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Agricultural Growth and Investment Options for Poverty Reduction in Malawi

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For more information, contact:
Coordinator
Regional Strategic Analysis and Knowledge Support System
c/o International Food Policy Research Institute
2033 K Street, NW
Washington, DC 20006-1002
Telephone: +1 202 862 5667
Facsimile: +1 202 467 4439
E-mail: resakss-africa@cgiar.org
www.resakss.org

The authors

Samuel Benin, Xinshen Diao, and James Thurlow are researchers in the Development Strategy and Governance Division of the International Food Policy Research Institute (IFPRI). Christen McCool is an IFPRI consultant, and Franklin Simtowe is a researcher with the University of Malawi, and the Africa Rice Center (formerly WARDA).

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agriculture, GDP, poverty, public investment, MDG

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Abstract

Malawi has experienced modest economic growth over the last decade and a half. However, agricultural growth has been particularly erratic, and while the incidence of poverty has declined, it still remains high. The Malawian government, within the framework of the Agricultural Development Plan (ADP), 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 agricultural growth and investment options that can support the development of a comprehensive agricultural development strategy consistent with the principles and objectives of the CAADP, which include achieving six percent agricultural growth and allocating at least ten percent of budgetary resources to the sector.

Economic modeling results indicate that it is possible for Malawi to reach the CAADP target of six percent agricultural growth. However, achievement of these goals will require additional growth in most crops and agricultural sub-sectors, meaning that Malawi cannot rely solely on growth in maize or tobacco to reach this growth target. Broader-based agricultural growth, including growth in pulses and horticultural crops, will be important if this target is to be achieved. So, too, is meeting the Maputo declaration of spending at least ten percent of the government's total budget on agriculture. In fact, even under a more optimistic and efficient spending scenario, the Government of Malawi must increase its spending on agriculture in real value terms by about 20 percent per year between 2006 and 2015, and account for at least 24 percent of its total expenditure by 2015 if the CAADP goals are to be met.

Although agriculture has strong linkages to the rest of the economy, with agricultural growth typically resulting in substantial overall growth in the economy and rising incomes in rural and urban areas, simply achieving the CAADP target of six percent will not be sufficient to halve poverty by 2015, i.e. achieving the first Millennium Development Goal (MDG1). To achieve this more ambitious target, agriculture and non-agriculture would need an average annual growth rate above seven percent. This growth requirement is substantial, as is the associated resource requirements, indicating that the MDG1 target may be beyond reach. However, achieving the CAADP target should remain a priority, as this goal has more reasonable growth and expenditure requirements, and will substantially reduce the number of people living below the poverty line by 2015 and significantly improve the well-being of both rural and urban households.

I. Introduction

Malawi has experienced modest economic growth over the past decade and a half. Agricultural growth has been particularly erratic, and while the incidence of poverty has declined, poverty still remains high. To accelerate growth and poverty reduction, Malawi's government is preparing its Agricultural Development Plan (ADP), which emphasizes the revitalization of agriculture as an engine of growth and development for the national economy. This is not surprising since agriculture is a vital income source for a majority of the Malawian population, contributing more than 40 percent to GDP, comprising 60 percent of foreign earnings, and employing three-quarters of the population. In association with the New Partnership for Africa's Development (NEPAD), the Government of Malawi is in the process of implementing the Comprehensive Africa Agriculture Development Programme (CAADP), which provides an integrated framework of development priorities aimed at restoring agricultural growth, rural development and food security in the African region. The main target of CAADP is achieving six percent agricultural growth per year supported by the allocation of at least ten percent of national budgetary resources to the agricultural sector.

Faced with limited resources, the government must not only decide on how much to allocate for the agricultural sector as a whole, but also across sub-sectors within the agricultural sector, as well as across different non-agricultural sub-sectors, in overall economic development. Many investment and policy interventions will be designed at the sub-sector level, and strong inter-linkages occur across sub-sectors and between agriculture and the rest of the economy. To understand these linkages and examine how sectoral growth will contribute to the country's broad development goals, we need an integrated framework that synergizes 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, while demand, in turn, depends on income growth both in agriculture and in the broader economy. Although agriculture is a dominant economic activity in Malawi and a majority of the population lives in rural areas, both rural and urban sectors should be included in this framework in order for us to understand the economy-wide impact of agricultural growth.

This study analyzes agricultural growth and investment options that can support a more comprehensive rural development component under Malawi's ADP, while also remaining 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 Malawi's agricultural sector and rural economy within a national strategy. For these purposes, and to assist policymakers and other stakeholders in making informed long-term decisions, an economy-wide, computable general equilibrium (CGE) model for Malawi is developed and used to analyze the linkages and trade-offs between economic growth and poverty reduction at both the macro- and micro-economic levels. In addition, the study assesses the public resources that will be required by the agricultural sector if the country is to achieve the development goals committed to by the government.

II. Modeling agricultural growth and poverty reduction

The computable general equilibrium (CGE) and microsimulation models

A new Malawi CGE model was developed to capture trade-offs and synergies from accelerating growth in alternative agricultural sub-sectors, as well as the economic inter-linkages between agriculture and the rest of the economy.[1] Although this study focuses on the agricultural sector, the CGE model also contains information on the non-agricultural sectors, for a total of 36 identified sub-sectors, 17 of which are in agriculture (Table 1). The agricultural crops considered herein fall into five broad groups: (i) cereal crops, which are separated into maize, rice, and other cereals, such as sorghum and millet; (ii) root crops, such as cassava, Irish potatoes, and sweet potatoes; (iii) pulses and nuts, which is separated into pulses and oil crops, and groundnuts and other nuts; (iv) horticulture, which is separated into vegetables and fruits; and v) higher-value export-oriented crops, which are separated into tobacco, cotton, sugar, tea, and other export crops, such as sunflower seeds. The CGE model also identifies two livestock sub-sectors, namely poultry, and other livestock, such as cattle, sheep, goats and pigs. To complete the agricultural sector, the model has two further sub-sectors capturing forestry and fisheries. Most of the

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

agricultural commodities listed above are not only exported or consumed by households, but are also used as inputs into various processing activities in the manufacturing sector.

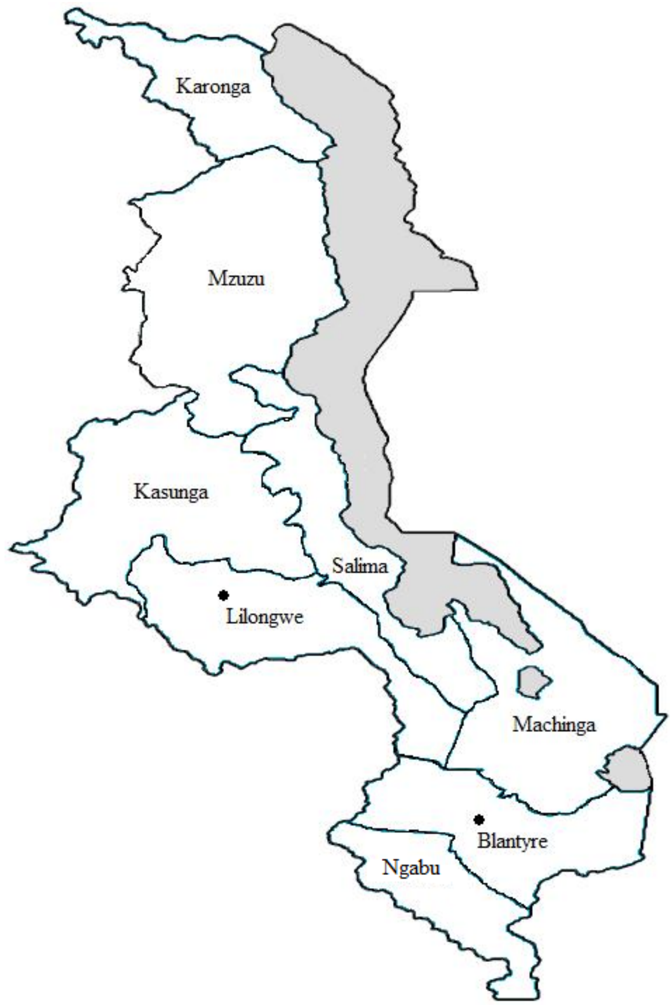
Table 1. Agricultural commodities and non-agricultural sectors in the CGE model

	Agricultural sub-sectors
	Cereals
1	Maize
2	Rice
3	Other cereals (incl. sorghum, millet, etc)
4	Root crops (incl. cassava, sweet potatoes, Irish potatoes)
	Pulses & nuts
5	Pulses & oils (incl. mixed beans, soybeans)
6	Groundnuts
	Horticulture
7	Vegetables
8	Fruits
	High-value export-oriented crops
9	Tobacco
10	Cotton
11	Sugarcane
12	Tea
13	Other crops (incl. sunflower seeds, paprika, etc)
	Livestock
14	Poultry
15	Other livestock (incl. cattle, goats, sheep and pigs)
16	Fisheries
17	Forestry
	Industrial sub-sectors
18	Mining
19	Food processing
20	Beverages & tobacco
21	Textiles & clothing
22	Wood & paper products (incl. furniture)
23	Chemicals & rubber products
24	Machinery, equipment and other manufacturing (incl. vehicles)
25	Construction
26	Electricity & water
	Service sub-sectors
27	Agricultural trade and transport services
28	Non-agricultural trade and transport services
29	Hotels & catering
30	Communication services
31	Financial & business services
32	Real estate services
33	Community & other private services
34	Government administration
35	Health services
36	Education services

Source: Thurlow et al. 2008.

The four agricultural processing activities identified in the model include food processing, beverages and tobacco, textiles, and wood processing. The agricultural sub-sectors also use inputs from non-agricultural sectors, such as fertilizer from the chemical sector and marketing services from the trade and transport sectors. The CGE model also captures regional heterogeneity. Rural agricultural production is disaggregated across Malawi's eight main agro-ecological regions, which are shown in Figure 1. Furthermore, to capture the importance and unique circumstances of urban agriculture, urban agricultural production is grouped into a separate region. Thus, nine sub-national regions are identified in the model (eight rural and one urban). Finally, within each region, rural crop production is further disaggregated across farm groups according to the amount of land farmed (this is discussed in detail below).

Figure 1. Agricultural Development Districts in the CGE model



Note: The Agricultural Development Districts (ADD) shown in the figure are the agro-ecological zones on which both the 2004/05 Integrated Household Survey (IHS2) (NSO, 2005) and official agricultural production data are stratified (MOAFS, 2007). The CGE model is therefore representative at the ADD-level. ‘Ngabu’ is referred to as ‘Shire Valley’ outside of IHS2.

The CGE model captures the initial cropping patterns in each of the nine sub-national regions. Each group of farmers in each region responds to changes in production technology, commodity demand and price by reallocating their land across different crops in order to maximize income. 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 farm-level production information across sub-national regions, the economywide CGE model can assess growth effects at the national level, while also taking into account the micro-level decision-making typically associated with more detailed farm models. The new Malawi CGE model is thus an ideal tool for capturing the growth linkages and income- and price-effects that result from accelerated growth in different agricultural sectors.

Finally, the CGE model endogenously estimates the impact of alternative growth paths on the incomes of various household groups. These household groups include both farm and non-farm households, and are also disaggregated across the nine regions and rural and urban areas. The rural farm households are further separated by land size into small-, medium- and large-scale farm households (see below for more details). Each of the households included in the 2004-05 Integrated Household Survey (IHS2) (NSO, 2005) are linked directly to their corresponding representative household in the CGE model. This is the micro-simulation component of the new Malawian 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. The new level of per capita expenditure for each survey household is compared to the official poverty line, and standard poverty measures are recalculated. Thus, poverty is measured in exactly the same way as in official poverty estimates, and changes in poverty draw on the consumption patterns, income distribution and poverty rates captured in IHS2.

Farm household groups in the model

Malawi has one of the highest rural population densities in Sub-Saharan Africa, at 2.3 rural people per hectare of agricultural land compared to 0.4 people for the sub-continent as a whole.[2] Accordingly, most Malawian farmers are smallholders, with a national average plot size of 1.13 hectares (see the first column of Table 2). Given such land constraints, the CGE model focuses on capturing the importance of farm size in determining the cropping patterns and opportunities of Malawian farmers. We separate farmers according to the size of the land they harvested, as reported in IHS2. To simplify the process of identifying farm groups, we focus on Malawi's two most important crops: maize and tobacco.[3] While almost all farmers in both urban and rural areas allocate some portion of their farm land to maize, we find that among the farmers with less than 0.75 hectares of land, none produced tobacco and very few produced other export-oriented crops (see the final three columns of Table 3). We therefore separate out this group of farmers, which we term 'small-scale.' Around one-third of all households in Malawi are rural small-scale farmers, and two-thirds of these farmers reside in the three larger southern regions of Lilongwe, Machinga and Blantyre (see Table 2 and Figure 1). The average plot size for small-scale farms is 0.69 hectares, of which 0.36 hectares is allocated to maize and 0.16 hectares to pulses. The average crop yields for small-scale farmers are slightly below the national average. Small-scale farm households also tend to have fewer household members, lower per capita incomes/expenditures, and a higher incidence of poverty. As such, while this farm group makes up only 30 percent of the total population, they account for 36 percent of the poor population. The sharp difference in cropping patterns and poverty between small-scale and other farm households highlights the importance of land constraints in Malawi and justifies the separation of this group of farmers in the CGE model.

[2] Malawi is the third most densely populated country in mainland Sub-Saharan Africa, after Rwanda (3.8 people per hectare) and Burundi (2.7 people per hectare). The World Bank (2007) reported that in 2003, Malawi had 4.4 million hectares of agricultural land; however only 3 million hectares were harvested, and 2.2 million were considered 'arable.'

[3] Maize and tobacco generate 25 and 15 percent of agricultural GDP, respectively (see Table 5). Other important broad crops categories include pulses and oil crops (nine percent) and root crops and vegetables (both seven percent).

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

	National	Urban		Rural											
		Farm	Non-farm	Rural farm households in each region								Non-farm	Small (<0.75 ha)	Med. (0.75-3ha)	Large (>3ha)
				Kar-onga	M-zuzu	Kas-ungu	Sal-ima	Lil-ongwe	Mach-inga	Blan-tyre	Ngabu				
Population (1000)	12,173	654	727	358	814	1,282	661	2,523	2,033	1,972	693	458	3,731	6,240	363
Number of households	2,694	133	189	71	163	246	143	537	465	474	137	134	942	1,241	54
Small-scale (<0.75ha)				30	44	69	72	203	237	217	70				
Household size	4.5	4.9	3.8	5.0	5.0	5.2	4.6	4.7	4.4	4.2	5.0	3.4	4.0	5.0	6.7
Per capita exp. ($US)	150.8	286.2	308.6	116.7	132.0	152.8	130.9	145.4	110.3	125.3	101.0	185.8	121.6	130.1	203.7
Poverty rate (%)	52.4	30.0	21.2	62.8	55.0	43.0	56.3	47.0	67.7	61.4	70.6	37.5	61.0	55.6	30.6
Share of poor (%)	100.0	3.1	2.4	3.5	7.0	8.7	5.8	18.6	21.6	19.0	7.7	2.7	35.7	54.4	1.7
Harvest area (1000 ha)	3,050	174	-	81	295	525	128	591	482	599	175	-	647	1,792	437
Average farm land (ha)	1.13	1.31	-	1.13	1.80	2.13	0.89	1.10	1.04	1.26	1.28	-	0.69	1.44	8.02
Maize	0.57	0.99	-	0.54	0.80	1.08	0.41	0.59	0.58	0.50	0.66	-	0.36	0.70	3.67
Other cereals	0.05	0.01	-	0.10	0.06	0.01	0.04	0.03	0.06	0.09	0.22	-	0.04	0.08	0.09
Root crops	0.12	-	-	0.28	0.36	0.20	0.18	0.09	0.10	0.17	-	-	0.09	0.18	0.36
Pulses & nuts	0.26	0.23	-	0.12	0.34	0.56	0.05	0.29	0.20	0.40	0.17	-	0.16	0.36	1.17
Horticulture	0.03	0.03	-	0.05	0.07	0.06	0.02	0.04	0.03	0.03	0.03	-	0.02	0.05	0.13
Tobacco	0.05	0.04	-	-	0.17	0.22	-	0.05	0.03	0.01	-	-	-	0.03	1.79
Other export crops	0.04	0.02	-	0.04	0.01	0.01	0.20	0.01	0.04	0.05	0.20	-	0.01	0.05	0.81
Crop yields (mt/ha)															
Maize	1.13	1.00	-	1.17	1.30	1.37	1.33	1.24	0.96	0.93	0.79	-	1.07	1.14	1.27
Rice	1.17	1.24	-	1.64	1.83	1.09	1.51	1.86	0.76	0.74	1.09	-	1.12	1.17	1.61
Sorghum & millet	0.58	-	-	0.77	0.57			0.57	0.68	0.64	0.44	-	0.59	0.58	0.59
Cassava	5.50	-	-	5.64	6.80	5.46	5.41	6.83	3.55	4.89	-	-	5.25	5.54	6.07
Groundnuts	0.75	0.75	-	-	0.75	0.81	1.03	0.88	0.57	0.49	-	-	0.68	0.76	0.78

Source: Own calculations using official agricultural production data (MOAFS, 2007) and the 2004/05 Integrated Household Survey (IHS2).
Note: 'Per capita expenditure' is mean expenditure unadjusted for adult-equivalence; 'poverty rate' is the poverty headcount based on the national basic needs poverty line (approximately Kwacha (Kw) 16,165 or US$115 per person per year).

Table 3. Crop land distribution across regions and farm households

	National	Urban		Rural											
		Farm	Non-farm	Rural farm households in each region								Non-farm	Small (<0.75 ha)	Med. (0.75-3ha)	Large (>3ha)
				Kar-onga	M-zuzu	Kas-ungu	Sal-ima	Lil-ongwe	Mach-inga	Blan-tyre	Ngabu				
Farm land (1000 ha)	3,050	174	-	81	295	525	128	591	482	599	175	-	647	1,792	437
Maize	1,538	132	-	38	130	266	58	315	270	238	90	-	343	863	200
Other cereals	143	1	-	7	10	1	5	18	30	41	31	-	40	97	5
Root crops	327	0	-	20	58	48	25	48	44	83	0	-	82	225	20
Pulses & nuts	700	30	-	8	55	137	7	155	92	191	23	-	155	452	64
Horticulture	94	4	-	4	12	16	3	22	14	16	4	-	21	61	7
Tobacco	133	5	-	0	28	54	0	28	14	6	0	-	0	31	97
Other export crops	116	3	-	3	1	3	29	6	18	25	27	-	6	63	44
Farm land shares (%)	100.0	5.7	-	2.6	9.7	17.2	4.2	19.4	15.8	19.6	5.7	-	21.2	58.8	14.3
Maize	100.0	8.6	-	2.5	8.5	17.3	3.8	20.5	17.6	15.5	5.9	-	22.3	56.1	13.0
Other cereals	100.0	0.5	-	4.9	6.7	1.0	3.6	12.9	20.6	28.5	21.3	-	28.3	67.9	3.4
Root crops	100.0	0.0	-	6.2	17.8	14.8	7.8	14.5	13.6	25.4	0.0	-	25.0	69.0	6.1
Pulses & nuts	100.0	4.3	-	1.2	7.9	19.6	1.0	22.2	13.2	27.3	3.3	-	22.1	64.5	9.1
Horticulture	100.0	4.2	-	3.7	12.8	16.8	3.0	23.8	14.6	16.6	4.6	-	22.9	65.3	7.6
Tobacco	100.0	3.5	-	0.0	21.0	40.3	0.0	20.7	10.3	4.3	0.0	-	0.0	23.3	73.2
Other export crops	100.0	2.7	-	2.6	1.1	2.6	25.4	5.0	15.9	21.5	23.2	-	5.0	54.3	38.0

Source: Own calculations using official agricultural production data (MOAFS, 2007) and the 2004/05 Integrated Household Survey (IHS2).

Secondly and conversely, we find that rural farmers with more than three hectares of land tend to be more heavily engaged in export-oriented crop production, most notably that of tobacco, tea and sugarcane. While these farmers account for only 14 percent of harvested land, they account for a much larger share of the land allocated to export-oriented crops (see Table 3). We term these farmers 'large-scale' and separate them out from other rural households in the CGE model. According to IHS2, these farmers tend to allocate a smaller share of their land to non-maize food crops, such as roots, pulses and horticulture, compared to smaller-scale farmers. This suggests that although Malawian farmers devote a roughly fixed proportion of their land to maize production, they are more likely to use additional land to farm higher-value and export-oriented crops, resulting in higher farm incomes. The average large-scale farm is eight hectares in size, although this is biased upwards by a relatively small number of very large farms, such that the median farm size for this group lies well below the mean. Large-scale farms tend to have large households, with an average of 6.7 members per household. However, these households have higher-than-average per capita expenditure: US$204 per person compared to US$122 for small-scale rural farmers. Accordingly, the incidence of poverty amongst large-scale farm households is about half that of other smaller-scale farm households (30.6 percent compared to 61.0 percent for small-scale farmers). Given lower poverty rates and since there are only about 54,000 rural farm households with more than three hectares of land, only 1.7 percent of Malawi's poor people live on large-scale farms. With the exception of tobacco, large-scale export crop production is often concentrated within specific agro-ecological zones. For example, tea production takes place mainly within the Blantyre region, while sugar production occurs mainly in Salima. Again, the distinct characteristics of this farm group underline the importance of accounting for spatial differences, and furthermore justify the separate treatment of large-scale farms within the CGE model.

A majority of Malawian farmers fall between the small- and large-scale groups identified above (i.e., they harvest between 0.75 and three hectares of land). These 'medium-scale' farmers, whose plots average 1.44 hectares, tend to have more diverse cropping patterns, with similar shares of land allocated to maize and non-maize food crops (see Table 2). These farmers, who number 1.2 million households, also produce export-oriented crops, particularly tobacco and cotton. They have larger-than-average household sizes, yet their per capita expenditures are above the national average. About 56 percent of people living on medium-scale farms fall below the national poverty line; this is well above the poverty rate of large-scale farms but only slightly below that of small-scale farms. Despite the slightly lower poverty rate, the large size of this population group means that more than half of poor Malawians live on medium-scale farms in rural areas. These farmers form the third farm group identified in the CGE model. Rural agricultural production in the model is therefore disaggregated across the eight main agro-ecological regions, and across three sizes of farm household within each region, for a total of 24 rural farm groups.

Finally, the CGE model captures urban and rural non-farm households as well as urban households engaged in agricultural production. Urban agriculturalists form an important part of the agricultural sector, accounting for almost six percent of harvested land (see Table 3). These urban farm households have cropping patterns similar to those of medium-scale rural farm households, with the exception that they do not typically grow root crops, opting instead to allocate a larger share of land to maize. This is not surprising given the concentration of urban households in the central and southern regions of the country, and the fact that roots tend to be a more important food crop for farmers in the northern regions (see Table 2). Urban farm households also tend to be more heavily engaged in higher-earning off-farm activities compared to rural households. Thus, while the farm sizes and agricultural incomes of urban farmers are similar to those of medium-scale rural farmers, the average per capita income is substantially higher for urban farmers. As such, the poverty level amongst urban farm households is below that of even large-scale and non-farm rural households, both of whose poverty rates are below the rural average. Finally, as is common in most countries, poverty is lowest for urban non-farm households, which comprise six percent of the Malawian population.

Capturing changing demand patterns

Above, we examine differences in agricultural production patterns across regions and farm households. However, potential agricultural growth also depends on available market opportunities. Exploring further export opportunities could increase the size of the market for many agricultural commodities produced in Malawi, which would in turn increase farm incomes.

Nevertheless, domestic-market-oriented food crops and livestock still account for the largest share of farm incomes, especially amongst small- and medium-scale farm households. The potential demand for these commodities depends on the size of domestic and regional markets. To capture how demand is likely to change in response to rising incomes, we econometrically estimate income elasticities for the various commodities identified in the model.[4] From this we determine deviations between households' average budget shares (ABS), which show *current* spending patterns, and their marginal budget shares (MBS), which indicate how the households are likely to spend *additional* incomes. The budget shares for rural and urban households are shown in Table 4.

Table 4. Household average and marginal budget shares

	Average budget shares		Marginal budget shares	
	Rural	Urban	Rural	Urban
Agricultural goods	46.80	34.79	49.69	22.50
Maize	16.73	13.81	10.76	5.55
Rice	1.48	1.56	2.58	1.34
Other cereals	0.39	0.15	1.05	0.18
Root crops	3.54	2.12	3.12	1.23
Pulses & oils	4.21	2.56	3.24	1.55
Groundnuts	3.66	0.63	8.18	0.45
Vegetables	5.17	4.16	5.69	3.29
Fruits	2.30	1.61	2.88	1.29
Other crops	0.94	0.14	1.49	0.11
Poultry	3.74	3.80	5.28	4.11
Other livestock products	1.48	1.50	2.46	1.68
Fish products	3.16	2.75	2.96	1.72
Manufactured goods	26.35	27.58	31.67	28.05
Processed foods	7.87	9.94	10.39	8.71
Beverages & tobacco	3.39	3.62	4.61	3.68
Textiles & clothing	4.26	3.93	4.90	3.87
Wood & paper products	4.01	4.66	4.30	5.53
Chemical products	1.34	0.98	1.48	1.13
Machinery & equipment	5.48	4.45	5.99	5.13
Other goods & services	26.85	37.62	34.93	51.76
Electricity & water	7.44	6.31	8.11	7.26
Trade & transport	6.60	9.84	13.06	16.40
Hotels & catering	0.91	0.89	0.93	0.94
Communication services	1.11	6.99	3.64	12.81
Financial services	3.32	4.06	2.70	4.07
Real estate services	2.81	3.42	2.29	3.43
Community services	2.69	3.59	2.24	3.77
Health services	0.97	0.88	0.85	1.07
Education services	1.00	1.64	1.11	2.01

[4] In this study we use a semi-log inverse function (RSLI) to estimate the marginal propensity to consume.

Source: Own estimates using 2004-05 Integrated Household Survey (IHS2) (NSO, 2005) and the 2004 Social Accounting Matrix (Thurlow et al. 2008).

Focusing first on how households spend their current incomes (i.e., the ABS), Table 4 shows that rural households spend a larger share of their incomes on agricultural and food products (58 percent) compared to urban households (48 percent). Furthermore, within food expenditures, urban consumption focuses more on processed foods, whereas rural households consume relatively more unprocessed agricultural products. Despite lower food expenditures, urban consumers spend a slightly larger share of their current incomes on certain agricultural products, such as rice, poultry and other livestock, than do rural households, whereas maize, pulses and groundnuts are far more important consumption items for rural households.

Comparing the ABS and MBS indicates how households would prefer to consume as their incomes rise. For example, Table 4 shows that the MBS is lower than the ABS for maize in both rural and urban households, suggesting that while maize forms a large portion of current expenditures, households are likely to spend a smaller share of additional income on maize (i.e., maize has an income elasticity of less than one). Following this explanation, it is clear that additional *rural* incomes are more likely to be spent on horticulture, livestock products and processed foods. In contrast, a smaller portion of additional *urban* incomes will be spent on agricultural and food products, while a greater share will be directed towards non-agricultural goods and services. It is important to account for these demand dynamics given the likely market constraints for expanding the production of domestic-market-oriented crops and comparing their growth potential with that of more export-oriented crops. By incorporating econometrically estimated income elasticities, the CGE model captures not only the production patterns discussed earlier, but also the changes in demand patterns expected as per capita incomes rise in Malawi.

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) (Thurlow et al., 2008). This SAM was constructed using information from national accounts from the National Statistical Office (NSO) and the balance of payments from the Bank of

Malawi. District-level agricultural production data, area data, and market-level price data were provided by the Ministry of Agriculture and Food Security (MOAFS, 2007). Whenever production information was unavailable for certain crops, information was taken from the Food and Agriculture Organization (FAO) of the United Nations (FAO, 2007). Agricultural production is first disaggregated across regions using official production estimates from MOAFS, and then disaggregated across farm groups using information from IHS2. 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 IHS2, national accounts, and the World Bank's World Development Indicators (World Bank, 2007). On the demand-side, information on industrial technologies (i.e., intermediate and factor demand) was taken from an earlier SAM for Malawi (Chulu and Wobst, 2001), while the income and expenditure patterns for the various household groups were taken from IHS2. The CGE model is therefore based on the most recent available data for Malawi.

III. Poverty reduction under Malawi's current growth path

In this section we use the CGE and micro-simulation model to examine the impact of Malawi's current growth path on poverty reduction. This 'business-as-usual' or Baseline scenario draws on production trends for various agricultural and non-agricultural sub-sectors. Malawi experienced modest growth during 1990-2005, with national GDP growing at 2.8 percent (NSO, 2007). During this same period the agricultural sector experienced more rapid growth of 4.6 percent per year. However, agricultural growth has been erratic, with the sector contracting during four of the 15 years since 1990 (and by as much as 29 percent during 1994). Given this volatility, the baseline scenario assumes that agricultural GDP will maintain a slower but steadier agricultural growth rate of 2.8 percent per year during 2005-2015. Moreover, three-fifths of the growth since 1997 has been due to area expansion, with the rest driven by yield improvements.[5] In the Baseline scenario, we assume that land expansion will continue at a slightly more modest pace,

[5] We take 1997 as the initial year for many of the trends cited in this paper since this is the first year for which we have a complete set of district-level production data. Although agricultural production is highly erratic, production patterns in 1997 are broadly consistent with an 'average year' for the 1990s.

with about half of production increases driven by area expansion.[6] This is equivalent to an increase in harvested land of 1.2 percent per year during 2005-2015, and is lower than the rural population growth rate of 1.9 percent. As shown in Table 5, the non-agricultural sectors are expected to maintain a stronger performance over the coming decade, with manufacturing and service sectors growing slightly more rapidly than agriculture, at 3.2 and 3.7 percent, respectively.

Table 5. GDP growth rates in the Baseline and CAADP scenarios

	Initial value of GDP (Kw mil.)	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	181,515	100.0		3.24	4.78
Agricultural sub-sectors	72,871	40.1	100.0	2.77	5.99
Cereals	21,667	11.9	29.7	2.53	6.35
Maize	18,273	10.1	25.1	2.57	6.67
Rice	2,128	1.2	2.9	2.42	4.67
Other cereals	1,266	0.7	1.7	2.18	4.11
Root crops	5,064	2.8	6.9	2.41	4.51
Pulses & nuts	9,564	5.3	13.1	2.48	5.05
Pulses & oils	6,252	3.4	8.6	2.38	4.70
Groundnuts	3,312	1.8	4.5	2.67	5.68
Horticulture	7,717	4.3	10.6	2.70	5.02
Vegetables	5,141	2.8	7.1	2.62	4.79
Fruits	2,576	1.4	3.5	2.85	5.46
Export-oriented crops	18,451	10.2	25.3	3.09	7.00
Tobacco	10,686	5.9	14.7	2.89	7.32
Cotton	1,653	0.9	2.3	3.33	7.40
Sugarcane	2,746	1.5	3.8	3.28	6.27
Tea	2,943	1.6	4.0	3.48	6.25
Other crops	423	0.2	0.6	3.37	6.93
Livestock	4,466	2.5	6.1	3.50	6.29
Poultry	2,006	1.1	2.8	3.64	6.29
Other livestock	2,460	1.4	3.4	3.38	6.30
Fisheries	4,096	2.3	5.6	3.12	4.99
Forestry	1,847	1.0	2.5	2.42	4.71
Manufacturing	19,523	10.8		3.20	3.73
Food processing	7,048	3.9		3.40	4.40
Beverages & tobacco	4,281	2.4		2.34	2.48
Textiles & clothing	2,613	1.4		3.05	3.10
Wood products	1,546	0.9		3.53	4.35
Other industry	10,371	5.7		3.23	3.09
Services	78,750	43.4		3.66	4.03

[6] Most of the area expansion between 1997/98 and 2004 was driven by increases in food crop production, especially that of maize, roots, pulses and groundnuts.

Source: Own calculations from the 2004 Malawi social accounting matrix and results from the Malawi CGE and microsimulation model.

The 2.8 percent agricultural growth rate in the Baseline scenario is based on more detailed assumptions for different agricultural sub-sectors. Table 6 shows the assumptions made about each sub-sector's yield growth. We initially adopt a more modest maize yield than that observed in 2006-2007 and then assume that maize yields will grow at 1.4 percent during 2005-2015, such that Malawi achieves a sustained maize yield of 1.31 tons per hectare by 2015. While this is below the yields that have been achieved since 2006, it is consistent with Malawi's long-term trend of 1.27 tons per hectare (i.e., as seen during 1997-2006), and thus reflects expected fluctuations in the performance of the maize sector over the next decade. Similarly, for rice and other cereals, we assume that initial yields are closer to the longer-term trends at 1.17 and 0.58 tons per hectare, respectively, and that these yields rise modestly to 1.33 and 0.64 tons per hectare by 2015.

Since population growth exceeds growth in cereal yield, there will be an increasing demand for these food crops, which encourages a slightly larger allocation of land towards maize, rice, and other cereals. Thus, even though total agricultural land is projected to grow at 1.2 percent per year, we allocate a larger share of land to cereals by 2015.[7] Together, rising yields and expanding land means that predicted production of these cereal crops will grow at around 2.9 percent per year during 2005-2015. Since cereal production growth is higher than population growth, annual average per capita cereal consumption increases from 145.7 to 153.5 kilograms by 2015 under the Baseline scenario. While most of this increase in consumption is satisfied by rising domestic production, Malawi's deficit in cereals is projected to widen (in absolute terms) under the current growth path.

[7] Note that crop yields are exogenously imposed on the model, but land and labor allocation is endogenously determined within the model based on the relatively profitability of different crops and non-farm activities. Crop profitability depends on both commodity prices and demand (subsistence and marketed) and on factor prices and the resource constraints facing different farm households in the model (as initially captured in IHS2).

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 the yields of these crops will grow as fast as that of maize over the coming decade. Based on average annual yield growth rates since 1997, root crop yields in the Baseline scenario grow at 1.43 percent per year (see Table 6). This is slightly higher than the yield growth rate of maize and other cereals. However, the lower income elasticity of root crops compared to cereals causes a small decline in the share of land allocated to these crops.[9] Overall, root crop production is expected to continue growing at a rate similar to that of maize.

[8] Initial national average yields are 5.39 tons per hectare for cassava (dry-weight), 12.72 tons per hectare for Irish potatoes, and 3.94 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 yields and land area change proportionately.

[9] Although the share of land allocated to roots declines slightly, the absolute amount of land allocated to these crops rises from 327,000 to 365,000 hectares in the Baseline scenario due to total land expansion of 1.2 percent per year.

Table 6. 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 2004	% 2005-15	mt/ha 2015	% 2005-15	1000 mt 2004	% 2005-15	1000 mt 2015	% 2005-15	1000 ha 2004	% 2004	% 2015	% 2015
Cereals												
Maize	1.13	1.40	1.64	3.47	1,733	2.68	2,994	5.10	1,538	50.4	50.8	52.5
Rice	1.17	1.20	1.82	4.10	50	2.59	79	4.39	42	1.4	1.4	1.3
Other cereals	0.58	0.81	0.93	4.30	59	2.47	89	3.81	101	3.3	3.5	2.8
Root crops	5.50	1.43	8.47	4.00	1,798	2.46	2,729	3.87	327	10.7	10.5	9.3
Pulses & nuts												
Pulses & oils	0.50	1.48	0.71	3.34	245	2.49	381	4.11	493	16.2	15.8	15.4
Groundnuts	0.75	1.51	1.01	2.77	155	2.70	264	4.96	207	6.8	6.8	7.5
Horticulture												
Vegetables	11.80	1.57	15.99	2.80	252	2.77	405	4.39	21	0.7	0.7	0.7
Fruits	8.82	1.51	12.50	3.22	637	2.98	1,083	4.94	72	2.4	2.4	2.5
Export crops												
Tobacco	0.78	1.96	1.43	5.66	104	3.19	217	6.93	133	4.4	4.4	4.4
Cotton	0.85	2.45	1.57	5.79	53	3.68	113	7.06	63	2.1	2.1	2.1
Sugarcane	43.95	2.40	74.83	4.96	944	3.63	1,832	6.22	21	0.7	0.7	0.7
Tea	3.04	2.58	5.18	4.97	50	3.81	97	6.23	17	0.5	0.5	0.5
Other crops	0.45	2.39	0.81	5.51	7	3.63	14	6.79	15	0.5	0.5	0.5

Source: Yield, area and production estimates were obtained from MOAFS (2007) and the Food and Agriculture Organization (FAO, 2007).

Other crop types, such as groundnuts and horticulture, have grown especially well over the last decade. To capture these recent trends, the Baseline scenario assumes that pulses and groundnut yields will grow at around 1.5 percent per year during 2005-2015 (see Table 6). By 2015 it is expected that groundnut yields will have reached 0.88 tons per hectare, which is significantly higher than the 0.73-ton average yield for 1997-2005. Pulses will also exceed its past average yield of 0.53 tons per hectare to achieve 0.58 tons by 2015 under the Baseline scenario. Furthermore, following recent production trends, it is assumed that vegetables and fruit yields will return to their previous high yields achieved during the late-1990s.[10]

Malawi's export crops have also performed well since the 1990s, and more recent trends are equally promising. Tobacco production has risen sharply from 97,000 tons in 1997 to 121,000 tons in 2006. Similarly, sugarcane production rose from 0.78 to 0.94 million tons during 1997-2004, while tea production nearly doubled during the same period. The Baseline scenario assumes that export-oriented crops will continue to have higher growth potential than food crops. Tobacco is a particularly important agricultural sub-sector for Malawi, accounting for almost half of the country's total export earnings. Other agricultural export crops, such as cotton, tea, coffee and sugar, make up a further 25 percent of exports. Tobacco production is expected to grow faster than agriculture as a whole, at 3.19 percent per year (see Table 4). This is higher than what has been experienced since 2000, but lower than the expected growth rates of other export agricultural sub-sectors.

Livestock is another important agricultural sub-sector, generating 6.1 percent of agricultural GDP in 2004 (see Table 5). Despite difficulties in compiling reliable time-series data, recent evidence suggests that Malawi's livestock population expanded significantly between 1996 and 2004 (FAO, 2007).[11] The Baseline scenario assumes that these population trends are indicative of changes in livestock GDP and assumes that this expansion will continue. 'Other livestock' GDP in the Baseline scenario grows at 3.4 percent per year during 2005-2015, which is higher

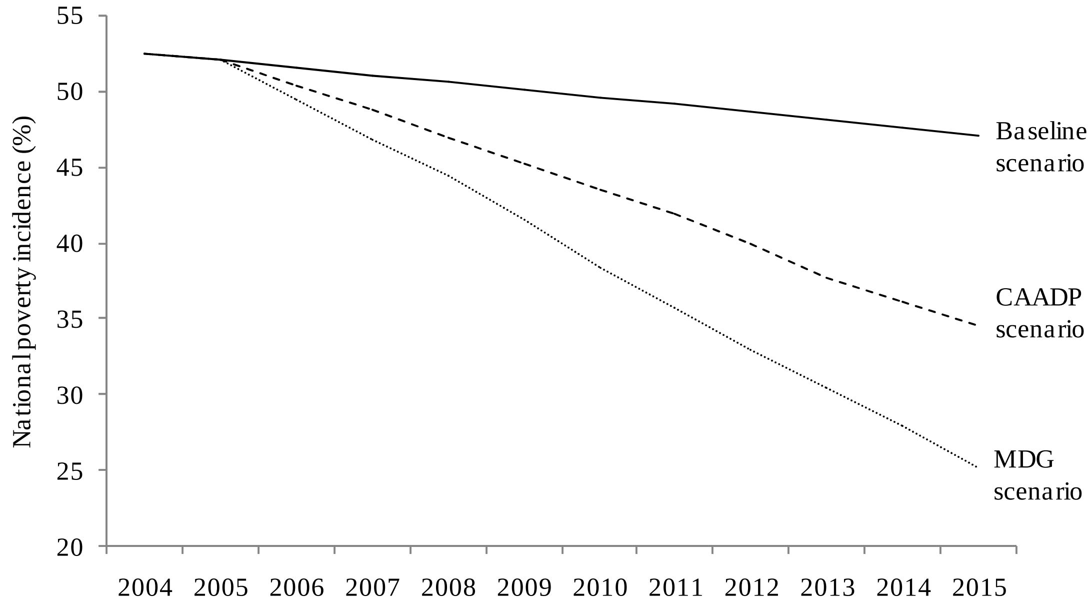
[10] Recent production of horticultural crops has been driven more by area expansion than yield improvements. However, under the Baseline scenario we assume that the latter will increasingly drive growth in these crops.
[11] The number of cattle rose from 700,000 in 1996 to 765,000 in 2004. Similarly, the number of sheep and goats rose from 93,000 and 1.26 million, respectively, in 1996 to 115,000 and 1.7 million, respectively, by 2004. Livestock equivalent units of 1:5:6 for cattle:sheep:goats are used to derive composite livestock growth.

than the livestock population's annual growth rate of 2.2 percent during 1996-2004 (measured in livestock equivalent units). The Baseline scenario also assumes more rapid growth in poultry production than recent trends suggest, due to rising urban incomes and poultry's higher income elasticity (see Table 4).

Fisheries and forestry are also important agricultural sub-sectors, together generating 8.1 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 Malawi's potential for further aquaculture (where production now stands at around 50,000 tons but with an estimated potential of 78,000 tons), and the offsetting resource constraints facing capture fisheries. For the forestry sub-sector, the Baseline scenario assumes that value-added in this sub-sector will continue to grow at the more modest pace of 2.4 percent per year.

Drawing on the above trends, the CGE model simulation results indicate that, with modest growth in the agricultural sector and more rapid growth in the non-agricultural sectors, overall national GDP will grow at an average rate of 3.2 percent during 2005-2015. This closely matches the average GDP growth rate of 2.8 percent experienced during 1990-2005. With population growth at about 2.2 percent per year, per capita GDP grows at 1.0 percent. With rising per capita incomes, the CGE model indicates that poverty will decline. However, this decline in poverty will remain modest, with national poverty falling from 52.4 percent in 2004 to 47.0 percent in 2015 (Figure 2). With such modest poverty reduction and an expanding population, the absolute number of poor people in Malawi would increase from 6.38 million in 2004 to 7.04 million by 2015. However, balanced growth across both agricultural and non-agricultural sectors as well as gradual urbanization means that national income growth will be quite evenly distributed across rural and urban areas. Accordingly, urban poverty falls from 25.4 to 23.7 percent by 2015, while rural poverty declines from 55.9 to 50.2 percent during the same period. However, the slow poverty reduction under the Baseline scenario and the persistent high levels of poverty, especially in rural areas, underlines the need to accelerate growth and poverty reduction if Malawi is to come close to achieving the Millennium Development Goal of halving poverty by 2015.

Figure 2. National poverty rate under alternative agricultural growth scenarios



Source: Results from the Malawi CGE and micro-simulation 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 Malawi's current growth path on poverty reduction. In this section we examine the potential contribution of different agricultural sub-sectors toward helping Malawi achieve the six percent agricultural growth target identified by the CAADP initiative. Accelerated crop production is modeled by increasing yields in order to achieve 'reasonable' yield improvements by 2015. Maximum potential yields are taken from field trials performed by Malawi's Agricultural Research and Extension Trust (ARET, 2003). However, it is not expected that Malawi will achieve and sustain the high yields predicted under the more ideal conditions of controlled field trials, nor is Malawi expected to achieve complete improved seed and technology uptake 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 1.13 and 1.31 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 1.4 percent per year to 3.5 percent per year (see Table 6). This implies that national average maize yields will rise consistently over the next ten years to reach 1.64 tons per hectare by 2015. This is well below the maximum potential yields identified by field trials, which is ambitiously set at five tons per hectare (see Table 7). However, it is equivalent to Malawi reaching and *sustaining* the high maize yields achieved during 2006-2007.

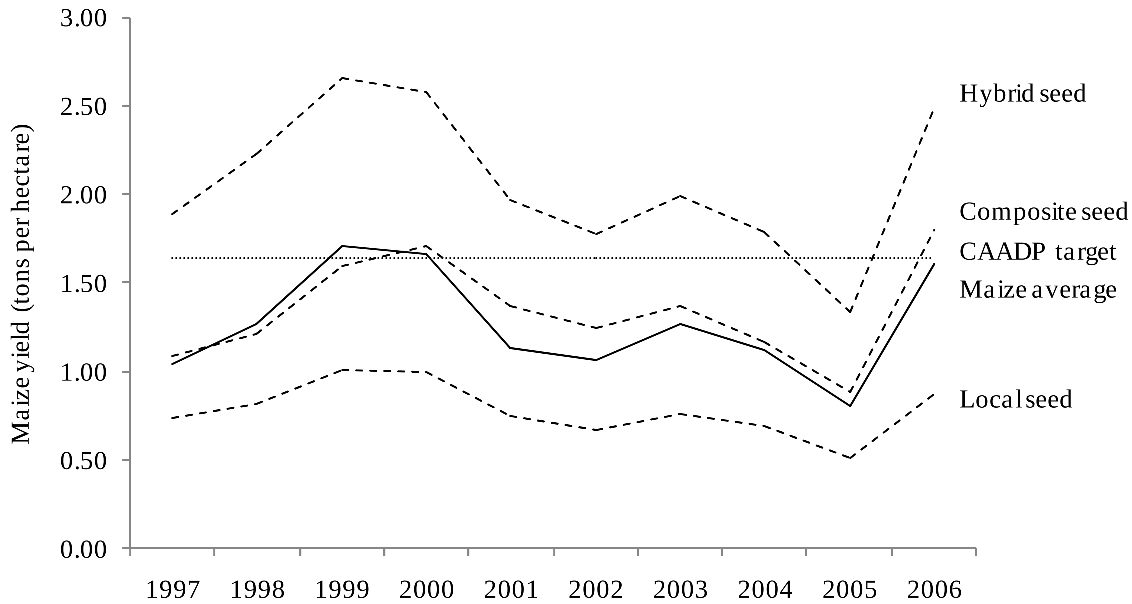
Table 7. Comparison of crop yields under model scenarios and research institute field trials

	Modeled crop yields (mt/ha)				Potential yield from research field trials (mt/ha)
	Initial value 2004	Baseline scenario 2015	CAADP scenario 2015	MDG1 scenario 2015	
Maize	1.13	1.31	1.64	1.85	5.00
Beans	0.46	0.54	0.66	0.75	2.50
Soya beans	0.76	0.90	1.09	1.24	2.25
Groundnuts	0.74	0.88	1.01	1.15	2.50
Cassava	5.39	6.30	8.30	9.28	10.00
Cotton	0.84	1.10	1.57	1.93	2.50
Paprika	0.29	0.38	0.53	0.70	1.30
Burley tobacco	0.78	0.97	1.43	1.75	1.80

Source: Agricultural Research and Extension Trust (ARET, 2003) and results from the Malawi CGE and micro-simulation model.

However, while acknowledging the less optimistic estimates of potential maize yields compared to field trials, recent trends in maize yields indicate that sustaining 1.6 tons per hectare by 2015 poses considerable challenges. According to MOAFS statistics, national maize yields using local seeds have averaged only 1.27 tons per hectare. This can be seen in Figure 3, which shows maize yields under different seed types over the past ten years. It is clear that maize yields for local seed varieties fall far below the CAADP target maize yield. With the exception of two of the ten years shown in the figure, the yields from composite seeds have also fallen short of the target yield. This implies that the government would not only have to improve the distribution of hybrid and composite seeds, but also improve current farming practices and the distribution of other inputs if it is to help farmers significantly increase maize yields by 2015. For these reasons, 1.64 tons per hectare is considered a reasonable, albeit challenging, maize yield target. Table 7 provides similar comparisons between modeled and field trial yields for other selected crops.

Figure 3. Recent maize yields under local and improved seeds, 1997-2006



Source: Agricultural Research and Extension Trust (ARET, 2003) and results from the Malawi CGE and micro-simulation model.

Table 8 shows the 11 different scenarios designed for this analysis. In Scenarios 1-10, we target specific groups of crops or agricultural sub-sectors. For instance, in the 'maize-led growth' scenario, we achieve the yield target shown in Tables 6 and 7 by increasing land productivity solely for the maize crop. 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 5. In Scenario 11, 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 8. Model growth scenarios

	Maize-led	Other-cereals-led	Root-crop-led	Pulses-led	Horti-culture-led	Tobacco-led	Other-export-crop-led	Live-stock-led	Fisheries-led	Forestry-led	CAADP scenario
	1	2	3	4	5	6	7	8	9	10	11
Maize	×										×
Rice		×									×
Other cereals		×									×
Root crops			×								×
Pulses & oils				×							×
Groundnuts				×							×
Vegetables					×						×
Fruits					×						×
Tobacco						×					×
Cotton							×				×
Sugarcane							×				×
Tea leaf							×				×
Other export crops							×				×
Poultry								×			×
Other livestock								×			×
Fisheries									×		×
Forestry										×	×

Source: The Malawi CGE and micro-simulation model.

Agriculture's current poor performance means that achieving the CAADP target of six percent growth poses a substantial challenge. Malawi needs to more than double its existing agricultural growth rate of 2.8 percent per year. However, our modeling indicates that it will be possible to reach the CAADP growth target. Based on the crop yield and agricultural productivity potentials identified at the sub-sectoral level, the CGE model indicates that Malawi could reach an average agricultural growth rate of six percent during 2005-2015 (see Table 5). Since agriculture is two-fifths of the Malawian economy, this acceleration of agricultural growth would significantly increase the national GDP growth rate from its current 3.2 percent to 4.8 percent per year. Faster agricultural growth will also stimulate additional growth in the non-agricultural sectors, both by increasing final demand for non-agricultural goods and by lowering input prices and fostering upstream processing. For instance, under the CAADP growth scenario, the GDP growth rate of the food-processing sector would increase from 3.4 percent under the Baseline scenario to 4.4 percent per year. Increased agriculture also generates additional demand for chemicals and transport services, which will further stimulate growth in other manufacturing and service sectors. Achieving the CAADP agricultural growth target, therefore, has strong economy-wide growth-linkage effects for non-agricultural sectors.

Impact on incomes and poverty

In this model, acceleration of agricultural growth to six percent per year and the spillover effects into non-agriculture causes poverty to decline by a further 12.5 percentage points. This is shown in Figure 2, where the share of Malawi's population under the poverty line is 34.5 percent by 2015 under the CAADP scenario compared to 47.0 percent under the Baseline scenario. Thus, taking population growth into account, achieving the CAADP growth target lifts an additional 1.88 million people above the poverty line by 2015, and would be sufficient to reverse current trends by substantially reducing the absolute number of poor people in Malawi by 2015.[12] Food security would also improve, with annual average per capita cereal consumption rising from 153.5 kilograms under the Baseline scenario to 176.7 kilograms by 2015 under the CAADP scenario.

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[12] The number of poor people in Malawi in 2004 was 6.38 million. This number rises to 7.04 under the Baseline scenario, and falls to 5.17 and 3.78 million under the CAADP and MDG scenarios, respectively.

Faster agricultural growth benefits a majority of households. However, not all households will benefit equally from Malawi's achievement of the crop yields and sub-sector growth rates targeted under the CAADP growth scenario. Table 9 shows the changes in production, incomes and poverty rates for different farm types and household groups in the model. Part 1 of the table gives changes in the real value of production for different farm household categories in the typology. For example, the growth rate of agricultural production for urban farm households rises by 3.25 percentage points, from 2.35 percent growth per year under the Baseline scenario to 5.6 percent under the CAADP scenario. In contrast, rural farm production increases by only 2.4 percentage points. This is because more than a quarter of the additional growth forecast under the CAADP scenario is driven by expanding maize production, which shows a GDP growth rate increasing from 2.6 to 6.7 percent per year (see Table 5). Accordingly, urban farmers, who allocate a greater share of land to maize, experience the largest increase in production under the CAADP scenario (see Tables 2 and 3).

As indicated in Tables 2 and 3, higher-value crops are typically grown on larger-scale farms. As such, larger-scale farms benefit more from 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 regional farm types. For example, Salima benefits more from more rapid growth in sugarcane; Blantyre and Ngabu benefit more from expanding tea and cotton production; and Lilongwe, Karonga and Mzuzu benefit more from faster tobacco growth. Taken together, these findings indicate that increases in export crops could generate the same additional agricultural production as maize-led growth, at least at the national level.

With the exception of larger-scale and urban producers, most rural farms benefit equally under the CAADP scenario. However, despite this even distribution of benefits, Figure 4 indicates that the sources of additional production vary across farm types. Not surprisingly, households that already depend heavily on maize tend to benefit more from maize-led growth. However, there are two forces driving changes in production following sub-sector-specific yield improvements. First, increasing yields directly affect farm incomes by increasing the quantity of output that a farm produces using the same quantity of factor inputs. However, increased production faces demand constraints, such that prices typically fall following yield increases. Thus, the direct impact of improved crop yields for a specific farm 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. Thus, the *indirect* impact of crop yield improvements is the potentially positive impact of reallocating land to other crops. It is therefore important to note that although Figure 5 indicates the importance of maize-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 facing better demand conditions. The CGE model captures both direct and indirect effects in its assessment of the effects of improved yields in different sub-sectors.

Table 9. 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 million)				
	National	103,110	2.63	5.08	2.45
	Urban farm	4,780	2.35	5.60	3.25
	Rural farm	98,340	2.64	5.05	2.41
	Karonga	3,300	2.46	4.74	2.28
	Mzuzu	12,930	2.63	5.23	2.60
	Kasungu	19,760	2.66	4.93	2.27
	Salima	7,650	3.03	5.52	2.50
	Lilongwe	21,410	2.56	4.83	2.27
	Machinga	12,080	2.47	5.07	2.60
	Blantyre	17,390	2.70	5.07	2.37
	Shire Valley	3,820	2.68	5.38	2.70
	Small-scale (<0.75ha)	15,540	2.31	5.14	2.83
	Medium-scale (0.75-3ha)	50,860	2.44	5.01	2.57
	Large-scale (>3ha)	31,920	3.11	5.08	1.97
Part 2: Incomes	Per capita incomes (Kw)				
	National	17,395	0.73	1.84	1.11
	Urban	69,582	0.22	1.22	1.00
	Farm	54,717	0.52	1.57	1.05
	Non-farm	82,891	-0.02	0.95	0.97
	Rural	10,678	0.81	2.01	1.20
	Karonga	11,566	0.93	2.12	1.20
	Mzuzu	11,881	0.98	2.44	1.47
	Kasungu	12,748	0.90	2.22	1.32
	Salima	7,045	1.01	2.33	1.32
	Lilongwe	8,610	0.87	2.12	1.24
	Machinga	6,575	0.84	2.10	1.26

Blantyre	10,569	0.81	1.96	1.15
Shire Valley	6,156	0.89	2.17	1.28
Non-farm	44,014	-0.01	0.87	0.88
Small-scale (<0.75ha)	5,450	0.80	2.04	1.24
Medium-scale (0.75-3ha)	9,185	0.82	2.08	1.26
Large-scale (>3ha)	47,749	1.16	2.46	1.30

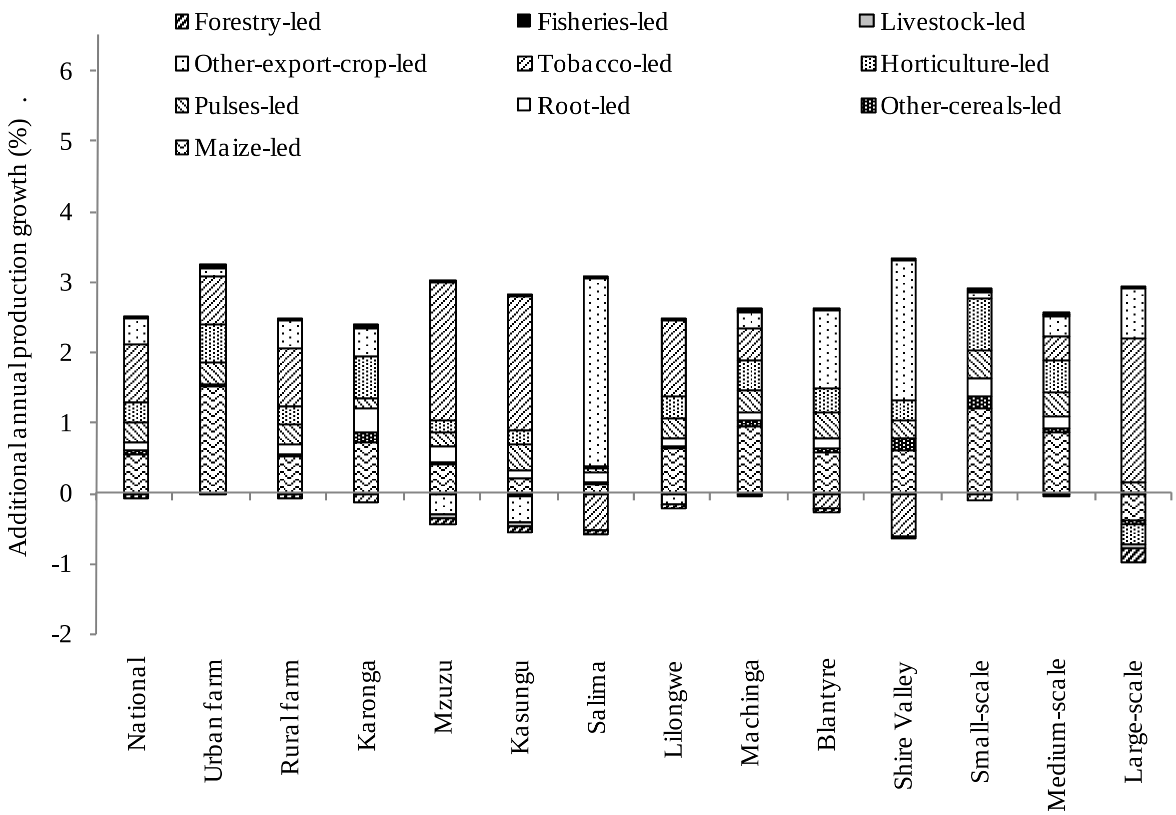
Source: Results from the Malawi CGE and micro-simulation model.

Table 9 continued. Income growth and poverty reduction in the model

		Initial poverty rate 2004	Final poverty rate under… Baseline scenario 2015	CAADP scenario 2015	Additional poverty reduction 2015
Part 3: Poverty	Poverty incidence (%)				
	National	52.41	47.01	34.49	-12.52
	Urban	25.40	23.71	17.71	-6.00
	Farm	30.03	26.09	20.56	-5.53
	Non-farm	21.23	21.67	15.27	-6.41
	Rural	55.86	50.20	36.78	-13.42
	Karonga	62.83	55.35	41.94	-13.42
	Mzuzu	54.99	49.11	33.76	-15.36
	Kasungu	43.04	35.18	19.96	-15.22
	Salima	56.33	47.37	32.45	-14.92
	Lilongwe	46.97	41.44	28.25	-13.19
	Machinga	67.72	63.22	50.24	-12.98
	Blantyre	61.40	56.07	43.13	-12.94
	Shire Valley	70.56	64.89	48.77	-16.11
	Non-farm	37.50	38.06	33.50	-4.56
	Small-scale (<0.75ha)	61.03	56.14	42.35	-13.79
	Medium-scale (0.75-3ha)	55.60	49.15	35.01	-14.14
	Large-scale (>3ha)	30.60	23.70	14.49	-9.22

Source: Results from the Malawi CGE and micro-simulation model.

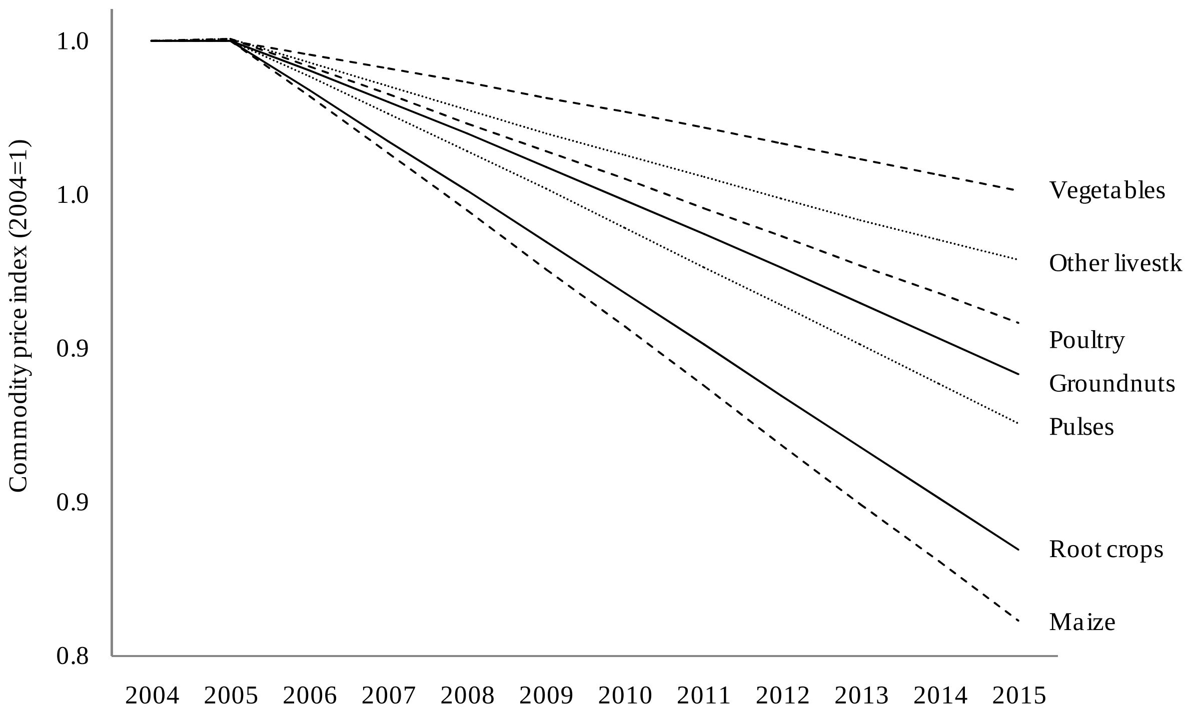
Figure 4. Sources of additional production growth by farm household group



Source: Results from the Malawi CGE and micro-simulation 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. Maize and root crops have low income elasticities (0.6 and 0.7 respectively) and the latter has weaker 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. Groundnuts, which have a slightly higher income elasticity (1.0) and stronger linkages to food processing, also show price declines under the CAADP scenario, but their prices fall by less than those of maize or root crops. Finally, the higher income elasticity of livestock and poultry (1.34 for both categories) means that demand for these commodities grows more rapidly than incomes, thereby preventing prices from falling far under the CAADP scenario.

Figure 5. Relative producer price changes under the CAADP scenario

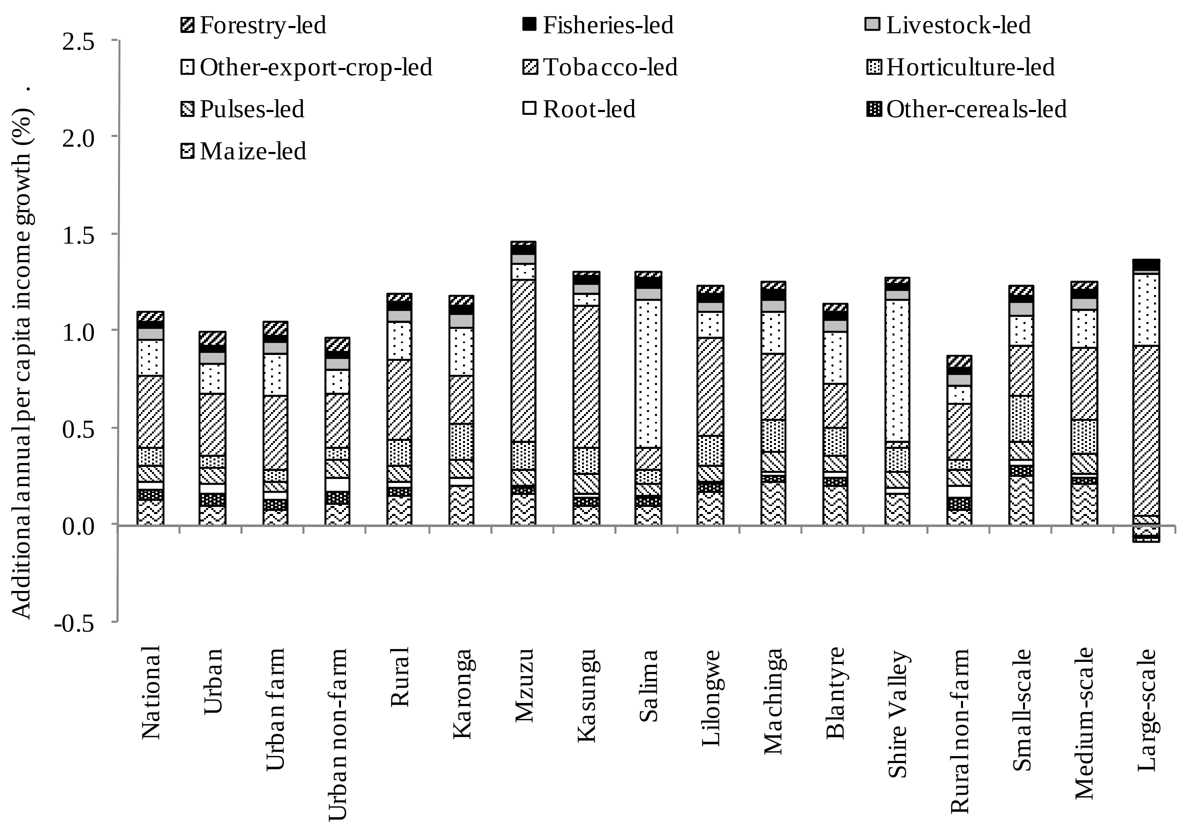


Source: Results from the Malawi CGE and micro-simulation model.

Finally, the CGE model takes into account potential competition over limited agricultural resources. For example, farmers in Salima and Ngabu appear to be hurt by tobacco-led growth (see Figure 4). However, this decline in production for non-tobacco producing regions reflects the shift in nationally mobile resources towards the production of export crops (i.e., unskilled labor and agricultural capital). The CGE model captures how the increased growth potential for tobacco causes farm labor and capital to shift towards the production of export crops on larger-scale farms, causing declines in production by other farm types. However, these resource reallocations or indirect effects from export-crop-led growth are relatively small; the model results indicate that rural and small-scale farms stand to benefit greatly from increasing agricultural growth to the six percent CAADP target.

The model results also indicate that rural household incomes increase more than those of urban households under the CAADP growth scenario. This can be seen in Table 9, which shows that per capita household incomes for rural households grow by an additional 1.2 percentage points per year compared to one percentage point for urban households. This is because agricultural incomes, which rise under the CAADP scenario, are more important for rural livelihoods. This is also reflected by changes in poverty. Rural poverty declines by an additional 13.4 percent, while urban poverty declines by only six percentage points (see Part 3 of Table 9). Therefore, accelerating agricultural growth under the CAADP scenario not only reduces poverty in both urban and rural areas, it also helps correct some of Malawi's current urban income bias. However, this is driven by strong rural income growth in certain parts of the country. Household incomes in the Mzuzu region are projected to grow by an additional 1.5 percentage points, compared to only 1.1 percentage points for households in Blantyre region. Differences in household outcomes can be explained by considering the sources of income growth across household groups.

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



Source: Results from the Malawi CGE and micro-simulation 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 rising incomes for rural farm households in Mzuzu and Kasungu are driven by growth in tobacco, with almost three quarters of the additional incomes being generated by this crop alone. In contrast, households in Salima benefit more from expanded sugarcane production. This is not surprising given the current concentration of Malawi's sugarcane production amongst larger-scale farmers in this region (see Tables 2 and 3).

In summary, the CGE model results indicate that it is possible for Malawi to reach the CAADP target of six percent agricultural growth. However, given the current performance of the agricultural sector, achievement of the ambitious CAADP growth target will require additional growth in all crops and sub-sectors; Malawi cannot rely on only maize or tobacco to achieve aggregate agricultural growth targets. If the crop- and sub-sector-level targets can be achieved, then the resulting broader-based agricultural growth is likely to benefit households in both rural and urban areas. However, the high growth potential of certain export crops and better market conditions in certain parts of the country may cause uneven income growth and poverty reduction. Finally, the fisheries and livestock sub-sectors will also have to contribute to agricultural growth and poverty reduction, albeit to a lesser extent than crops.

Comparing sub-sector growth in terms of growth and poverty reduction

The previous section highlights the potential contributions of different crops and sub-sectors toward increasing agricultural growth and poverty reduction. However, the different sizes of these sub-sectors makes it difficult to compare the effectiveness of sectoral growth in reducing poverty. Understanding how growth-poverty linkages vary at the sub-sector and household level is important for designing pro-poor growth strategies. In this section, we calculate poverty-growth elasticities that allow us to compare the 'pro-poorness' of growth in alternative sub-sectors. These elasticities are endogenous outcomes from the model results. Growth affects individual households differently due to heterogeneity across household groups. The above analysis has shown how, with differences in household and farm characteristics, changes in income and consumption across households can differ considerably from average changes at the national level. Thus, to capture growth-poverty linkages, changes in the distribution of incomes, which are primarily determined by a country's initial conditions, need to be understood. In the previous section, we saw how households in Blantyre have better opportunities to produce higher-value tea crops, and are thus better positioned to benefit from export-led agricultural growth. However, per capita incomes are higher for households in this region, and export-crop-producing households are typically less poor than other rural households (see Table 9). Thus, agricultural growth driven by export crops may have less of an impact on poverty, especially amongst poorest households. In contrast, food crops tend to be a more important source of agricultural incomes for poorer small-scale farm households in more remote areas of the country. Thus, growth in food crops is expected to be more effective at reducing poverty than similar growth in export crops.

The poverty-growth elasticity used in this study measures the responsiveness of the poverty rate to changes in per capita agricultural GDP growth. More specifically, the elasticity measures the percentage change in the poverty rate caused by a one percent increase in agricultural GDP per capita. Table 10 shows the calculated poverty-growth elasticities under the different growth scenarios. The results indicate that agricultural growth driven by maize, pulses, groundnuts and horticulture is more effective at reducing poverty than growth in export crops.[13] For example, a one percent increase in maize GDP causes the national poverty headcount rate (P0) to decline by 0.74 percent, while a similar degree of growth in other export crops, such as tea and sugarcane, causes the poverty rate to decline by only 0.57 percent. This emphasizes the importance of maize for poorer households in Malawi, both as a source of income and as an item in households' consumption baskets. Although root crops are less effective at reducing the incidence of poverty, they are somewhat more effective at reducing the severity of poverty among Malawi's poorest households, as reflected in the crop's relatively large poverty gap (P1) and squared-gap (P2) elasticities. The importance of the food crops in reducing urban poverty is also shown in the table, which indicates that the national elasticity for maize-led growth is higher than the rural elasticity. Thus, the elasticity is higher in urban than in rural areas; this is largely because maize growth reduces urban poverty by reducing urban food prices.

[13] The poverty-growth elasticity for livestock may be underestimated, since the model does not capture the use of livestock to facilitate production in other agricultural sub-sectors (e.g. animal traction for land preparation). Instead, the model treats livestock solely as producers of final products, such as meat and dairy.

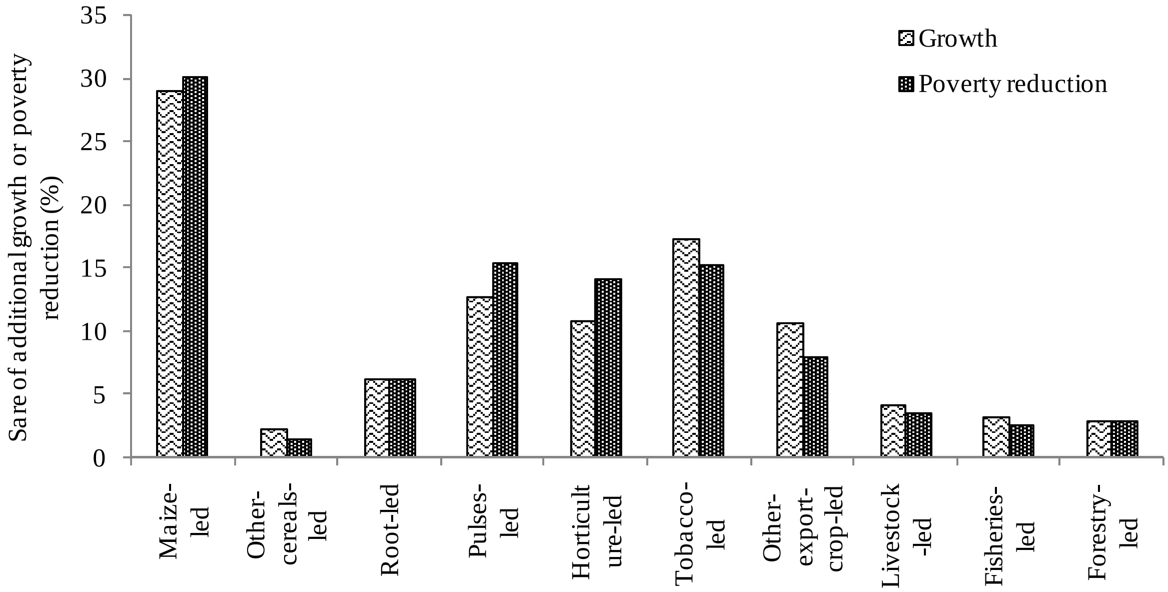
Table 10. Poverty-reduction-growth elasticities under alternative agricultural growth scenarios

	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
Maize-led	-0.742	-1.173	-1.474	-0.721	-1.195	-1.503
Other-cereals-led	-0.430	-0.672	-0.833	-0.384	-0.641	-0.802
Root-led	-0.621	-1.048	-1.312	-0.592	-1.048	-1.317
Pulses-led	-0.778	-1.237	-1.514	-0.779	-1.265	-1.549
Horticulture-led	-0.854	-1.360	-1.694	-0.866	-1.405	-1.747
Tobacco-led	-0.621	-0.855	-1.009	-0.600	-0.841	-0.993
Other-export-crop-led	-0.572	-0.836	-1.051	-0.529	-0.825	-1.041
Livestock-led	-0.335	-0.515	-0.637	-0.312	-0.506	-0.629
Fisheries-led	-0.512	-0.846	-1.078	-0.499	-0.859	-1.096
Forestry-led	-0.437	-0.715	-0.891	-0.385	-0.675	-0.850

Source: Results from the Malawi CGE and micro-simulation model.

An alternative representation of poverty-growth linkages is shown in Figure 7, which compares each sectoral scenario's contribution to agricultural growth and poverty reduction. The higher-than-average poverty-growth elasticities of maize-, pulses- and horticulture-led growth can be seen in the fact that these sectors contribute more to poverty reduction than growth under the CAADP scenario. However, Malawi 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 tobacco has a lower poverty-growth elasticity than horticulture, the rapid growth potential of both sectors means that they account for a similar share of overall poverty reduction under the CAADP scenario. Conversely, a growth strategy should not overly rely on high growth potential sectors without accounting for their potential contributions to the national economy. For example, the small size of the pulse and nut sectors means that even though they have higher poverty-growth elasticities than maize, the small sizes of the sectors will limit their ability to substantially raise national agricultural GDP.

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



Source: Results from the Malawi CGE and microsimulation model.

Finally, agriculture's proponents often cite the sector's strong linkages to the rest of the economy as justification for promoting agricultural growth (Diao et al., 2007). Table 11 measures agriculture's growth-linkage-effects at the sub-sector-level. For example, the maize-led growth scenario causes agricultural GDP to increase by Kw11.5 billion (see Column 5). However, total GDP increases by more than this amount due to backward and forward production and consumption linkages. For example, increasing maize production stimulates growth in food processing within the manufacturing sector, while also reducing food prices and increasing real incomes that are then spent on non-agricultural commodities. The overall GDP therefore increases by Kw12.8 billion, which means that for every one kwacha increase in agricultural GDP driven by maize-led growth, there is an additional 0.11 kwacha increase in non-agricultural GDP (i.e., a growth-linkage ratio of 1.11). Comparison of these ratios across model scenarios suggests that even through fisheries-led growth contributes less to agricultural growth under the CAADP scenario (see Figure 8), it is more effective at stimulating non-agricultural growth than export-crop-led growth. This is because latter has weaker economy-wide growth-linkages, reflecting the fact that most export crops are exported directly as raw agricultural materials rather than contributing to upstream production.

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 (1)	2015 (2)	(1) / (2)
Maize-led	18,273	2.57	6.95	12,819	11,539	1.11
Other-cereals-led	3,394	2.33	4.30	1,540	867	1.78
Root-led	5,064	2.41	4.03	3,036	2,392	1.27
Pulses-led	9,564	2.48	4.78	6,165	4,888	1.26
Horticulture-led	7,717	2.70	6.96	4,915	4,196	1.17
Tobacco-led	10,686	2.89	8.65	7,133	6,765	1.05
Other-export-led	7,765	3.37	7.74	3,421	3,218	1.06
Livestock-led	4,466	3.50	6.13	1,649	1,629	1.01
Fisheries-led	4,096	3.12	4.21	904	778	1.16
Forestry-led	1,847	2.42	8.03	1,188	1,144	1.04

Source: Results from the Malawi CGE and microsimulation model.

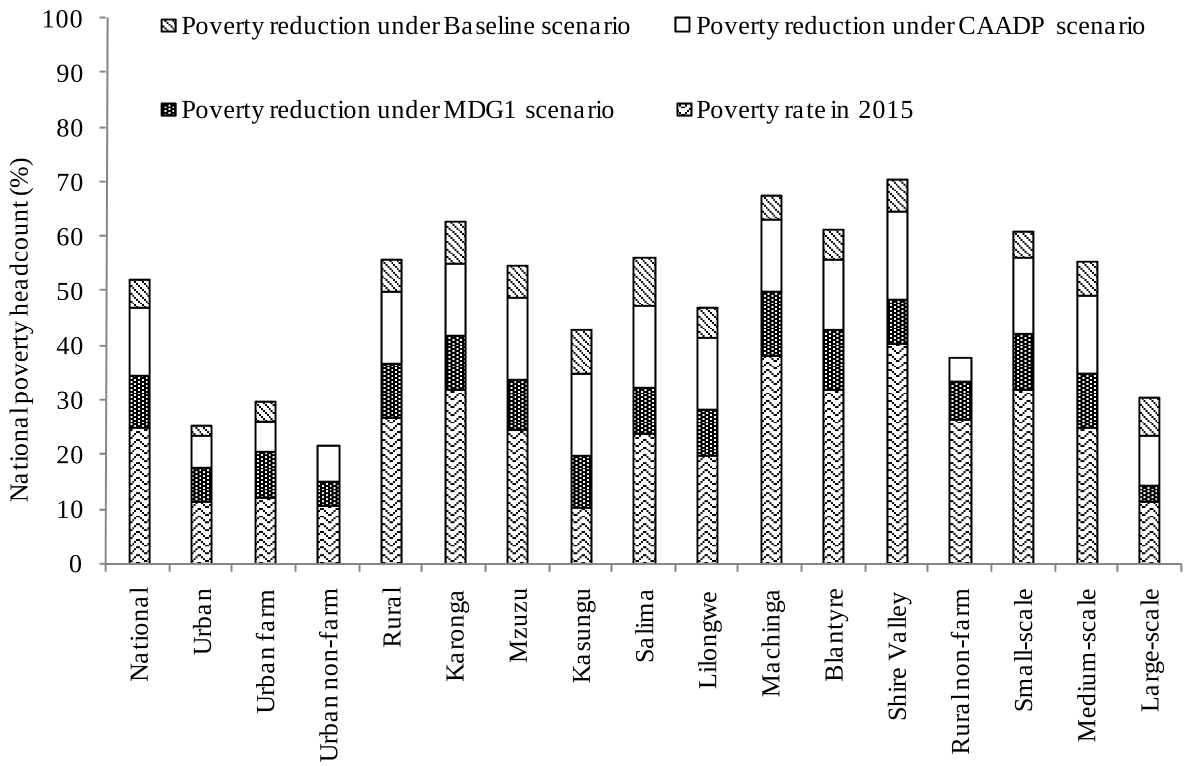
The previous section concluded that in order to substantially increase agricultural growth and reach the CAADP growth target, it will be necessary to encourage growth in most agricultural sub-sectors. However, the poverty-growth elasticities, sectoral growth potentials, and size- and linkage-effects presented in this section suggest that the highest priority should be given to improving maize and tobacco yields, while also encouraging pulses and horticultural 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, this change will achieve only three-fifths of the first Millennium Development Goal (MDG1) of halving the 1990 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 7 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 Malawi will be targeted through the agricultural sector, without explicitly modeling accelerated growth in the non-agricultural sectors. In this section, therefore, we model a more ambitious growth scenario in which the agricultural sector comes closer to achieving its maximum yield targets, and more rapid growth is seen in the non-agricultural sectors. The modeled crop yield targets for the MDG1 scenario are shown in the fourth column of Table 7. For some crops, such as cassava and burley tobacco, the MDG1 scenario is almost equivalent to meeting maximum potentials. While maize yields remain below the highest potentials identified by ARET, the MDG1 scenario is equivalent to planting all maize land under hybrid seeds (see Figure 3). Thus, the MDG1 scenario is ambitious, not necessarily because of its target yields, but more because of the short period time available for implementation (less than ten years).

The model results indicate that if Malawi achieves the more ambitious yield targets outlined above, then agriculture would reach an average annual growth rate of 6.9 percent per year during 2005-2015. However, such rapid agricultural growth is still insufficient if Malawi is to achieve MDG1. In total, national GDP growth would need to be sustained at 7.4 percent per year over the coming decade, implying that non-agricultural GDP would need to grow at 7.6 percent per year. As shown in Figure 8, under a relatively balanced annual GDP growth rate of 7.4 percent, the national poverty headcount rate would be reduced from 54.0 percent in 1991 and 52.4 percent in 2004 to 25.2 percent in 2015, which is close to the MDG1 target. The CGE model results also indicate that, although reaching the MDG1 poverty target will generate broad-based poverty reduction, poverty would still remain high amongst certain household groups, especially in rural areas. For instance, two fifths of the population living in the rural regions of Machinga, Blantyre and Ngabu will remain poor even under the MDG1 scenario. This means that by 2015, more than half of Malawi’s poor population will be living within these three southern regions. In contrast, poverty amongst urban households will decline to 11.4 percent, and poverty in the Kasungu region is projected to fall by three-quarters (due primarily to faster tobacco growth). This highlights the importance of increasing investments in the agricultural sector as well as targeting pro-poor interventions.

Figure 8. Additional poverty reduction under the Millennium Development Goal scenario



Source: Results from the Malawi CGE and microsimulation model.

VI. Agricultural spending required to reach CAADP targets

Achieving the agricultural growth needed to meet both CAADP and MDG1 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 Malawi's stated growth and poverty reduction objectives? How should public investment resources be allocated among the 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 the investments be financed? In this section, we consider the public agricultural expenditure (PAE) required to achieve the growth targets described in the previous sections.

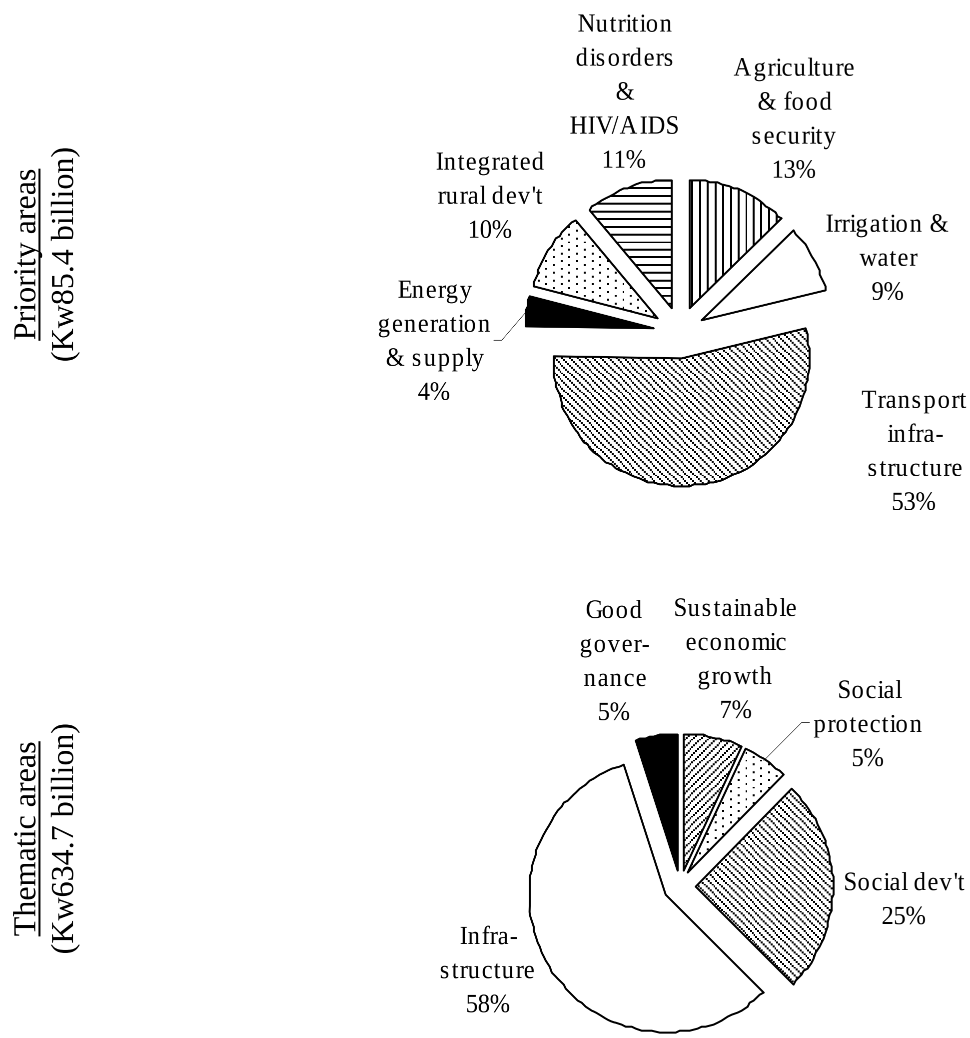
The CGE modeling indicates that Malawi's agricultural sector could grow at six percent per year over the next decade if certain crop- and other sub-sector-level growth targets within agriculture can be achieved. The Government of Malawi seems committed to increasing its investment in agriculture, and is one of a few African governments currentlyallocating more than five percent of its budgetary resources to the sector (AU 2006). To promote general agricultural growth and poverty reduction in Malawi, the Government of Malawi and its development partners have implemented more than 150 agricultural development programs since 2000. Furthermore, the government is planning to spend Kw634.7 billion over the next five years under its MGDS for overall economic growth and development (GOM 2006). About 13.5 percent of the resources have been earmarked for priority areas covering agriculture and food security, irrigation, transport infrastructure, and integrated rural development (see Figure 9).

While these interventions and investments will provide a better foundation for achieving higher agricultural growth, it remains unclear whether the planned investments will be sufficient to meet the desired growth and poverty-reduction targets. Detailed knowledge on the rates of return to different types of public investment is needed to answer this question. Due to limited data for estimating the returns to different types of investment for Malawi specifically, we use the results from a cross-country econometric analysis (Benin et al., 2007) and other research (Fan et al. 2004; Fan and Rao, 2003) to assess the aggregate PAE required to reach the CAADP and MDG1 growth targets. First, we examine recent trends in PAE to establish a baseline scenario for the required spending.

Trends in public agricultural expenditure

Government financial statistics obtained from the International Monetary Fund (IMF, 2007) and the Government of Malawi's national statistical office (NSO, 2007) show that the share of public resources allocated to the agricultural sector has risen in recent years, and has returned to the relatively higher levels achieved in the 1990s (see Table 12). Over the last five years, the share of PAE in total government expenditure has averaged about eight percent per year, which is high compared to that of many other African countries (AU, 2006). While the government's non-agricultural and total spending grew at about 5.7 percent per year in real terms over recent years, PAE grew by about 12.4 percent per year, reflecting the government's commitment to the sector. Unfortunately, there was no information available on spending in specific sub-sectors (i.e. crops, livestock, fishery, forestry) or functions (research, extension, irrigation, input support, etc.).

Figure 9. Expected allocation of public resources under Malawi's MGDS, 2006/07–2010/11



Source: Malawi Growth and Development Strategy (GOM, 2006).
Notes: Total resource envelope is Kw634.7 billion (2005/06), with 13.5 percent allocated to the priority areas.

Table 12. Government spending on agriculture and non-agriculture sectors in Malawi, 1975-2005

	1975	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005
Expenditure (Billion 2004 Kw)											
Total	38.5	41.0	38.8	34.7	49.5	39.9	40.6	44.7	44.3	59.5	59.2
Agriculture	5.0	4.2	3.3	3.8	5.5	3.5	2.0	3.9	2.9	4.2	6.5
Non-agriculture	33.5	36.8	35.5	30.8	43.9	36.3	38.6	40.8	41.4	55.4	52.7
Expenditure shares (%)											
Agricultural expenditure in total expenditure	13.0	10.2	8.4	11.1	11.1	8.8	4.9	8.7	6.6	7.0	11.0
Agricultural expenditure in agricultural GDP	17.1	9.9	7.2	7.5	13.3	5.3	3.2	6.1	4.3	6.0	10.3
Non-agricultural expenditure in non-agricultural GDP	60.8	56.7	48.4	37.7	39.0	30.3	33.6	34.5	33.0	40.3	35.4
Total expenditure in total GDP	45.6	38.3	32.7	26.1	32.1	21.4	22.9	24.5	22.9	28.7	27.9

Sources: Government Finance Statistics (IMF, 2006; NSO, 2007)

Estimated spending required for agricultural growth

Methods and data

How much public agricultural spending is required to achieve the CAADP and MDG1 growth targets? To answer this question, we need to know the annual growth rate in agricultural expenditure ($\dot{E}_{agexp}$) required to achieve a particular growth rate in agriculture (θ_{ag}), which can be expressed as:[14]

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

where ε_{agexp} is the 'agricultural growth-agricultural expenditure elasticity'; ε_{nagexp} is the 'agricultural growth-non-agricultural expenditure elasticity'; $\dot{E}_{nagexp}$ is the annual growth rate in non-agricultural expenditure; $_{nag,ag}$ is the multiplier effect or the linkages (i.e. trade-offs and complementarities) between agriculture and non-agricultural expenditure; 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 the different types of public investment, private investment, and agricultural production (for example see Fan et al. 2000 and 2004). The main concept underlying such estimation is that public and private capital are complements, meaning that increases in public capital stocks raise the productivity of all factors in agricultural production, which in turn leads to higher farm wages, incomes and poverty reduction. 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, repair shops) and for urban industrial and service development. The development of the non-farm rural sector can have multiplier effects if it expands the market opportunities for farmers and creates off-farm employment. The latter is particularly important for absorbing excess labor and other factors of production that arise from increased agricultural productivity. In addition to agricultural productivity impacts, public investment in rural areas also creates non-

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

farm rural employment opportunities, which directly improves rural wages and incomes and reduces rural poverty.

Due to limited data for undertaking an econometric analysis separately for Malawi, we use results from previous studies as well as from a cross-country regression analysis that was estimated for this purpose. The latter includes panel data from 1975 to 2004 on 13 countries in Sub-Saharan Africa (Benin et al., 2007).[15] The estimated 'agricultural growth-agricultural expenditure elasticity' (i.e. ε_{agexp}) was 0.15, which means that every one percent increase in PAE generates 0.15 percent growth in agricultural GDP. This compares favorably with estimated elasticities for the sector 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 here is lower than some estimates in other studies. This includes, for example, the elasticity with respect to agricultural research in India (0.25; Fan et al., 2000) and agriculture development expenditure in Africa (0.36; Fan and Rao 2003). This suggests that the estimated 'agricultural growth-agricultural expenditure elasticity' of 0.15 reflects a low spending efficiency. Thus, in addition to using the estimated elasticity of 0.15 in the simulations, we use the upper-end value from constructing a 95 percent confidence interval on the estimated value 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' value (i.e. ε_{nagexp}), we use the results of Fan et al. (2004) on Uganda, where they estimated the effect on agricultural production of different types of public capital including: feeder roads (estimated productivity coefficient of 0.14), education (0.33) and health (0.46). Due to limited historical data on actual expenditures, however, the previous study did not estimate the 'public capital-expenditure elasticity' needed to obtain the 'agricultural growth-non-agricultural expenditure elasticity.' Several studies on other countries show that these 'public capital-expenditure elasticities'

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

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 between agriculture and non-agricultural expenditure ($_{nag,ag}$), we were unable to obtain reliable estimates. For simplicity, we assume that it is zero, noting that both positive and negative elasticities are possible, where positive indicates complementarity and negative indicates trade-offs. Non-agricultural expenditure is treated as exogenous, and historical data from 1991 are used to calculate the annual growth rate ($\dot{E}_{nagexp}$), which is 5.7 percent per year for Zambia (IMF, 2007; NSO, 2007). Similarly, historical data on GDP are used to calculate the shares of agriculture and non-agriculture in GDP, which are 0.37 and 0.63, respectively.

Scenarios

To estimate the PAE requirements, we simulate three scenarios from the Baseline scenario, where we assume that PAE and non-agricultural spending continue to grow according to the respective recent trends at 12.4 and 5.7 percent per year during 2004-2015. As with the CGE model scenarios, we use 2004 as the starting point for the simulations. This means that the share of agricultural spending in total expenditure will rise from 7.0 percent to 9.8 percent in 2010 and 12.8 percent in 2015 (see Table 13), since PAE grows more rapidly than total spending.

To estimate the aggregate PAE required to support the acceleration in agricultural growth under the CAADP and MDG growth scenarios, as identified in the CGE model, we perform three simulations: (i) we assume the agricultural growth will be supported solely by an increase in PAE, without accounting for the effect of non-agriculture expenditure on agricultural growth, which continues to grow at the baseline rate of 5.7 percent per year; (ii) we relax the latter assumption and take the effect of non-agriculture expenditure on agricultural growth into account, but still assume that it continues to grow at the baseline rate at 5.7 percent per year; and

(iii) we simulate an increase in non-agriculture expenditure growth in proportion to growth in the sector's GDP under the MDG growth scenario in the CGE model, which is 7.6 percent per year.

Table 13. Estimated Resource Allocation

	Baseline	Agriculture growth due to agricultural expenditure growth only: CAADP low elasticity	CAADP high elasticity	MDG low elasticity	MDG high elasticity
Real growth rates					
Total government expenditure	6.4	12.3	8.4	15.5	9.3
Agriculture	12.4	33.7	23.0	39.9	26.1
Non-agriculture	5.7	5.7	5.7	5.7	5.7
Government expenditure shares (%)					
Agricultural expenditure in total expenditure					
2004	7.0				
2010	9.8	23.6	15.7	28.8	17.8
2015	12.8	49.9	28.5	62.2	34.3
Agricultural expenditure in agricultural GDP					
2004	6.0				
2010	10.2	24.1	14.6	30.0	16.1
2015	15.9	76.8	30.7	114.9	36.6
Non-agricultural expenditure in non-agricultural GDP					
2004	40.3				
2010	45.7	44.8	44.8	36.2	36.2
2015	50.7	48.8	48.8	33.1	33.1
Total expenditure in total GDP					
2004	28.7				
2010	34.1	37.2	33.8	34.1	29.6
2015	39.6	59.7	41.8	59.4	34.2

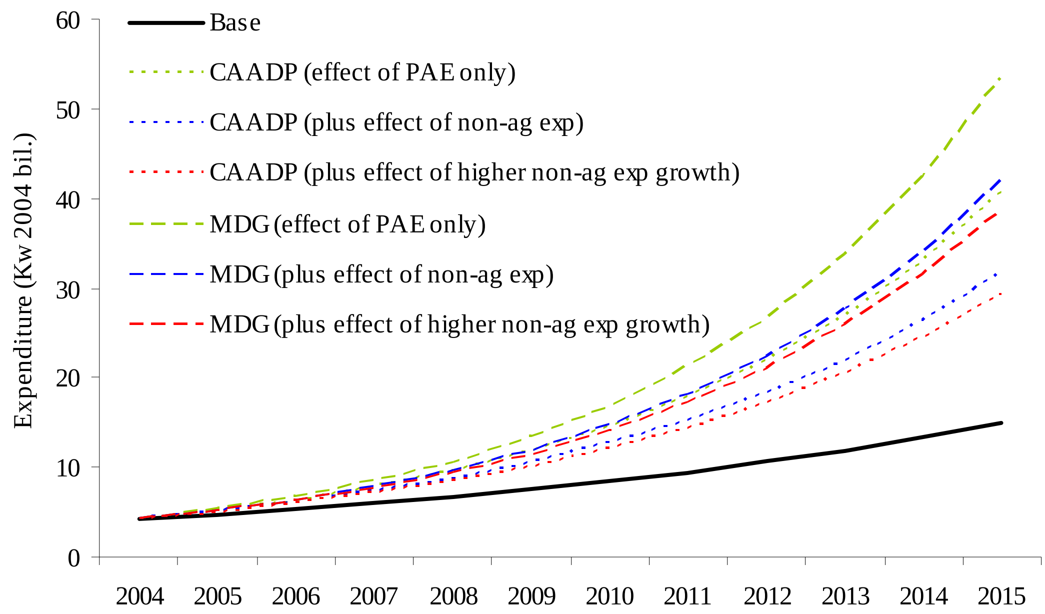
	Baseline	Accounting for effect of non-agricultural expenditure on agriculture growth: CAADP low elasticity	CAADP high elasticity	MDG low elasticity	MDG high elasticity
Real growth rates					
Total government expenditure	6.4	10.0	7.7	12.6	8.5
Agriculture	12.4	28.2	20.2	34.4	23.3
Non-agriculture	5.7	5.7	5.7	5.7	5.7
Government expenditure shares (%)					
Agricultural expenditure in total expenditure					
2004	7.0				
2010	9.8	19.3	14.0	24.1	16.0
2015	12.8	38.6	23.7	51.4	29.1
Agricultural expenditure in agricultural GDP					
2004	6.0				
2010	10.2	18.7	12.7	23.6	14.1
2015	15.9	48.4	33.9	73.9	28.7
Non-agricultural expenditure in non-agricultural GDP					
2004	40.3				
2010	45.7	44.8	44.8	36.2	36.2
2015	50.7	48.8	48.8	33.1	33.1
Total expenditure in total GDP					
2004	28.7				
2010	34.1	35.3	33.1	32.0	28.9
2015	39.6	48.7	44.2	46.2	31.7

	Baseline	Accounting for effect of non-agricultural expenditure and allowing for faster non-agricultural expenditure growth: CAADP low elasticity	CAADP high elasticity	MDG low elasticity	MDG high elasticity
Real growth rates					
Total government expenditure	6.4	10.7	9.0	12.8	9.7
Agriculture	12.4	26.3	19.3	32.5	22.4
Non-agriculture	5.7	7.6	7.6	7.6	7.6
Government expenditure shares (%)					
Agricultural expenditure in total expenditure					
2004	7.0				
2010	9.8	16.5	12.3	20.8	14.0
2015	12.8	30.5	19.0	42.7	23.7
Agricultural expenditure in agricultural GDP					
2004	6.0				
2010	10.2	17.1	12.2	21.7	13.5
2015	15.9	41.2	22.0	63.5	26.5
Non-agricultural expenditure in non-agricultural GDP					
2004	40.3				
2010	45.7	49.9	49.9	40.3	40.3
2015	50.7	59.5	59.5	40.3	40.3
Total expenditure in total GDP					
2004	28.7				
2010	34.1	37.9	36.1	34.2	31.5
2015	39.6	52.4	45.0	47.7	35.9

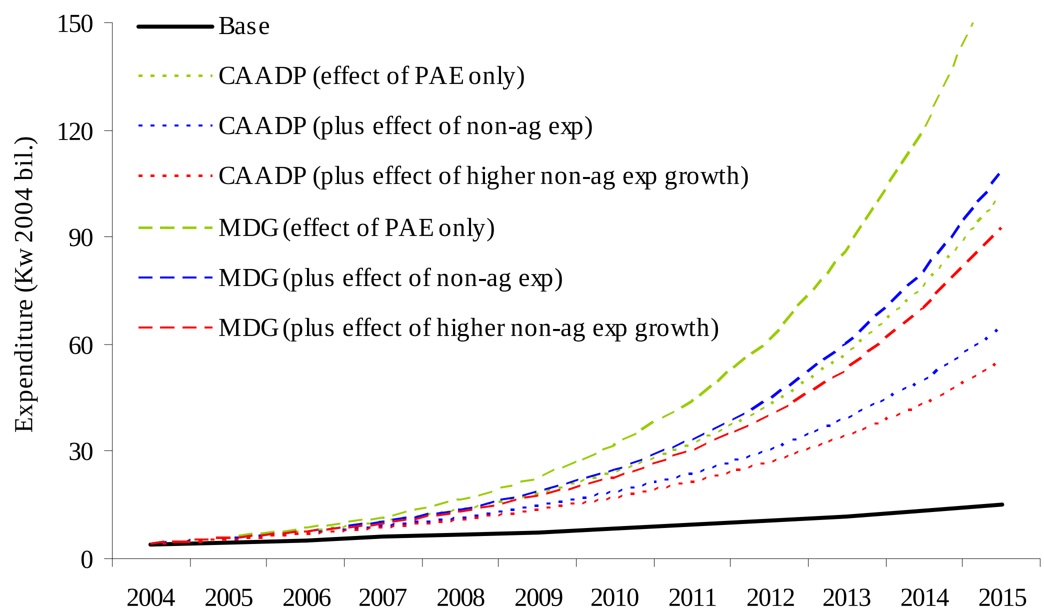
Source: Authors estimates.

Figure 10. Value of agricultural expenditure required under alternative growth scenarios

More efficient expenditure scenario (high growth-expenditure elasticity)



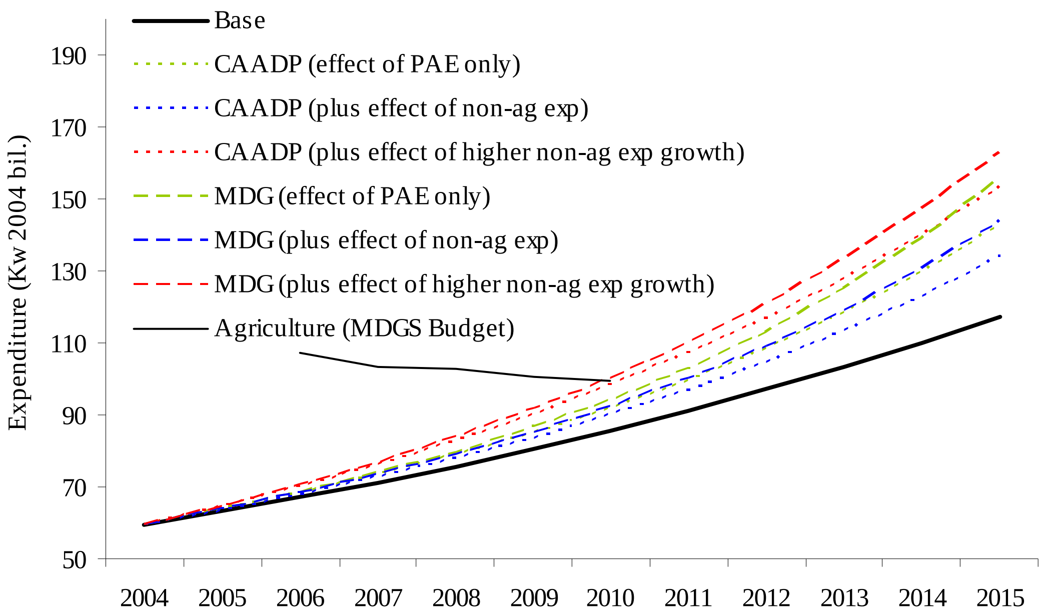
Less efficient expenditure scenario (low growth-expenditure elasticity)



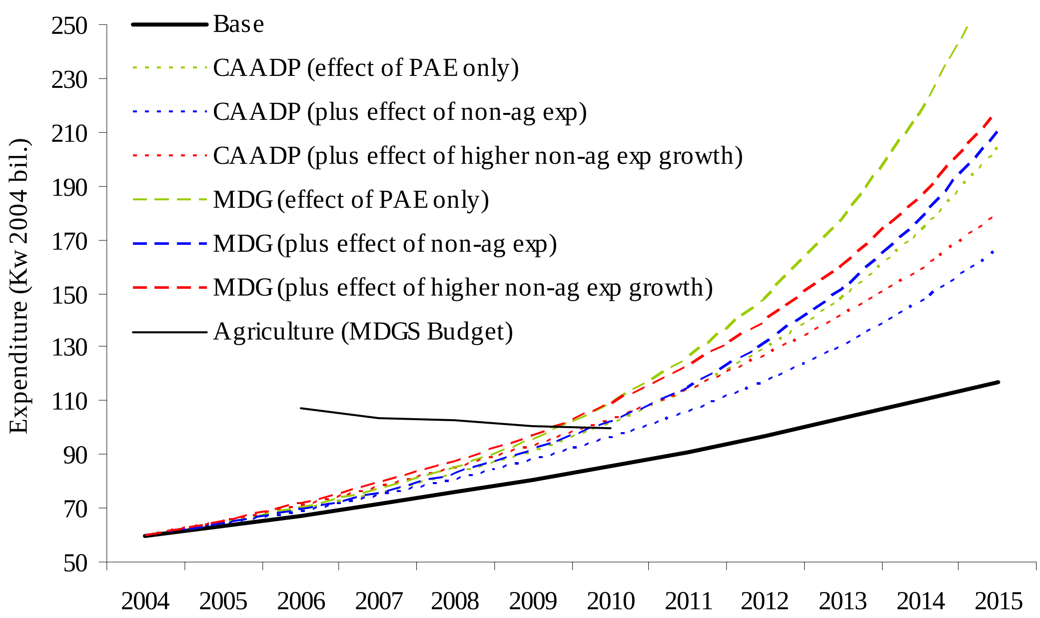
Source: Own calculations using results from the Malawi CGE-microsimulation model and cross-country public expenditure regressions.

Figure 11. Value of total expenditure required under alternative growth scenarios

More efficient expenditure scenario (high-growth expenditure elasticity)



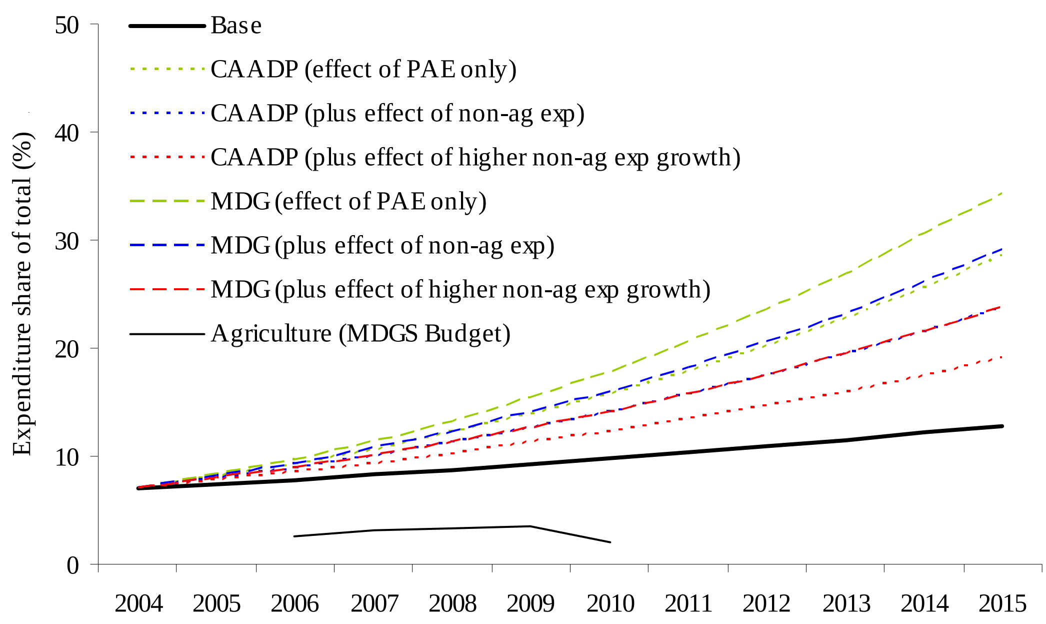
Less efficient expenditure scenario (low growth-expenditure elasticity)



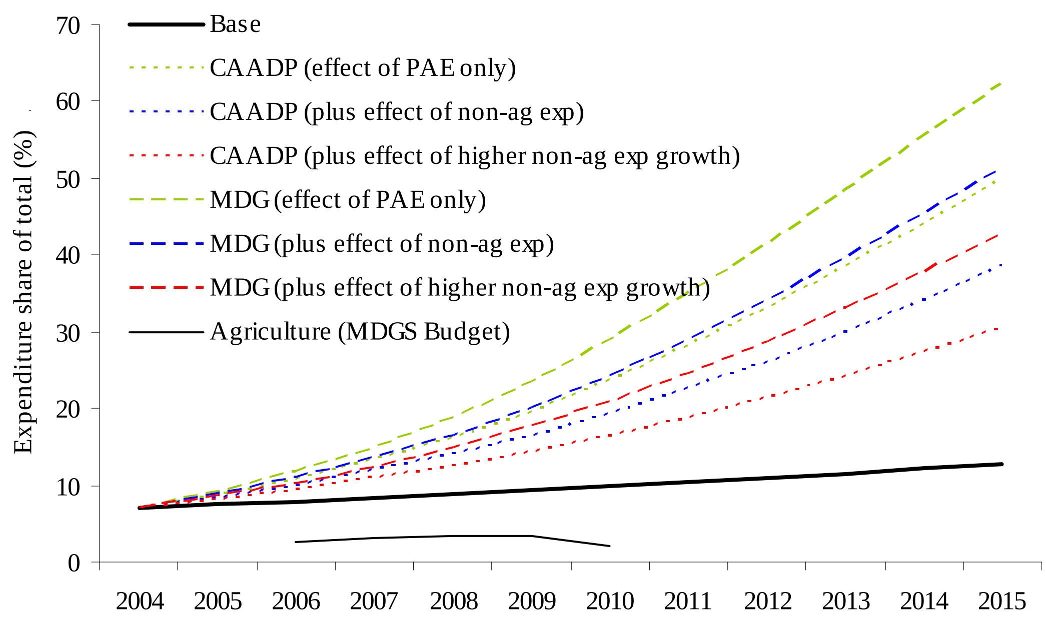
Source: Own calculations using results from the Malawi CGE-microsimulation model and cross-country public expenditure regressions.

Figure 12. 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 Malawi CGE-microsimulation model and cross-country public expenditure regressions.

PAE requirements for achieving CAADP growth target

In the first scenario for achieving the CAADP target, agricultural growth accelerates from the baseline value of 2.8 to 6.0 percent per year during 2004-2015, while non-agricultural GDP growth increases marginally from 3.5 to 3.9 percent per year, and total GDP growth increases from 3.2 to 4.8 percent per year. The accelerated growth in agricultural GDP requires an associated growth in PAE from the baseline value of 12.4 to 23.0 percent per year under the high elasticity scenario, and 33.7 percent under the low elasticity scenario (see Table 13 and Figure 10). Assuming that the government's allocation to non-agriculture continues to grow as in the Baseline scenario, then the total government budget is estimated to grow at 8.4 percent per year under the high elasticity scenario, and at 12.3 percent under the low elasticity scenario (see Table 13 and Figure 11). Again, with agricultural spending growing more rapidly than total spending, the share of agricultural spending in total expenditure will rise to 15.7-23.6 percent in 2010 and 28.5-49.9 percent in 2015 (see Table 13 and Figure 12), with the lower bound numbers corresponding to high elasticity and vice versa. These increases translate to additional spending on the sector in a total amount of Kw 96-289 billion over 2004-2015, or Kw 8-24 billion per year.

In the second scenario for achieving the CAADP target, we take the effect of non-agricultural expenditure on agricultural growth into account. In this case, PAE is now expected to grow at a lower rate of 20.2 percent per year under the high elasticity scenario, and 28.2 percent under the low elasticity scenario (see Table 13 and Figure 10). The total government budget is estimated to grow at 7.7 percent per year under the high elasticity scenario, and at ten percent under the low elasticity scenario (see Table 13 and Figure 11). Again, agricultural spending grows more rapidly than total spending; the share of agricultural spending in total expenditure will be 14.0-19.3 percent in 2010 and 23.7-38.6 percent in 2015 (see Table 13 and Figure 12). These increases translate to additional sector spending of Kw 65-174 billion over 2004-2015, or Kw 5-14 billion per year.

In the third scenario, we assume that non-agricultural expenditure grows at 7.6 percent per year instead of the baseline rate of 5.7%. As in the second scenario, PAE is expected to grow at 20.2

percent per year under the high elasticity scenario and 28.2 percent under the low elasticity scenario (see Table 13 and Figure 10). However, in this case the total government budget is estimated to grow at nine percent per year under the high elasticity scenario, and at 10.7 percent under the low elasticity scenario (see Table 13 and Figure 11), while the share of agricultural spending in total expenditure will be 12.3-16.5 percent in 2010 and 19.0-30.5 percent in 2015 (see Table 13 and Figure 12). These increases translate to additional sector spending of Kw 55-143 billion over 2004-2015, or Kw 5-12 billion per year.

These results confirm the importance of Malawi 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 28.5 percent of its total budget to agriculture by 2015 in order to achieve the CAADP growth target of six percent per year. As Figure 11 shows, the total resource envelope proposed under the MGDS seems to be in line with the overall requirement, considering the 2006-11 period. However, nearly 51 percent of the total budget is earmarked for the development of the Shire-Zambezi Waterway (GOM, 2006), and it is not clear how much of this will be spent on the agriculture sector, which includes crops, livestock, forestry and fishery (i.e., 'agriculture' as defined under the CAADP; AU, 2006). Taking spending on the priority areas of agriculture and food security, irrigation and water, and integrated rural development as a guide (see Figure 9), this represents only 4.3 percent of the total resource envelope proposed under the MGDS.

PAE requirements for achieving MDG1 growth target

The CGE model analysis indicates that reaching the CAADP target of six percent agricultural growth will significantly improve poverty outcomes. However, even under this accelerated growth scenario, Malawi will not be able to achieve the first MDG of halving poverty by 2015. Without complementary accelerated growth in the non-agricultural sectors, the binding demand and/or market constraints for agricultural outputs will prevent the agricultural growth from translating into higher household incomes. Halving poverty by 2015 and meeting the MDG1 target will require a doubling of the growth rate in the non-agricultural sectors (from 3.5 to 7.6 percent) and a higher annual growth rate in agricultural GDP (6.9 percent, which is more than double the baseline case). To support such a high growth rate and achieve the desired poverty outcomes, and assuming that agricultural growth is driven by growth in PAE only, then PAE would have to grow at 26.1 percent annually under the high elasticity scenario, or 39.9 percent under the low elasticity scenario (see Table 13 and Figure 10). Again, assuming that the government's allocation to non-agricultural sectors grows as in the baseline case, the total government budget is estimated to grow at 9.3 and 15.5 percent per year under the high and low elasticity cases, respectively (see Table 13 and Figure 11). The share of PAE in total spending would rise to 17.8-28.8 percent in 2010 and 34.3-62.2 percent in 2015 (see Table 13 and Figure 12), translating to additional sector spending of Kw 139-475 billion over 2004–2015, or Kw 12–40 billion per year. However, these 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 are Kw 8–26 billion per year when the effect of non-agricultural expenditure on agricultural growth is taken into account, or 7-22 billion per year with faster non-agricultural expenditure growth. See Table 13 and Figures 10-12 for details.

These results suggest that, in all likelihood, Malawi faces insurmountable growth and resource constraints to achieving its MDG1 target. However, achieving the CAADP target should remain a priority, as this 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.

Identifying investment priorities

Estimating the total public resources needed to reach particular agricultural growth targets is important, but prioritizing investments is equally important. Due to a lack of historical data on PAE on specific investment programs in Malawi, as well as related data on program outputs and outcomes, this study is unable to analyze specific investment priorities based on their potential returns in terms of agricultural growth and poverty reduction. However, using the results of the cross-country regression analysis, this section attempts to offer a guide to key investments that could help promote higher agricultural growth and rural poverty reduction. Two sets of elasticities are used for this: (i) the effect of increases in agricultural land, labor, capital and inputs on changes in agricultural GDP (i.e., production function estimates); and (ii) the effect of increased government agriculture spending on changes 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).

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, which is equivalent to one cattle of 250 kg weight.

The production function estimates shown in the top panel indicate that increases in agricultural labor, machinery and fertilizer have contributed the most to agricultural GDP growth over the 1975-03 period. One percent increases in agricultural machinery, labor and fertilizer result in 0.35, 0.44 and 0.18 percent increases in agricultural GDP, respectively, while the contributions of increases in livestock and irrigation are relatively lower.[16] However, these elasticities do not take the effect of spending into account. Assuming that total government agricultural spending is distributed equally across the expenditure categories associated with farm investments in agricultural land, labor and capital and use of inputs by farmers, the bottom panel of Table 14 shows that government agricultural spending that results in increases in farm investments in

[16] 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.

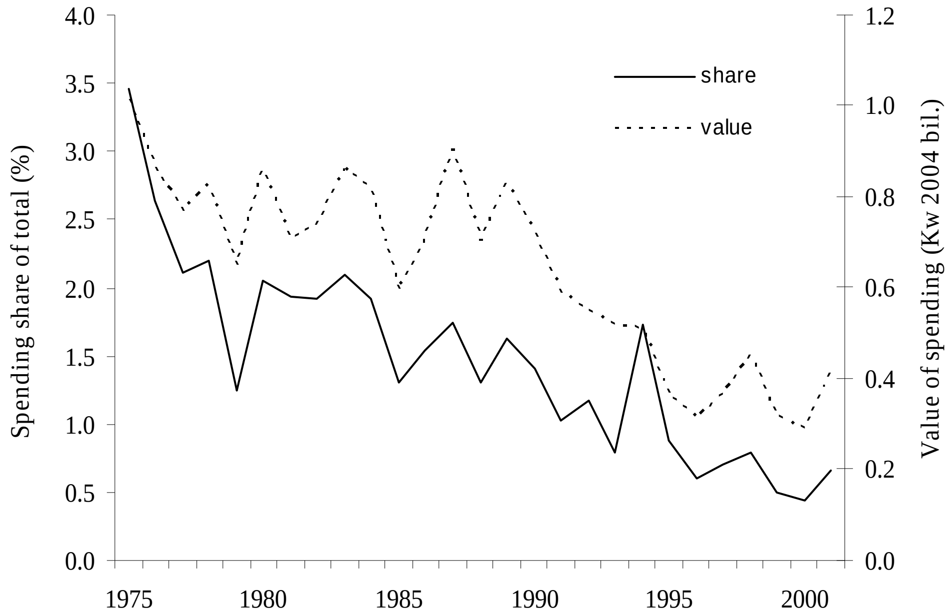
agricultural machinery yields the greatest returns, followed by spending that leads to increased farm use of fertilizers and investments in livestock, labor and irrigation.

The large return associated with fertilizer use seems to support the Government of Malawi's commitment to subsidizing fertilizers and other inputs used by farmers. In 2007, for example, the government spent about 6.5% of its total budgetary resources on subsidizing fertilizer packs to allow low-income farmers to purchase 50-kg sacks of fertilizer at Kw 950 rather than the market price of Kw 4,500. This, along with good rains, helped raise the average maize yield from 800 kg to two tonnes per hectare (Nolen, 2007). While an impact assessment is needed to evaluate programs with such large short-run distributive impacts,[17] the results of the growth-poverty analysis presented earlier show that an investment strategy dominated by a single sector cannot generate sufficient economy-wide growth and poverty reduction. Thus, although we are unable to assess the impact of different types of agricultural spending on increasing growth (due to data limitations), it will be critical to enact a more balanced spending portfolio that includes long-term growth-enhancing public agricultural and rural investments.

In order to increase agricultural production, reduce production costs and protect the environment for sustainable agricultural production, Malawian farmers need to use improved technologies that are profitable under local farming and market conditions to increase yields, manage water, and apply natural resources in a more sustainable manner. A key investment area is therefore the support of 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 Malawi has been erratic and declining (Figure 13); this trend must be reversed. The current allocation is at the level of the African average of 0.5-0.6 percent, but below the one percent recommended by the World Bank.

[17] The Government of Malawi, in partnership with the Department for International Development (DFID), has called for a study to evaluate the government's agricultural input subsidy program and maize market interventions over the 2007–11 period.

Figure 13. Government spending on agricultural R&D in Malawi



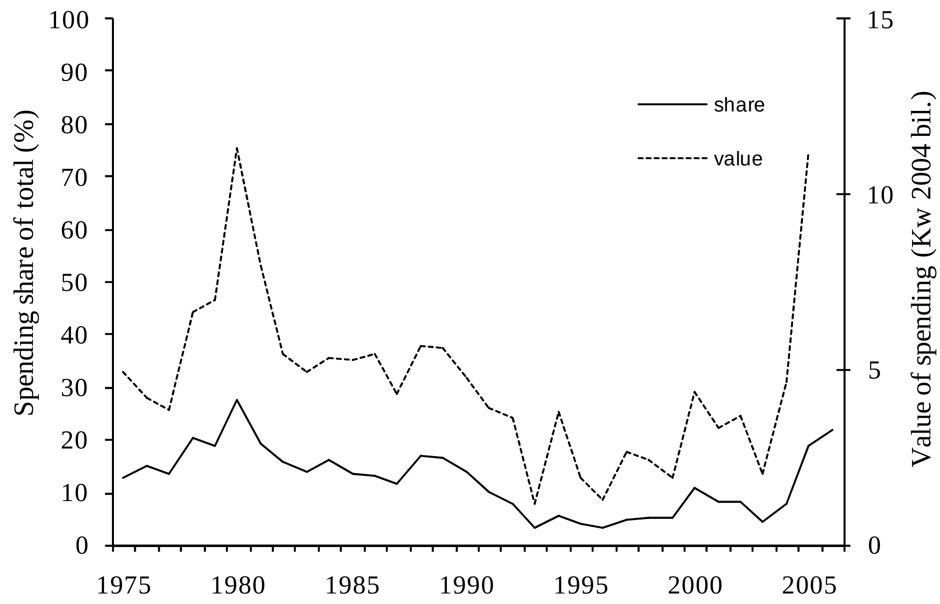
Source: Government Finance Statistics (IMF, 2007; NSO, 2007); Agriculture Science and Technology Indicators (IFPRI 2007).

Irrigation is another key investment area that should be considered by the Government of Malawi. The impacts of irrigation are well known, and it is widely maintained that the success of the Asian Green Revolution in the 1960s and 1970s was built on the rapid expansion of irrigated areas (Spencer 1994). Malawi has an irrigation potential of about 162,000 hectares, but only a little over two percent of the total arable land is presently under irrigation (FAO 2007). Nevertheless, the Government of Malawi has recognized that irrigation and water development is key to the country's future success, due to its direct linkages with agriculture and energy. It is hoped that irrigation will contribute towards reducing over-dependence on rain-fed agriculture, while proper conservation of water will also contribute towards the generation of electricity. The government's key strategies under the MGDS for 2006-11 (GOU 2006) include construction and promotion of small- and medium-scale irrigation schemes to enhance food and cash crop production. To this end, the government has earmarked about 1.2 percent of the total budgetary resources for irrigation and water development (see Figure 9), with the plan of rehabilitating existing schemes and developing new ones, for a projected irrigated area of 16,000 hectares by 2011. Whether this allocation will be sufficient to reach the set target is uncertain.

The results from the cross-country regression analysis 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 observed 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 in 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 in turn significantly contributes to poverty reduction (Thurlow and Wobst 2004; Diao and Nin-Pratt 2005).

The Government of Malawi has recognized that the inadequacy of the country's current transportation infrastructure results in high costs of production, with transportation representing about 55 percent of costs, compared to 17 percent in other less-developed countries (GOM, 2006). With the current road density standing at 161 kilometers per 1000 square kilometers, Malawi is ranked 16th in Sub-Saharan Africa (IRF 2007). Government spending on transport and communications in Malawi has only recently started to improve, following a decline in the late 1990s (Figure 14). Investments 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 agriculture output and poverty reduction is three to four times larger than the return to public spending on murram and tarmac roads. Under the MGDS for 2006-11, the Government of Malawi is planning to spend Kw 7.6 billion to improve the road network, focusing on routine and periodic maintenance, rehabilitation and upgrading of the road network, replacement of timber decked bridges, etc. (GOM, 2006). Although this is not likely to improve the road density, the road condition is likely to improve significantly, with a target of 71 percent of the road network being in good condition, 18 percent in fair condition, and only 11 percent in poor condition.

Figure 14. Government spending on transport and communications in Malawi



Source: Government Finance Statistics (IMF, 2007; NSO 2007).

VII. Summary of major findings

A dynamic CGE model is herein developed and used to examine the contribution of accelerating growth in alterative agricultural crops and sub-sectors, and to assess how Malawi can achieve the CAADP target of six percent agricultural growth 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, is 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 indicated that if Malawi 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, which will increase overall GDP growth from 3.2 to 4.8 percent per year. This higher growth rate would reduce national poverty to 34.5 percent by 2015, which is considerably lower than the 47.0 percent poverty rate projected in the absence of the additional agricultural growth. This means that the higher growth under the CAADP scenario would lift an additional 1.88 million 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, households in regions growing higher-value export-oriented crops, such as tobacco and cotton, will stand to gain more than households in other regions. Furthermore, poverty amongst households in the southern regions will remain high, despite faster agricultural growth. Finally, while rural households will benefit more than urban households, not least because these households are more dependent on agricultural incomes, urban households will also benefit. This is because urban agriculturalists farm six percent of agricultural land in Malawi, and 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 13.4 percentage points under the CAADP scenario, urban poverty also falls by six 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, additional growth driven by maize, pulses and horticultural crops will have larger impacts on poverty reduction than similar growth in export-oriented crops. This is because yield improvements in these crops will not only directly benefit households by increasing incomes from agricultural production, but also indirectly by allowing farmers to diversify their land allocation towards higher-value crops. Food crops and fisheries also have strong growth-linkages to non-agricultural sectors, thereby stimulating broader economy-wide growth and poverty reduction. However, the higher growth potential of export crops relative to that of the non-maize food crops means that export-led growth will still account for a significant share of overall poverty reduction under the CAADP scenario. Furthermore, the small initial size and geographic concentration of certain crops, such as tea and sugarcane, means that their potential contribution to national-level growth and poverty reduction will remain limited, at least over the near-term. Taken together, the characteristics of the various sub-sectors highlight the importance of broader-based agricultural growth, but suggest that priority should be given to maize, pulses, horticulture, and smallholder export crops, such as tobacco and cotton.

Agricultural spending needs to increase substantially

Increasing agricultural growth to meet the CAADP growth target will require both additional investment in the sector and improvements in the efficiency of public spending. Our investment analysis indicates that government spending on agriculture would have to grow by at least 20 percent per year in order to achieve and sustain the target of six percent agricultural growth. This implies that the government will need to allocate almost a third 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, namely 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 achieves a more modest return on its spending, say 0.15 percent increase in agricultural GDP for every one percent increase in total agricultural spending, then public spending on agriculture would have to grow at about 28 percent per year in order to reach the CAADP target. This would mean that the government would have to allocate around half 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, resulting in substantial overall growth in the economy and increases in incomes of both rural and urban households, achieving the CAADP target of six percent will be insufficient to halve poverty by 2015. To achieve this more ambitious target, both agriculture and non-agriculture would need an average annual growth rate above seven percent. Compared to Malawi’s past performance, these growth requirements are substantial, as are the associated resource requirements. However, while the MDG1 target may be beyond reach, achieving the CAADP target should remain a priority.

Its less ambitious growth and expenditure requirements 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.

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Appendixes

Appendix A: Specification of the CGE and micro-simulation model

A computable general equilibrium (CGE) model was developed to assess sector-specific growth options and their poverty impacts. The model is calibrated to a 2004 social accounting matrix (SAM) that provides information on demand and production for 36 detailed sectors (see Table 1). The model further disaggregates agricultural activities across agro-ecological zones using district-level production and price data (see Section II). Constrained by the data, non-agricultural production is not disaggregated across regions. Based on the SAM, the production technologies across all sectors are calibrated to their current situation, including each sector's use of primary inputs, such as land, labor and capital, and intermediate inputs. To capture existing differences in labor markets, the model classifies employed labor into different sub-categories, including self-employed agricultural workers, unskilled workers laboring in both agriculture and non-agriculture, and skilled non-agricultural workers. Information on employment and wages by sector and region is taken from the 2004-05 Integrated Household Survey (IHS2).

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 rural laborers moving from working on their own small-scale farms to finding employment opportunities in the labor market. Capital moves freely within regions and within the broad agricultural and non-agriculture sectors, and capital is accumulated through investments financed by domestic savings and foreign inflows. Increased capital is allocated across sectors and regions according to their relative profitability. Incomes from employment accrue to different households according to employment and wage data from IHS2. The detailed specification of production and factor markets in the model allows it to capture changing scale and technology of production across sectors and sub-national regions, thereby showing how changes in Malawi's structure of growth influence the distribution of incomes.

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

Incomes from production, trade and employment accrue to different households according to employment and wage data from IHS2. As with production, households are defined at the regional level according to agro-ecological zones, and within each zone by 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 the household survey. 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 on households' income and expenditure patterns as possible, the CGE model is linked to a micro-simulation module based on IHS2. 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 in the survey, and standard poverty measures are estimated using this updated expenditure measure.

The model makes a number of assumptions about how the economy maintains macroeconomic balance. These 'closure rules' concern the foreign or current account, the government or public sector account, and the savings-investment account. For the current account, a flexible exchange rate maintains a fixed level of foreign savings. This assumption implies that 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 expenditure 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 change, including 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 its unique factor endowment and income and expenditure patterns. The structure of the growth-poverty relationship is therefore defined explicitly ex ante based on observed country-specific structures and behavior. This allows the 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)	$trnsfr_{i\,f}$	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^a_{fat}	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)

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI} \quad (36)$$

System Constraints and Macroeconomic Closures

$$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR \quad (37)$$

$$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c \quad (38)$$

$$\sum_{a \in A} QF_{f\,a} = QFS_f \quad (39)$$

$$YG = EG + GSAV \quad (40)$$

$$\sum_{r\ c \in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f \in F} trnsfr_{row\,f} = \sum_{r\ c \in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i \in INSD} trnsfr_{i\,row} + FSAV \quad (41)$$

$$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \quad (42)$$

$$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right) \quad (43)$$

Capital Accumulation and Allocation Equations

$$AWF_{f\,t}^{a} = \sum_{a} \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right] \quad (44)$$

$$\eta_{f\,a\,t}^{a} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^{a} \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF_{f\,t}^{a}} - 1 \right) + 1 \right) \quad (45)$$

$$\Delta K_{f\,a\,t}^{a} = \eta_{f\,a\,t}^{a} \cdot \left(\frac{\sum_{c} PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right) \quad (46)$$

$$PK_{f\,t} = \sum_{c} PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}} \quad (47)$$

$$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K_{f\,a\,t}^{a}}{QF_{f\,a\,t}} - \upsilon_f \right) \quad (48)$$

$$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_{a} \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f \right) \quad (49)$$

Appendix B: Method for estimating agricultural spending required for agricultural growth

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

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

Where: $\dot{E}_{agexp}$ is 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 agriculture and non-agricultural expenditure, respectively; $_{nag,ag}$ is the multiplier effect or linkage (i.e. trade-offs and complementarities) between agriculture 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 for to obtain the agricultural spending required to achieve a particular growth rate in agriculture ($\overline{\theta}_{ag}$):

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

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

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

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For more information, contact:

Coordinator
Regional Strategic Analysis and Knowledge Support System
c/o International Food Policy Research Institute
2033 K Street, NW
Washington, DC 20006-1002
Telephone: +1 202 862 5667
Facsimile: +1 202 467 4439
E-mail: resakss-africa@cgiar.org
www.resakss.org