little time remaining before 2015 to achieve these targets.

The model results indicate that if Zambia achieves the more ambitious yield targets outlined above, agriculture will reach an average annual growth rate of 9.2 percent per year during 2005-2015. However, such rapid agricultural growth is still insufficient if Zambia is to achieve MDG1. In total, national GDP would need to be sustained at 9.8 percent per year over the coming decade, implying that non-agricultural GDP would need to grow at ten percent per year. As shown in Figure 9, under a balanced annual GDP growth rate of about ten percent, the national poverty headcount rate would be reduced from 67.9 percent in 2004 to 36.1 percent in 2015, which is close to the MDG1 target. However, the CGE model results also indicate that, even if the MDG1 poverty target were achieved, poverty would still remain high amongst certain household groups, especially in rural areas. For instance, poverty amongst households in Zone 2b would decline by only one-quarter, which is well below the MDG1 target. By contrast, poverty amongst urban non-farm households would decline by two-thirds. This is because, while urban households benefit from agriculture's growth linkages, the linkage effects from more urban-based non-agriculture to rural households are far weaker (Thurlow and Wobst, 2006). This highlights the importance of the designing targeted pro-poor interventions and increasing investment in the agricultural sector.

Figure 9. Additional poverty reduction under the Millennium Development Goal scenario



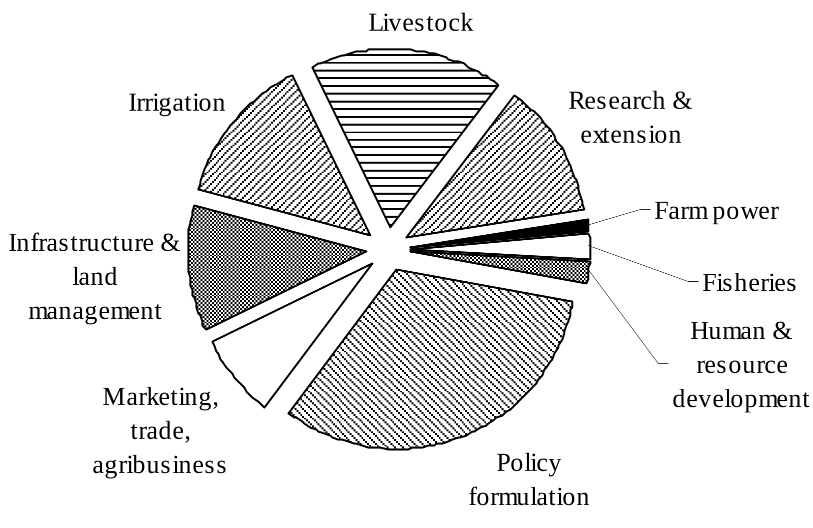
Source: Results from the Zambian CGE-microsimulation model.

VI. Agricultural spending required for the CAADP growth and poverty targets

Achieving the agricultural growth needed to meet both CAADP and the first MDG will be challenging. In addition to an improved policy environment, public investment will be instrumental, not only in improving public services and their provision, but also in attracting private investment and inputs. This raises a number of key questions for the government such as: What kinds of public investments are needed to achieve Zambia's stated growth and poverty reduction objectives? How should 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), in order to improve distributed outcomes and impacts? And finally, how can investments be financed? In this section, we consider the public agriculture expenditure (PAE) required to achieve the growth targets described in the previous sections.

The CGE modeling analysis indicated that Zambia's agricultural sector could grow at six percent per year over the next decade if certain crop- and other sub-sector-level growth targets can be achieved. To promote agricultural growth and poverty reduction in Zambia in general, the Government of Zambia is committed to increasing its investment in agriculture, and has already implemented a number of agricultural development programs. For example, under the FNDP, investment programs valued at Kw4069 billion are planned for the 2006-2010 period (measured in 2004 prices). These include broader investments in research and extension, markets, rural infrastructure, and human and natural resource development, as well as additional spending in livestock and fisheries (see Figure 10).

Figure 10. Expected allocation of public agriculture expenditure under Zambia's FNDP



Notes: Total expected resource envelope is 4,069 billion (2004 Kw).

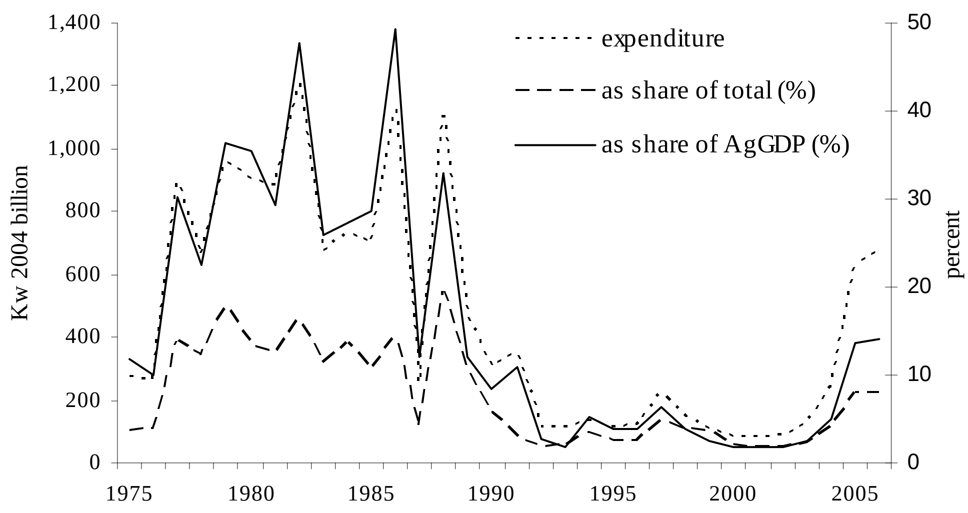
While these interventions and investments will provide a better foundation for achieving higher agricultural growth, it is yet unclear whether the planned investments will be sufficient to meet the desired growth and poverty-reduction targets. We need detailed information on the rates of return to such types of public investment; however, these data are limited for Zambia. Thus, we use results from cross-country econometric analysis and other research to assess the aggregate

PAE required to reach the CAADP and MDG1 growth targets. First, though, we examine recent trends in PAE to establish a baseline scenario for the required spending.

Trends in public agriculture expenditure

Government financial statistics from the International Monetary Fund (IMF, 2007) and the Government of Zambia (CSO, 2007b) show that the share of public resources allocated to the agricultural sector up until the early 1990s was very erratic and generally declining (see Figure 11). Following a period of stagnation thereafter, it began rising towards the mid-2000s, and has only recently reached the levels achieved in the early 1980s. As shown in Figure 10 and Table 12, the share of PAE in total government expenditure currently stands around eight percent, which is high compared to that in many African countries (AU, 2006). However, a review of the government's agricultural spending indicates that nearly 50 percent of recent resources earmarked for the sector have been allocated to poverty reduction programs. Of this pool, 80 percent has been spent on the Fertilizer Support Program (FSP) and operations of the Food Reserve Agency (FRA) (Govereh et al., 2006). In contrast, spending on agricultural infrastructure, research, and extension programs has fallen dramatically between 1975 and 2005 (IMF, 2007; IFPRI, 2007).

Figure 11. Government spending on agriculture in Zambia



Source: Government Finance Statistics (IMF and Government of Zambia).

Table 12. Government spending on agricultural and non-agricultural sectors in Zambia, 1975-2006

	1975	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005	2006
Expenditure (Billion 2004 Kw)												
Total	7712	6743	6548	5503	4690	3987	4602	4701	5633	5842	7886	8386
Agriculture	275	904	699	308	117	82	84	87	128	240	627	674
Non-agriculture	7437	5840	5849	5195	4572	3905	4518	4615	5505	5602	7259	7712
Expenditure shares (%)												
Agriculture in total expenditure	3.6	13.4	10.7	5.6	2.5	2.1	1.8	1.8	2.3	4.1	8.0	8.0
Agriculture in agricultural GDP	13.0	42.3	28.9	11.3	3.4	2.2	2.3	2.4	3.4	6.2	16.2	16.8
Non-agriculture in non-agricultural GDP	47.2	36.4	36.1	29.7	29.8	21.9	23.8	23.3	26.4	25.4	31.0	31.1
Total expenditure in total GDP	43.2	37.1	35.1	27.3	24.9	18.5	20.3	20.1	22.9	22.5	28.9	29.1

Sources: World development Indicators (World Bank, 2007); Government Finance Statistics (IMF and Government of Zambia); African Economic Outlook on Zambia (AfDB/OECD, 2007).

Estimated spending required for agricultural growth

Methods and data

In order to determine how much public agricultural spending is required to achieve the CAADP and MDG1 growth targets, we need to know the annual growth rate in agricultural expenditure ($\dot{E}_{agexp}$) needed to achieve a particular growth rate in agriculture (θ_{ag}). This can be expressed as:[10]

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

where ε_{agexp} and ε_{nagexp} are the 'agricultural growth-agricultural expenditure elasticity' and the 'agricultural growth-non-agricultural expenditure elasticity,' respectively; $\dot{E}_{nagexp}$ is the annual growth rate in non-agricultural expenditure; $_{nag,ag}$ 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 shares of agriculture and non-agriculture in GDP, respectively. These parameters (i.e. ε_{agexp}, ε_{nagexp}, and $_{nag,ag}$) can be estimated econometrically using historical data on different types of public investment, private investment, and agricultural production (for example, see Fan et al. 2000 and 2004). The main concept underlying such econometric estimation is that public and private capital complements one another, meaning that an increase in the public capital stock raises 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 as well as for non-farm rural development (e.g. in food processing and marketing, transportation and trade, restaurant services, electronic repair shops, etc.), and for urban industrial 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 investment in rural

[10] See Appendix B and Fan et al. (2008, forthcoming) for details.

areas directly creates non-farm rural employment opportunities, directly improving rural wages and incomes and reducing rural poverty.

Due to the limited availability of data for undertaking an econometric analysis specific for Zambia, we use results from previous studies (Fan and Rao 2003; Fan et al. 2004) and a cross-country regression analysis estimated for this purpose. This analysis estimates the returns to government spending in agriculture, education, health, transport and communications on agricultural GDP, using a simultaneous equations framework and panel data from 1975 to 2004 on 13 countries in sub-Saharan Africa (Benin et al. 2007).[11] The estimated agricultural growth-expenditure elasticity is 0.15, which means that every one percent increase in total agricultural spending generates 0.15 percent growth in agricultural GDP. This compares favorably with sector elasticities estimated in other countries, including, for example, elasticity with respect to agricultural development expenditure in Rwanda (0.17; Diao et al., 2007), agricultural research and extension in the US (0.11-0.19; Huffman and Evenson, 2006), and agricultural research in Uganda (0.19; Fan et al., 2004). However, the elasticity estimated herein is lower than some of those estimated in other studies, such as the elasticity with respect to agricultural research in India (0.25; Fan et al., 2000), and that for agriculture development expenditure in Africa (0.36; Fan and Rao 2003). This suggests that our estimated agricultural growth-agricultural expenditure elasticity of 0.15 may reflect a low spending efficiency. Thus, in addition to using the estimated elasticity of 0.15 in the simulations, we also use the upper-end value obtained from constructing a 95 percent confidence interval on the estimated value, in order to obtain a more optimistic spending efficiency scenario. The elasticity associated with this is 0.3, which is close to the estimates obtained by Fan and others for India and Africa as a whole (Fan et al., 2000; Fan and Rao 2003).

To obtain the agricultural growth-non agricultural expenditure elasticity (ε_{nagexp}), we use the results of Fan et al. (2004) on Uganda, where the authors estimated the effect on agricultural production of different types of public capital stock including: feeder roads (estimated productivity coefficient of 0.14), education (0.33), and health (0.46). Due to limited historical

[11] The 13 countries are Botswana, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Kenya, Malawi, Mali, Nigeria, Togo, Uganda, Zambia and Zimbabwe.

data on actual expenditures, the authors did not estimate the public capital-expenditure elasticity necessary to obtain the agricultural growth-non-agricultural expenditure elasticity. Several studies on other countries, including some by Fan and his colleagues, show that these public capital-expenditure elasticities typically lie in the lower range of zero to one. We therefore assume an elasticity of 0.5 across the board, which when multiplied by the above productivity coefficients gives the estimated agricultural growth-non-agricultural expenditure elasticity for feeder roads (0.07), education (0.15) and health (0.23).

Regarding the multiplier effect or linkage (trade-offs and complementarities) between agriculture and non-agricultural expenditure ($_{nag,ag}$), we were unable to obtain any reliable estimates. For simplicity, we assume that it is zero, noting that both positive and negative are possible; in this case, a positive sign indicates complementarity and a negative sign indicates trade offs. Non-agricultural; expenditure is treated as exogenous, and historical data from 1991 are used to calculate the annual growth rate (i.e. $\dot{E}_{nagexp}$), which is about 2.2 percent per year. The year 1991 is used as the cut-off point in order to use a period of relatively predictable spending, compared to the highly erratic nature of expenditure prior to 1991 (see Figure 11). Similarly, historical data on GDP are used to calculate the shares of agriculture and non-agriculture in GDP, which are 0.22 and 0.78, respectively.

It is important to note 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 returns to public investments in extension and research in India's agriculture sector decline over time, the returns to public investments in irrigation increase over time due mostly to substantial increments in private investment in irrigation. They also found that the returns to education were greater in the post-Green Revolution period than before or during the Green Revolution period. However, the prior study used data over a 30-year period. The present report looks forward over a relatively short period of time (ten years from 2005 to 2015), so we assume that the above parameters remain unchanged over the simulation period.

Scenarios

To estimate the PAE requirements, we simulate four scenarios. The first one is the Baseline scenario, where we assume that PAE and non-agricultural spending continue to grow according to their respective recent trends, at 8.4 and 2.2 percent per year during the 2004-2015 period. For the starting point of our simulations, we use the annual average government expenditures between 2000 and 2004, which are Kw 124.1 and 4953.2 billion for PAE and total expenditure, respectively. The results of the simulation reveal that the share of PAE in total expenditure will rise from the starting point of 2.5 percent to 3.5 percent in 2010 and 4.5 percent in 2015 (see Table 13), since PAE grows more rapidly than total spending.

The objective of the other three scenarios is to assess the aggregate PAE required to support the acceleration in agricultural growth necessary to meet the CAADP and MDG1 targets, as calculated using the CGE model. The three scenarios are: (i) we assume that agricultural growth will be supported by an increase in PAE alone, without taking into account the effect of non-agricultural expenditure on agricultural growth, which continues to grow at the baseline rate of 2.2 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 at 2.2 percent per year; and (iii) we simulate a doubling in non-agricultural expenditure growth, which is in proportion to the increase in this sector's GDP growth rate between the baseline rate (five percent) and the rate under the MDG growth path in the CGE model (ten percent; see Table 13). The second and third scenarios are more realistic in terms of the inter-sectoral linkages in the economy and recent increase (or pledges to do so) in resources and development assistance for African agriculture. The assumptions regarding the various parameters, however, can be improved upon when data availability allows us to estimate them specifically for Zambia.

PAE requirements for achieving CAADP target growth

In achieving the CAADP target, agricultural growth more than doubles from the baseline value of 2.5 to 6.1 percent per year during 2004-2015, while non-agricultural GDP growth increases marginally from 5.0 to 5.1 percent per year, and total GDP growth increases from 4.6 to 5.3 percent per year. Assuming that this agricultural growth will be supported solely by an increase in PAE, then the required growth in PAE is estimated to be 19.8 percent per year under high elasticity and 31.7 percent under low elasticity (see Table 13 and Figure 12). Assuming that the government's allocation to non-agricultural expenditure continues to grow as in the Baseline scenario, then the total government budget is estimated to grow at 3.5 percent per year under high elasticity and at 5.3 percent under low elasticity (see Table 13 and Figure 13). Again, with agricultural spending growing more rapidly than total spending, the agricultural spending share will rise to 6.2-10.5 percent in 2010 and 12.8-29.4 percent in 2015 under high and low elasticity, respectively (see Table 13 and Figure 14). These increases translate into additional government spending on the sector in a total amount of Kw 2,496-7,902 billion over 2004-2015, or Kw 208-659 billion per year.

In the second scenario for achieving the CAADP target, we take into account the effect of non-agricultural expenditure on agricultural growth. In this case, PAE is expected to grow at a lower rate of 18.5 percent per year under the high elasticity scenario and 29.1 percent under the low elasticity scenario (see Table 13 and Figure 12). The total government budget is estimated to grow at 3.1 percent per year under the high elasticity scenario and at 4.7 percent under the low elasticity scenario (see Table 13 and Figure 13). Again, with agricultural spending growing more rapidly than total spending, the share of agricultural spending in total expenditure will be 5.9-9.4 percent in 2010 and 11.6-25.0 percent in 2015 under high and low elasticity, respectively (see Table 13 and Figure 14). These increases translate into additional spending on the sector in the total amount of Kw 2,116-6,341 billion over 2004-2015, or Kw 176-528 billion per year.

In the third scenario, we assume that non-agricultural expenditure grows at 4.4 percent per year instead of the baseline rate of 2.2 percent. In this case, PAE is expected to grow at 17.2 percent per year under the high elasticity scenario and 26.5 percent under the low elasticity scenario (see Table 13 and Figure 12). The total government budget is estimated to grow at 5.0 percent per year under the high elasticity scenario and at 6.0 percent under the low elasticity scenario (see Table 13 and Figure 13), while the share of agricultural spending in total expenditure will be 4.9-7.5 percent in 2010 and 8.4-17.5 percent in 2015 under high and low elasticity, respectively (see

Table 13 and Figure 14). These increases translate into additional spending on the sector of Kw 1,771-5,030 billion over 2004-2015, or Kw 148–419 billion per year.

The results confirm the importance of Zambia 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 11.6 percent of its total budget to agriculture by 2015 if the CAADP growth target is to be achieved, assuming that non-agricultural expenditure continues to grow at the baseline rate of 2.2 percent per year. As shown in Figure 11, under the less efficient spending scenario (i.e. low elasticity), the public agriculture investment program proposed under FNDP will be insufficient for meeting the CAADP target over the 2006-10 period. Under the more optimistic and efficient spending scenario, however, the proposed spending will put Zambia on a path to meet the CAADP target as long as the increased spending is continued into the 2010-15 period.

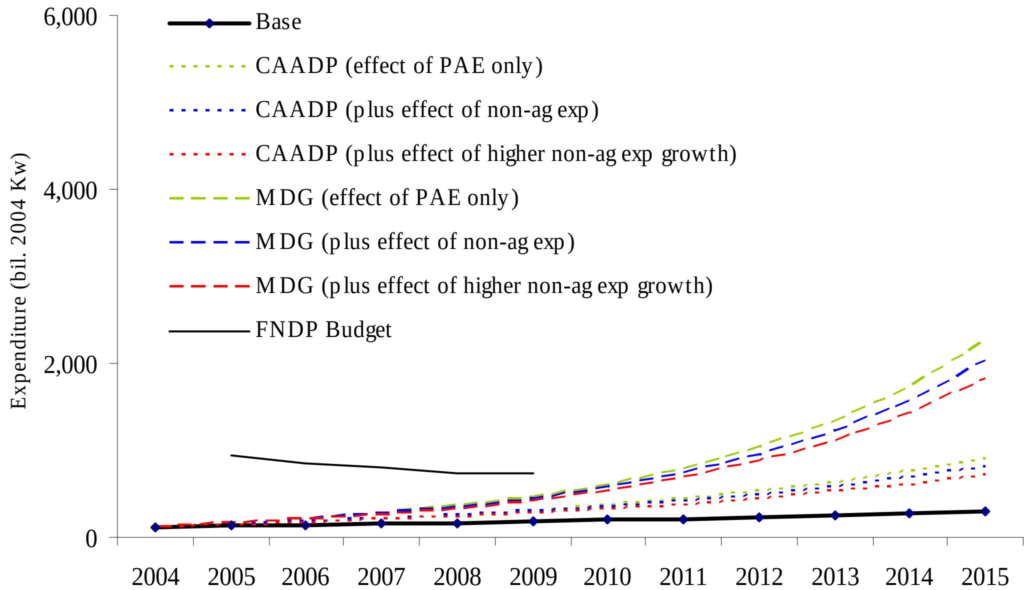
Table 13. Estimated resource allocation

	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		MDG		CAADP		MDG		CAADP		MDG	
		low elasticity	high elasticity	low elasticity	high elasticity	low elasticity	high elasticity	low elasticity	high elasticity	low elasticity	high elasticity	low elasticity	high elasticity
Real growth rates													
Total GDP	4.6	5.3	5.3	9.8	9.8	5.3	5.3	9.8	9.8	5.3	5.3	9.8	9.8
Agricultural GDP	2.5	6.1	6.1	9.2	9.2	6.1	6.1	9.2	9.2	6.1	6.1	9.2	9.2
Non-agricultural GDP	5.0	5.1	5.1	10.0	10.0	5.1	5.1	10.0	10.0	5.1	5.1	10.0	10.0
Total government expenditure	2.4	5.3	3.3	13.4	4.9	4.7	3.1	12.0	4.7	6.0	5.0	11.7	6.2
Agriculture	8.1	31.7	19.8	52.5	30.2	29.1	18.5	49.9	28.9	26.5	17.2	47.3	27.6
Non-agriculture	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	4.4	4.4	4.4	4.4
Government expenditure shares (%)													
Agricultural expenditure in total expenditure													
2004	2.5												
2010	3.5	10.5	6.2	22.1	9.9	9.4	5.9	20.3	9.4	7.5	4.9	16.8	7.9
2015	4.5	29.4	12.8	67.6	26.8	25.0	11.6	63.3	24.7	17.5	8.4	53.0	18.9
Agricultural expenditure in agricultural GDP													
2004	2.6												
2010	3.5	9.3	5.3	18.9	7.3	8.3	5.0	17.0	6.9	7.3	4.6	15.4	6.5
2015	4.5	27.5	9.7	100.2	17.6	22.1	8.6	82.9	15.8	17.7	7.7	68.4	14.1
Non-agricultural expenditure in non-agricultural GDP													
2004	25.6												
2010	21.8	21.7	21.7	16.5	16.5	21.7	21.7	16.5	16.5	24.6	24.6	18.8	18.8
2015	19.1	18.8	18.8	11.5	11.5	18.8	18.8	11.5	11.5	23.8	23.8	14.5	14.5
Total expenditure in total GDP													
2004	20.9												
2010	18.5	19.0	18.2	17.0	14.7	18.8	18.1	16.6	14.6	20.9	20.3	18.1	16.3
2015	16.7	20.8	16.8	28.6	12.6	19.5	16.6	25.2	12.3	22.4	20.2	24.9	14.4

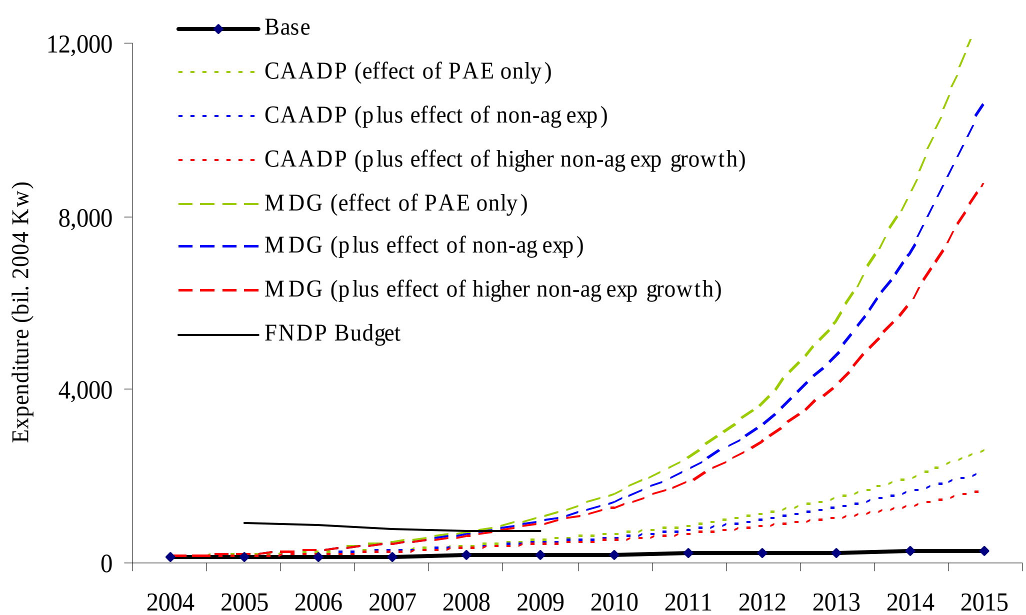
Source: Authors estimates using results from the Zambian CGE-microsimulation model and cross-country public expenditure regressions (Benin et al. 2007).

Figure 12. Value of agricultural expenditure required under the various growth scenarios

More efficient expenditure scenario (high growth-expenditure elasticity)



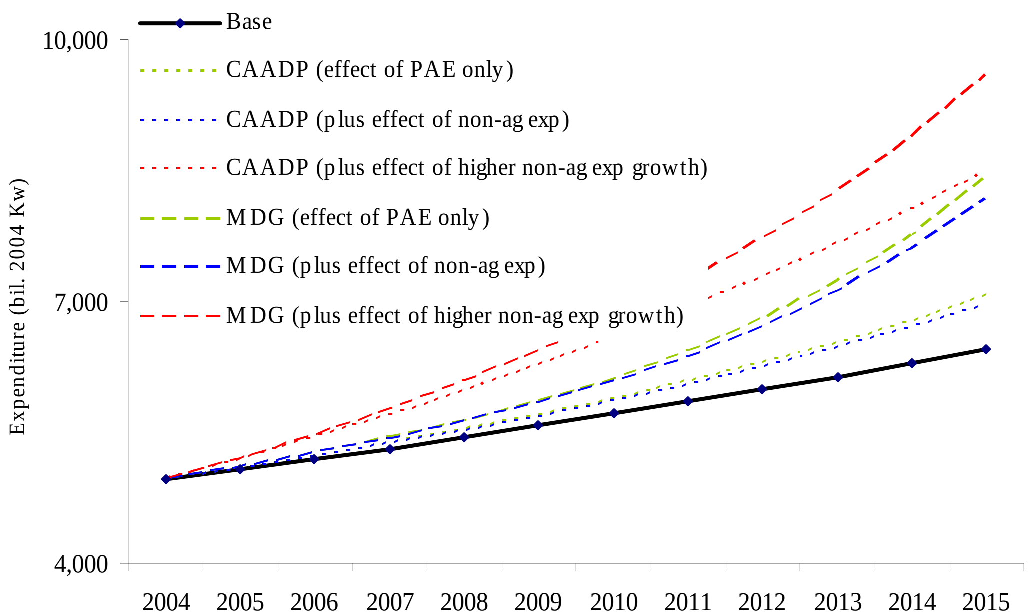
Less efficient expenditure scenario (low growth-expenditure elasticity)



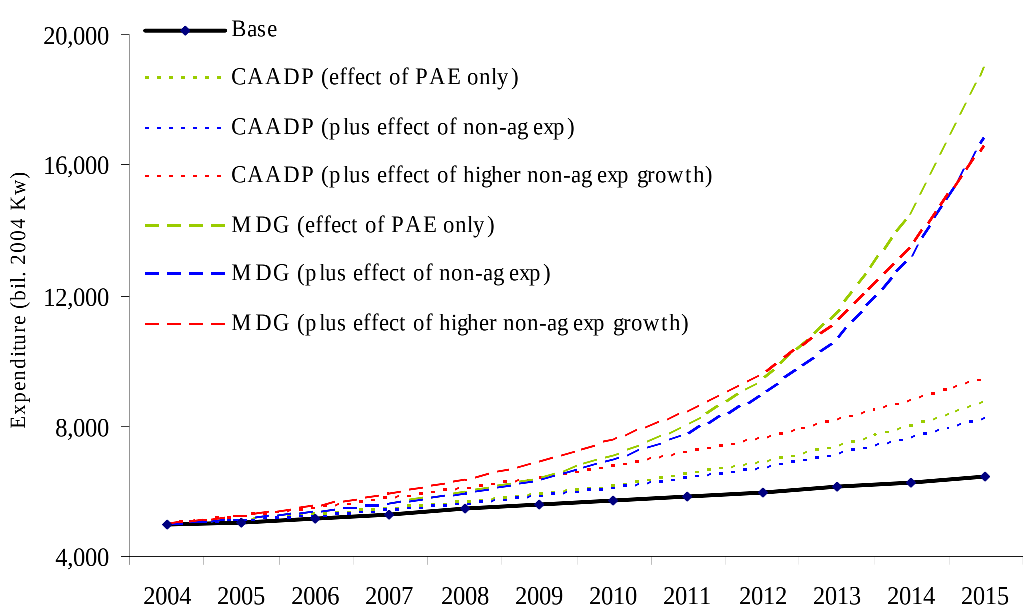
Source: Own calculations using results from the Zambian CGE-microsimulation model and cross-country public expenditure regressions (Benin et al. 2007).

Figure 13. Value of total expenditure required under alternative growth scenarios

More efficient expenditure scenario (high-growth expenditure elasticity)



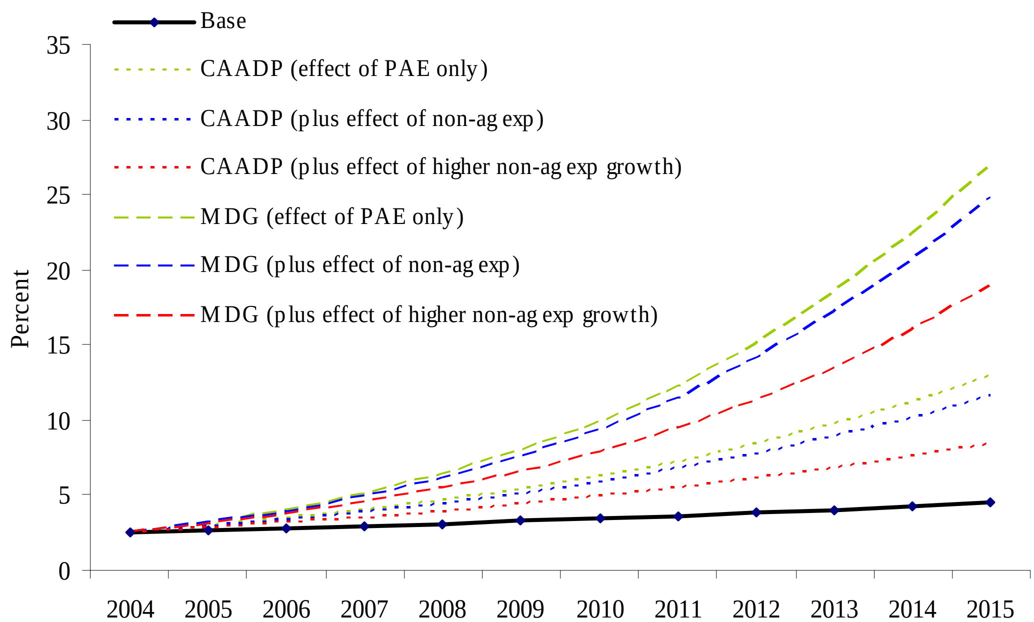
Less efficient expenditure scenario (low growth-expenditure elasticity)



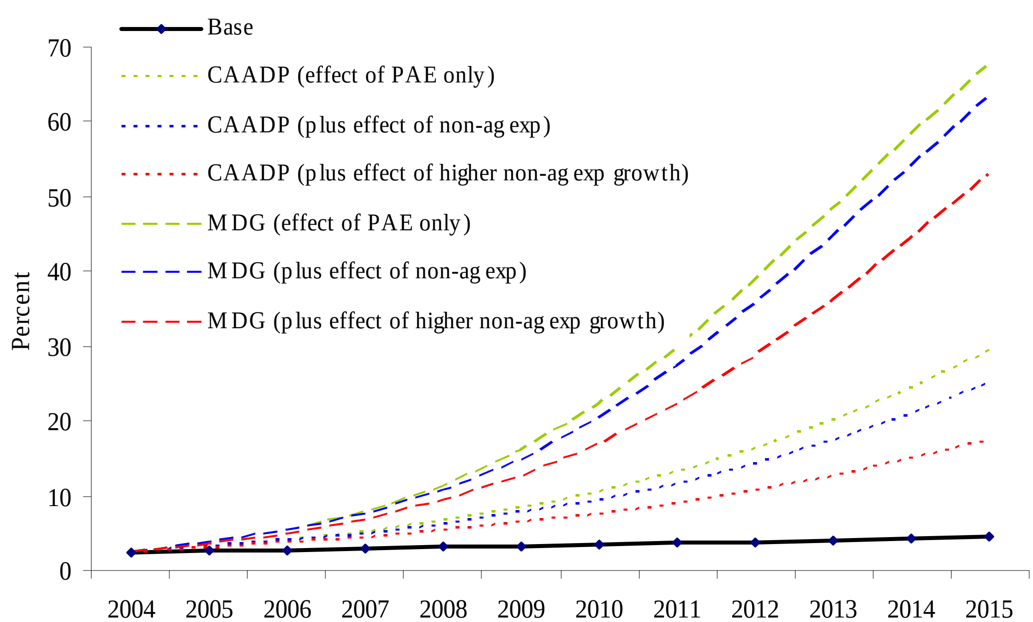
Source: Own calculations using results from the Zambian CGE-microsimulation model and cross-country public expenditure regressions (Benin et al. 2007).

Figure 14. Share of agricultural spending in total expenditure 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 Zambian CGE-microsimulation model and cross-country public expenditure regressions (Benin et al. 2007).

PAE requirements for achieving MDG1 target growth

The CGE model analysis indicated that reaching the CAADP target of six percent agricultural growth will significantly improve poverty outcomes. However, even under this accelerated growth scenario, Zambia will not be able to achieve the first MDG of halving poverty by 2015. Without complementary accelerated growth in the non-agricultural sectors, binding demand/market constraints arise for agricultural outputs, preventing rapid agricultural growth from translating into higher household incomes. To halve poverty by 2015 and meet the MDG1 target, a doubling of the growth rate in non-agricultural sectors (from five to ten percent) is required in addition to an even faster growth in agricultural GDP of 9.2 percent year, which is nearly four times the baseline rate of 2.5 percent. To support such a high growth rate and achieve the desired poverty outcomes, PAE would have to grow at 30.2 percent annually under high elasticity or 52.5 percent under low elasticity, assuming that agricultural growth is driven solely by growth in PAE (see Table 13 and Figure 12). Again, assuming that the government's allocation to non-agricultural sectors grows as in the Baseline case, then total government budget is estimated to grow at 3.4 and 4.9 percent per year under high and low elasticity, respectively (see Table 13 and Figure 13). The share of PAE in total spending would rise to 9.9-22.1 percent in 2010 and 26.8-67.6 percent in 2015 (see Table 13 and Figure 14). These increases translate into additional spending on the sector in a total amount of Kw 6,967-34,772 billion over 2004-2015, or Kw 581-2,898 billion per year. However, the PAE requirements are significantly reduced if we account for the effect of non-agricultural expenditure on agricultural growth or assume higher growth in non-agricultural expenditure. For example, the additional PAE requirements become Kw 519-2,446 billion per year when the effect of non-agricultural expenditure on agricultural growth is taken into account, or 463-2,061 billion per year when modeled with faster non-agricultural expenditure growth (see Table 13 and Figures 12-14 for details).

These results suggest that, in all likelihood, Zambia faces insurmountable growth and resource constraints to achieving its MDG1 target. However, the more reasonable CAADP growth and expenditure scenario can still 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. Thus, while the MDG1 target appears to be beyond reach, achieving the CAADP target should remain a priority.

Identifying investment priorities

Although the main objective of this part of the paper is to estimate the aggregate public agricultural resources needed to reach particular agricultural growth and related poverty-reduction targets in Zambia, it is also important to consider how to prioritize resources within the sector. Due to a lack of data on PAE on specific investment programs in Zambia, and a general dearth of related data on program outputs and outcomes, we are unable to analyze specific investment priorities based on their potential returns in terms of agricultural growth and poverty reduction.[12] However, using the results of the cross-country regression analysis and other studies on best practices, we herein attempt to offer an indicative guide to key investments needed to promote higher agricultural growth and rural poverty reduction. Based on the cross-country analysis, two sets of elasticities are used for this: (i) the effect of increases in agricultural land, labor, capital and inputs on change in agricultural GDP (production function estimates); and (ii) the effect of increases in government agricultural spending on change in agricultural land, labor, capital and inputs. Combining these two sets of elasticities gives the returns in agricultural growth to government spending via agricultural land, labor, capital and inputs, which can then be compared and ranked (see Table 14). The production function estimates shown in the top panel indicate that increases in agriculture labor, machinery and fertilizers contributed the most to agricultural GDP growth over the 1975-03 period. One percent increases in the agricultural labor force, agricultural machinery, and fertilizers, resulted in 0.44, 0.35, and 0.18 percent increases in agricultural GDP, respectively. The contribution of increases in livestock and irrigation were relatively lower.[13] However, these elasticities do not take the effect of spending into account. Assuming that total government agricultural spending is distributed equally across the

[12] The data requirements for doing this are even more demanding when compared to the data needs for undertaking the preceding analysis. Data on expenditure on specific investment programs in Zambia (e.g. on research, extension, natural resource management (NRM), irrigation, input support, etc), as well as related data on program outputs and outcomes (e.g. number of technologies developed and adopted, extension services provided and used by farmers, area under NRM and irrigation, etc.), are needed. Time series on these data disaggregated at the sub-national level (preferably district) and by commodity are also needed. See Benin et al. (2008) for details on methods and data for estimating the returns of public investments on agricultural growth and poverty reduction.

[13] The effect of other inputs (e.g. improved seeds), and sectors (forestry and fisheries) could not be estimated due to lack of time-series data on relevant indicators for all the countries included in the study.

expenditure categories that are associated with private investments in agricultural land, labor and capital and use of inputs by farmers, the bottom panel of Table 14 shows that the greatest return is associated with government agricultural spending that leads to increased private investment in agricultural machinery, followed by spending that leads to increased use of fertilizers and investments in livestock, labor and irrigation.

Table 14. Returns to agricultural expenditure in Sub-Saharan Africa

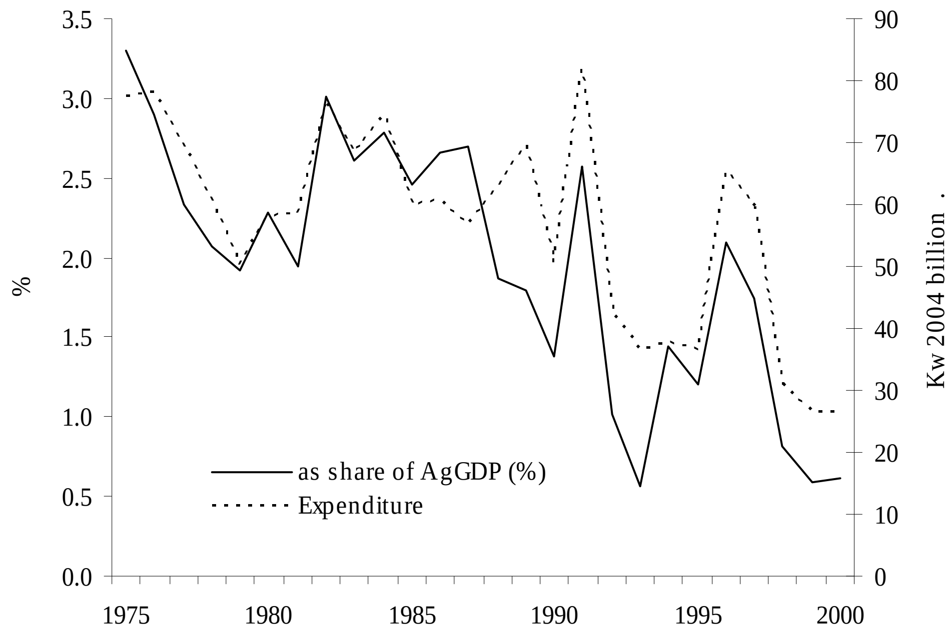
	Elasticity with respect to agricultural GDP		Rank
	Low elasticity	High elasticity	
Production function estimates			
Labor force (agricultural workers per unit agricultural land)	0.440	0.503	1
Machinery (tractors per unit agricultural land)	0.353	0.422	2
Livestock (TLU per unit agricultural land)	0.098	0.198	4
Fertilizer (kg per unit agricultural land)	0.181	0.231	3
Irrigation (percent of agricultural)	0.045	0.091	5
Returns to government agricultural expenditure via:			
Labor force (agricultural workers per unit agricultural)	0.013	0.031	4
Machinery (tractors per unit agricultural land)	0.061	0.109	1
Livestock (TLU per unit agricultural land)	0.017	0.049	3
Fertilizer (kg per unit agricultural land)	0.053	0.089	2
Irrigation (percent of agricultural)	0.006	0.025	5
Total returns to government agricultural expenditure	0.151	0.303	

Source: Benin et al. (2007). TLU is tropical livestock unit equivalent to one cattle of 250 kg.

The large return associated with chemical fertilizers in the cross-country regression analysis speaks to the importance of soil fertility management in the production process. With declining soil fertility seem as a principal constraining factor for raising and sustaining high agricultural production growth in sub-Saharan Africa (SSA) (Sanchez et al. 1997; Larson and Frisvold 1996), the low use of chemical fertilizers by farmers, which is attributed mainly to its high cost relative to output prices, has prompted many governments (including that of Zambia) to subsidize fertilizers used by farmers. In Zambia, however, nearly 40 percent of the resources earmarked for the agricultural sector have been spent on the Fertilizer Support Program and the operations of the Food Reserve Agency, both of which directly support the maize sub-sector. For example, the 2001/02 post-harvest survey indicates that 99 percent of the fertilizer used in Zambia was applied to maize. The results of our growth-poverty analysis presented earlier show that such a single sub-sector dominant investment strategy is unlikely to yield desirable outcomes on its own. The CGE model analysis also showed that root crops and export crops will be important sub-sectors for accelerating growth and poverty reduction, especially in certain parts of the country (see Table 10). Thus, although we are unable to assess the impact of agricultural spending on raising yields and growth in the individual sub-sectors, we strongly recommend pursuit of a more balanced spending portfolio.

In order to increase agricultural production, reduce production costs and protect the environment for sustainable agricultural production, Zambian farmers need improved technologies capable of helping them increase yields, manage water, and use natural resources in a more sustainable manner, while still being profitable under local farming and market conditions. A key investment area to support such technology generation and dissemination is agricultural research and development (R&D) and extension. For example, IFPRI research on Uganda confirms that investment in agricultural R&D offers the greatest potential for enhancing productivity and reducing poverty (Fan et al. 2004). Similarly, Thirtle et al. (2003) showed that for every one percent increase in yield brought about by investments in agricultural R&D, two million Africans can be lifted out of poverty. However, agricultural R&D spending in Zambia has been declining rapidly over time (Figure 15). This trend must be reversed. Under the FNDP, the government of Zambia has planned to allocate about 12.5 percent of the total PAE budget to agricultural R&D (see Figure 10). This planned budgetary allocation translates into about three percent of agricultural GDP, which is similar to the shares realized in the mid 1970s and early 1980s (Figure 15). If this planned spending is achieved, it will be higher than the African average of 0.5–0.6 percent, as well as the one percent recommended by the World Bank. Most importantly, it will put Zambia on a reasonable path towards development and dissemination of the technologies that are needed for realizing the crop yields assumed in the CGE model simulations.

Figure 15. Government spending on agricultural R&D in Zambia



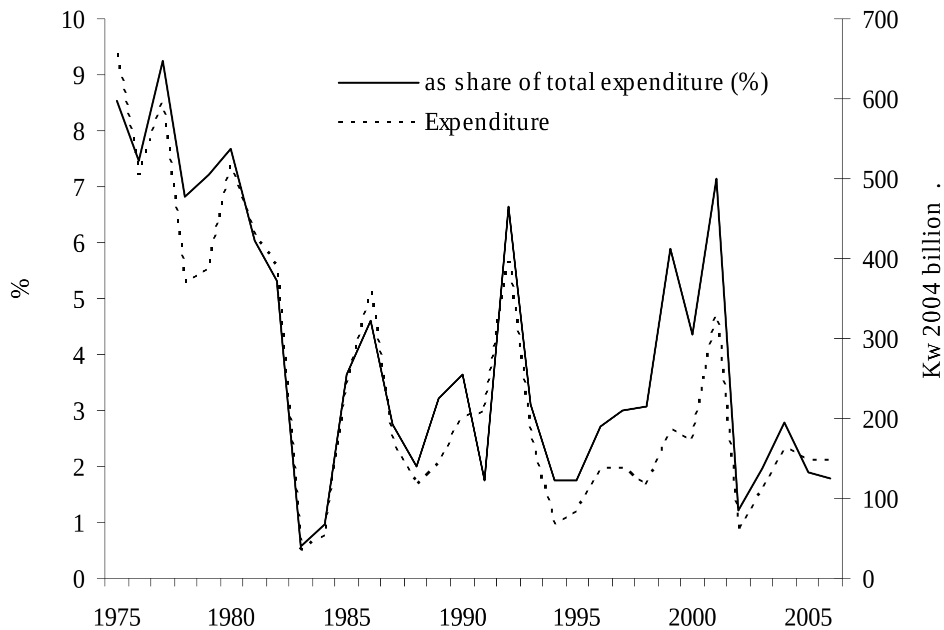
Source: Government Finance Statistics (IMF and Government of Zambia); Agriculture Science and Technology Indicators (IFPRI, 2007).

Another key investment area that Zambia's government needs to consider is irrigation. Although irrigation ranks fifth in the cross-country regression analysis in terms of returns to spending, the impacts of irrigation are well known, and it is common knowledge that the success of the Asian Green Revolution in the 1960s and 1970s was built on the rapid expansion of irrigated areas (Spencer, 1994). Rosegrant and Evenson (1995) found that irrigation was one of few public investments where return increase over time when matched by private increments. The data used in the cross-country analysis, however, show very little growth in the minimal crop areas under irrigation. Zambia, for example, has an irrigation potential of more than half a million hectares, but only about three percent of the total arable land is under irrigation (FAO, 2007). The Zambian government, under the framework of the FNDP, is planning to double the area irrigated by 2010 and, has, consequently, earmarked about 14 percent of the total PAE budget for irrigation development (see Figure 10). It is unclear whether this allocation will be sufficient to reach the set target. Even doubling the irrigated area will only raise the percentage of area under irrigation to six percent (assuming total crop area remains unchanged), which is far below the 30-50 percent seen in Asia during its period of massive growth in the agricultural sector.

The results from the cross-country regression analysis also show that government spending on broad infrastructure development contributes significantly to agricultural growth. A one percent increase in government spending on transport and communications is associated with a 0.01-0.14 percent increase in agricultural GDP growth (Benin et al., 2007). This positive effect of public infrastructure spending on agricultural growth is consistent with that found in previous studies. 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 et al., 2000; Fan and Zhang, 2004; Mogues et al., 2007). IFPRI studies for countries as diverse as Ethiopia, Ghana, Uganda, 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, which significantly contributes to poverty reduction (Thurlow and Wobst, 2004; Diao and Nin-Pratt, 2005).

Zambia has a sparse road system. With the current road density standing at 121 kilometers per 1000 square kilometers and only 22 percent of the roads paved, Zambia ranks 23rd in SSA (IRF 2007). This suggests that farmers lack general access to affordable yield-enhancing inputs and inexpensive marketing channels. Investment in rural feeder roads, in particular, can have large poverty reduction effects per unit of investment, as Fan et al. (2004) show in the case of Uganda, where the marginal returns to public spending on feeder roads on agricultural output and poverty reduction is found to be three to four times larger than the returns to public spending on murram and tarmac roads. Unfortunately, however, spending on transport and communications in Zambia has been declining (Figure 16). Under the current road rehabilitation program (ROADSIP II), the government and its development partners is planning to spend US$1.6 billion between 2005 and 2013 to improve the road network. The main objective of the program is to rehabilitate the existing network, meaning that the road density will still remain low, although the road condition is likely to improve significantly. New roads must be built, especially for improving the market integration of Zone 3, where large growth and poverty-reduction potentials have been identified.

Figure 16. Government spending on transport and communications in Zambia



Source: Government Finance Statistics (IMF and Government of Zambia).

VII. Summary of major findings

A dynamic CGE model is herein developed and used to examine the contribution of accelerating growth in various agricultural crops and sub-sectors in assessing how Zambia can achieve the CAADP target of six percent agricultural growth, as supported by raising agricultural expenditure to at least ten percent of the government's total budgetary resources. The impact of agricultural growth at the macro- and microeconomic levels, as well as on poverty, was 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 if Zambia 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 during 2005-2015. Agricultural growth at 6.1 percent per year would increase overall GDP growth from 5.6 to 5.3 percent per year. This higher growth rate would reduce national poverty to 51.9 percent by 2015, which is lower than the 57.7 percent poverty rate that would have been achieved without the additional agricultural growth. This means that the higher growth under the CAADP scenario would lift an additional 780,000 people above the poverty line by 2015.

Not everyone will benefit 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, households in agro-ecological Zones 1 and 2a benefit more than households in the more remote zones of the country. Finally, while rural households benefit more than urban households, not least because the former are more dependent on agricultural incomes, urban households also benefit. This is because urban agriculturalists make up a significant share of agricultural producers in Zambia, 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 6.4 percentage points, urban poverty falls by 4.8 percentage points.

The composition of agricultural growth matters

Comparing the effectiveness of growth driven by different sub-sectors in reducing poverty and encouraging broader-based growth, we see that a one percent growth driven by either cereals or root crops has considerably larger impacts on poverty reduction than similar growth in export-oriented crops. This is because yield improvements in these crops not only benefit households directly by increasing incomes from cereals and root crop production, but also indirectly by allowing farmers to diversify their land allocation toward higher-value crops. Food crops and fisheries also have stronger growth-linkages to non-agricultural sectors, 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 large share of overall poverty reduction under the CAADP scenario. Furthermore, the small initial size and geographic concentration of certain food crops, such as root crops, means that their potential contribution to national-level growth and poverty reduction is limited, at least over the short term. Taken together, our findings highlight the importance of broad-based agricultural growth, but accord a high priority to maize, roots, 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. It would be helpful to reforming public institutions, particularly those with any agriculture-related functions, to improve the provision and delivery of agricultural public goods and services. Our investment analysis indicates that aggregate government spending on agriculture would have to grow by about at least 17 percent per year in order to achieve and sustain the six percent agricultural growth targeted by the CAADP. This implies that the government will need to allocate at least eight percent of its total budgetary resources to agriculture by 2015. However, this spending scenario assumes that the government is able to invest more efficiently than the average sub-Saharan African country, realizing a 0.3 percent increase in agricultural GDP for every one percent increase in total agricultural spending. If this is not the case and the government can only achieve a modest return on its spending, say a 0.15 percent increase in agricultural GDP for every one percent increase in total agricultural spending, then public spending on agriculture in Zambia would have to grow at about at least 27 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 at least 18 percent 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.

Halving poverty by 2015 seems an insurmountable challenge

Although agricultural growth has strong linkages to the rest of the economy, leading to substantial overall growth in the economy and increases in incomes of both rural and urban households, achieving the CAADP target of six percent agricultural growth is insufficient to halve poverty by 2015. To achieve this more ambitious target, both agriculture and non-agriculture would need an average annual growth rate around ten percent per year. These growth requirements are substantial, as are the associated resource requirements. However, while the MDG1 target appears to be beyond reach, achieving the CAADP target should remain a priority for Zambia, as its growth and expenditure scenario is more reasonable, and 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.

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Appendix A: Specification of the CGE and microsimulation model

A recursive dynamic computable general equilibrium (CGE) model is herein developed to assess sector-specific growth options and their impacts on poverty. The CGE model is calibrated to a 2004 social accounting matrix (SAM) that provides information on the demand and production structure for 34 detailed sectors in the economy (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 working in both agriculture and non-agriculture, and skilled non-agricultural workers. Information on employment and wages by sector and region is taken from the 2004 Living Conditions Monitoring Survey (LCMS4). The model further disaggregates agricultural activities across agro-ecological zones using district-level production and price data (see Section II). Due to data constraints, non-agricultural production is not disaggregated across regions. Goods produced and consumed in Zambia are traded in national and international markets.

Workers in the model can migrate between sectors and regions, although agricultural family labor remains within regions. 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 their own small farms to finding employment through the labor market. Capital moves freely within regions and within the broad agricultural and non-agricultural sectors, and capital is accumulated through investments financed by domestic savings and foreign inflow. Increased capital is allocated across sectors and regions according to their relative profitabilities. Income from employment accrues to different households according to employment and wage data from LCMS4. Households are defined at the regional level according to agro-ecological zone, and within each zone are divided into rural and urban areas. Metropolitan areas are treated as a separate group given their unique role as national hubs. The government collects direct taxes from households and indirect taxes from imports, exports and domestic sales, and supplements its revenues with foreign borrowing and grants. It uses these funds for recurrent and investment expenditures.

The growth-poverty relationship is examined using a CGE-microsimulation model. An important factor that helps determine the contribution of agriculture to overall economic growth is its linkage with the rest of the economy. Proponents of agriculture argue that it has strong growth linkages. The model captures consumption linkages by explicitly defining a set of nested constant elasticity of substitution (CES) production functions, allowing producers to generate demand for both factors and intermediates. The CGE model also captures forward and backward production linkages between sectors. To reflect the heterogeneity of producers in Zambia, the model is calibrated to highly disaggregated social accounting matrices (SAM) that distinguish among producers by different sectors, regions, and produced commodities. These commodities are traded in national and international markets (the model does not capture interregional trade within Zambia). The model disaggregates agricultural activities across agro-ecological zones using district-level production and price data (see Section 2). Due to data constraints, non-agricultural production is not disaggregated across regions.

To capture existing differences in labor markets, the model classifies employed labor into different sub-categories, including self-employed agricultural workers, unskilled workers working in both agriculture and non-agriculture, and skilled non-agricultural workers. Information on employment and wages by sector and region is taken from the 2004 Living Conditions Monitoring Survey (LCMS4). Workers in the model can migrate between sectors and regions, although agricultural family labor remains within regions. 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 their own small farms to finding employment through the labor market. Capital moves freely within regions and within the broad agricultural and non-agricultural sectors, and capital is accumulated through investments financed by domestic savings and foreign inflow. Increased capital is allocated across sectors and regions according to their relative profitabilities. This detailed specification of production and factor markets in the model allows it to capture changes in the scale and technology of production across sectors and sub-national regions, and therefore reflects how changes in Zambia's structure of growth influences its distribution of incomes.

The CGE model captures import competition and export opportunities 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 employment and wage data drawn from LCMS4. As with production, households are defined at the regional level according to their agro-ecological zones, and within each zone they are grouped into rural and urban areas. Metropolitan areas are treated as a separate group given their unique role as national economic hubs. 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 LCMS4. Households in the model receive income through the employment of their factors in both agricultural and nonagricultural production, and then pay taxes, save and make transfers to other households. The disposable income of a representative household is allocated to 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' income and expenditure patterns, the CGE model is linked to a microsimulation module based on information derived from LCMS4. Endogenous changes in commodity consumption for each aggregate household in the CGE model are used to adjust the level of commodity expenditure of the corresponding households in the survey. Real consumption levels are then recalculated from 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 governments cannot simply increase foreign debt, but instead must 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 a 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 2004-2015, with each equilibrium period representing a single year. The model also exogenously captures demographic and technological changes, including alterations in population, labor supply, human capital and factor-specific productivity. Capital accumulation occurs through endogenous linkages with previous-period investments. Although the allocation of newly invested capital is influenced by each sector's initial share of 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 sub-national regions and 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 that household's 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 model to capture the poverty and distributional changes associated with agricultural growth.

Table A1. 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)	$trnsfr_{if}$	Transfer from factor f to institution i
pwm_c	Import price (foreign currency)		

Table A1 continued. CGE model sets, parameters, and variables

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 A1 continued. CGE model sets, parameters, and variables

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 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_{fat}^{a}	Quantity of new capital by activity a for time period t

Table A2. CGE model equations

Production and Price Equations

$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}-1}$	(4)
$QF_{f\,a} = \alpha_{f\,a}^{van} \cdot \left(\sum_{f' \in F} \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}^{\;-\rho_{f\,a}^{van}} \right)^{-\frac{1}{\rho_{f\,a}^{van}}}$	(5)
$W_{f'} \cdot WFDIST_{f'\,a} = W_f \cdot WFDIST_{f\,a} \cdot QF_{f\,a} \cdot \left(\sum_{f'' \in F} \delta_{f\,f''\,a}^{van} \cdot QF_{f''\,a}^{\;-\rho_{f\,a}^{van}} \right)^{-1} \cdot \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}^{\;-\rho_{f\,a}^{van}-1}$	(6)
$QVA_a = iva_a \cdot QA_a$	(7)
$QINTA_a = inta_a \cdot QA_a$	(8)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(9)
$QXAC_{a\,c} = \theta_{a\,c} \cdot QA_a$	(10)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(11)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{\;-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(12)
$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1}$	(13)
$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(14)
$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$	(15)
$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}}$	(16)

Table A3. CGE model equations (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)
$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right]$	(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 A3. CGE Model Equations (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)
$MPS_i = \overline{mps}_i \cdot (1 + MPSADJ)$	(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: Method for estimating spending-growth elasticities

Estimates of the growth in public 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, and then taking their interactions (i.e. any trade-offs and complementarities) into account (see Fan et al. 2008 for details) as follows:

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

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; ${}_{nag,ag}$ 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 required agriculture spending to achieve a particular growth rate in agriculture ($\bar{\theta}_{ag}$), as follows:

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

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

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

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