ReSAKSS
Regional Strategic Analysis and Knowledge Support System
Africa Wide

ReSAKSS Working Paper No. 20

November 2008

Agricultural Growth Options for Poverty Reduction in Mozambique:

Preliminary Report Prepared for Mozambique's Ministry of the Agriculture and Strategic Analysis and Knowledge Support System (SAKSS)

James Thurlow

Regional Strategic Analysis and Knowledge Support System (ReSAKSS)

ReSAKSS Working Paper No. 20

November 2008

Agricultural Growth Options for Poverty Reduction in Mozambique:

Preliminary Report Prepared for Mozambique's Ministry of the Agriculture and Strategic Analysis and Knowledge Support System (SAKSS)

James Thurlow

About ReSAKSS

The Regional Strategic Analysis and Knowledge Support System (ReSAKSS) is an Africa-wide network of regional nodes supporting the Common Market of Eastern and Southern Africa (COMESA), the Economic Community of West African States (ECOWAS), and the Southern African Development Community (SADC), in collaboration with the International Food Policy Research Institute (IFPRI) and the Africa-based centers of the Consultative Group on International Agricultural Research (CGIAR), to facilitate the implementation of the AU/NEPAD Comprehensive Africa Agriculture Development Program (CAADP) and other regional agricultural development initiatives in Africa.

The ReSAKSS nodes offer high-quality analyses to improve policymaking, track progress, document success, and derive lessons for the implementation of the CAADP agenda. ReSAKSS is jointly funded by the United States Agency for International Development (USAID), the UK Department for International Development (DFID), and the Swedish International Development Cooperation Agency (SIDA). The nodes are implemented by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Institute of Tropical Agriculture (IITA), the International Livestock Research Institute (ILRI) and the International Water Management Institute (IWMI), in collaboration with regional and national partners.

About the Working Paper series

The goal of the ReSAKSS Working Paper series is to provide timely access to preliminary research and data analysis results that relate directly to strengthening ongoing discussions and critical commentaries on the future direction of African agriculture and rural development. The series undergoes a standard peer review process involving at least one reviewer from within the ReSAKSS network of partners and at least one external reviewer. It is expected that most of the working papers eventually will be published in some other form and that their content may be revised further.

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 author

James Thurlow is a researcher in the Development Strategy and Governance Division of the International Food Policy Research Institute (IFPRI).

Thurlow, J. 2008. *Agricultural Growth and Investment Options for Poverty Reduction in Mozambique.* ReSAKSS Working Paper # 20, International Food Policy Research Institute (IFPRI).

agriculture, GDP, poverty, public investment, MDG

Introduction

Mozambique has experienced rapid economic growth over the last decade. Agricultural growth has also been strong, and the incidence of poverty has declined substantially since the mid-1990s. However, poverty remains high and is still concentrated in rural areas. To accelerate growth and poverty reduction, Mozambique's government is revising its agricultural strategy, which will strengthen the role of agriculture as an engine of growth and development for the national economy. This is essential given that agriculture is a vital income source for a majority of the population, contributing more than 25 percent to GDP, 20 percent of export earnings, and providing key inputs into the manufacturing sectors, whose agricultural processing sectors contribute a further 7 percent to national GDP. In parallel to the revision of the agricultural strategy, the New Partnership for Africa's Development (NEPAD) is in the process of implementing the Comprehensive Africa Agriculture Development Programme (CAADP), together with African governments. The CAADP initiative supports the identification of 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.

Since there are choices involved within the agricultural sector, both for the sector as a whole and across sub-sectors, many investment and policy interventions will be designed at the sub-sector level. However, strong inter-linkages occur across sub-sectors and between agriculture and the rest of the economy. To understand these linkages and how sectoral growth will contribute to the country's broad development goals, an integrated framework is needed in order to synergize the growth projections among different agricultural commodities or sub-sectors and evaluate their combined effects on economic growth and poverty reduction. Moreover, agricultural production growth is often constrained by demand in both domestic and export markets, and demand, in turn, depends on income growth both in agriculture and in the broader economy. While agriculture is a dominant economic activity in Mozambique and a majority of the population lives in rural areas, both rural and urban sectors need to be included in this framework in order to understand the economy-wide impact of agricultural growth.

This study analyzes agricultural growth options that can support the development of a more comprehensive rural development component under Mozambique's revised agricultural strategy that is also in alignment with the principles and objectives collectively defined by African countries as part of the broader NEPAD agenda. In particular, the study seeks to position Mozambique's agricultural sector and rural economy within the country's national strategy. For these purposes, and to assist policymakers and other stakeholders to make informed long-term decisions, an economy-wide, computable general equilibrium (CGE) model for Mozambique has been developed and used to analyze the linkages and trade-offs between economic growth and poverty reduction at both macro- and micro-economic levels. The results from the model simulations are intended to guide debate in prioritizing the contribution of different subsectors in helping Mozambique achieve its broader development objectives.

II. Modeling agricultural growth and poverty reduction

The computable general equilibrium (CGE) and microsimulation model

A new Mozambique 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. In total the model identifies 56 sub-sectors, 24 of which are in agriculture (see Table 1). Agricultural crops fall into five broad groups: (i) cereal crops, which are separated into maize, rice, wheat, and other cereals, such as sorghum and millet; (ii) root crops, which are separated into cassava and other roots, such as Irish and sweet potatoes; (iii) pulses and nuts, which is separated into beans and oil crops, groundnuts, and cashew 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. A number of new export-oriented or import-displacing crops are also included in the model, such as bananas for direct export, jatropha for biodiesel production, and sugarcane for ethanol production. The CGE model also identifies three livestock sub-sectors, including cattle, poultry, and other livestock, such as sheep, goats and pigs.

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

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

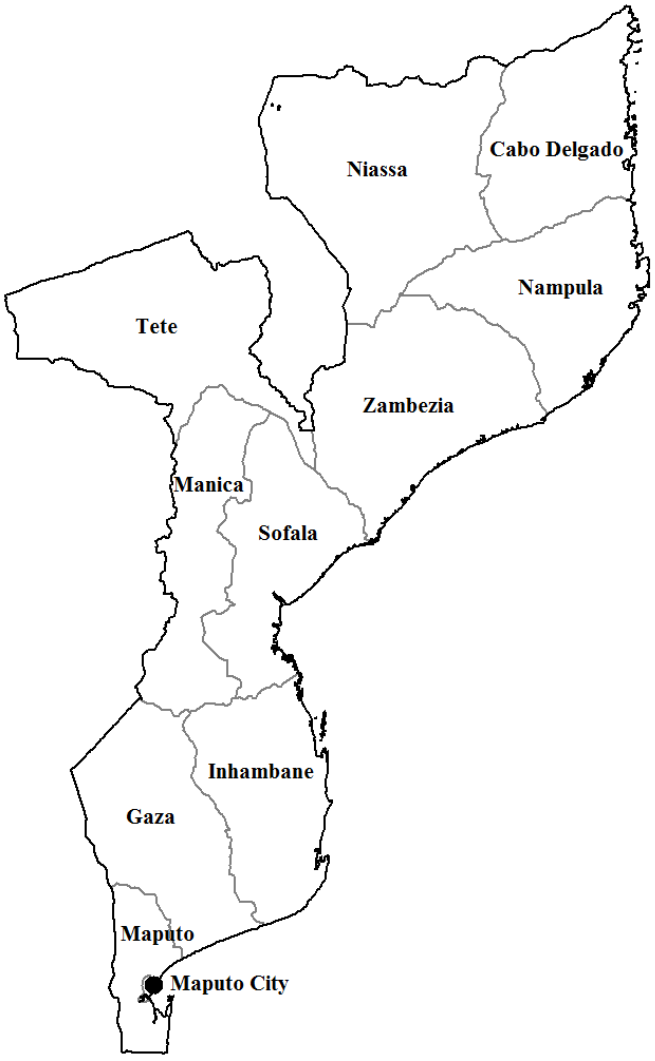
	Agricultural sub-sectors
	Cereals
1	Maize
2	Rice
3	Wheat
4	Other cereals (incl. sorghum, millet, etc)
	Root crops
5	Cassava
6	Other roots (incl. sweet potatoes, Irish potatoes)
	Pulses and nuts
7	Pulses & oils (incl. mixed beans, soybeans)
8	Groundnuts
9	Cashew nuts
	Horticulture
10	Vegetables
11	Fruits
	Export-oriented crops
12	Tobacco
13	Cotton
14	Sugarcane
15	Tea
16	Other crops (incl. sunflower seeds, paprika, etc)
	New export-oriented or import-displacing crops
17	Bananas
18	Sugarcane (ethanol)
19	Jatropha (biodiesel)
	Livestock
20	Cattle
21	Poultry
22	Other livestock (incl. goats, sheep and pigs)
23	Fisheries
24	Forestry

	Manufacturing sub-sectors
25	Meat and fish processing
26	Grain milling
27	Other food processing
28	Sugar processing
29	Tobacco processing
30	Beverages
31	Cotton ginning
32	Textiles & clothing
33	Wood products (excl. furniture)
34	Petroleum products
35	Diesel products
36	Ethanol production
37	Biodiesel production
38	Other fuels
39	Other chemical products (incl. plastics)
40	Non-metallic minerals (incl. glass)
41	Metal products (incl. aluminum)
42	Machinery
43	Transport equipment
44	Other manufacturing (incl. furniture)

	Other industrial sub-sectors
45	Mining
46	Electricity
47	Water
48	Construction
	Service sub-sectors
49	Wholesale & retail trade services
50	Hotels & catering
51	Transport services
52	Communication services
53	Financial services
54	Business & real estate services
55	Government administration and services
56	Community & other private services

To complete the agricultural sector, the model has two further sub-sectors capturing forestry and fisheries. Most of the 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. The nine agricultural processing activities identified in the model include meat and fish processing; grain milling; sugar, tobacco and cotton processing; other food processing; beverages; textiles; and wood processing. The agricultural sub-sectors also use inputs from non-agricultural sectors, such as fertilizer from the chemicals sector and marketing services from the trade and transport sectors.

Figure 1. Regions in the CGE model



The model also captures regional heterogeneity. Rural agricultural production is disaggregated across Mozambique's ten provinces, as shown in Figure 1 and Tables 2 and 3. These provinces reflect different agroecological conditions across the country. Furthermore, to capture the importance and unique circumstances of Mozambique's urban economy, urban areas in each of the provinces are grouped into a single region in the model. Finally, Maputo City is identified as a separate metropolitan region. This means that there are 12 sub-national regions identified in the model (i.e., 10 rural provinces, 1 provincial urban center, and 1 metropolitan city).

The CGE model captures the initial cropping patterns in the rural areas of each of the 10 provinces. The representative farmer in each province responds to changes in production technology and commodity demand and prices by reallocating their land across different crops in order to maximize incomes. These farmers also reallocate their labor and capital between farm and non-farm activities, including livestock and fishing, wage employment, and diversification into non-agricultural sectors, such as transport, trade and construction. Thus, by capturing production information across sub-national regions, the CGE model combines the national or macroeconomic consistency of an economy-wide model with province-level production models. The new Mozambique CGE model is thus an ideal tool for capturing the growth linkages and income-and price-effects resulting from accelerating growth in different agricultural sectors.

Finally, the model endogenously estimates the impact of growth on household incomes. There are 66 representative household groups in the model, disaggregated across income quintiles and 12 sub-national regions. The top quintile in urban centers and metropolitan Maputo are further disaggregated into four income groups. Each household questioned in the 2002/03 household survey (IAF) is linked directly to the corresponding representative household in the model. This is the micro-simulation component of the Mozambique model. In this formulation of the model, changes in representative households' consumption and prices in the CGE model are passed down to their corresponding households in the survey, where total consumption expenditures are recalculated. This new level of per capita expenditure for each survey household is compared to the official poverty line, and standard poverty measures are recalculated. Thus, poverty is measured in exactly the same way as official poverty estimates, and changes in poverty draws on the consumption patterns, income distribution and poverty rates captured in IAF.

Table 2. Land and population distribution across urban households and rural farm households

	Nat-ional	Urban		Rural households in each province									
		Maputo City	Other urban	Niassa	Cabo Delg.	Nam-pula	Zam-bezia	Tete	Manica	Sofala	Inham-bane	Gaza	Maputo prov.
Population (1000)	18,302	1,052	4,819	751	1,194	2,058	3,137	1,194	783	921	1,048	954	393
Quintile 1 (%)	20.0	0.3	12.2	11.2	23.4	31.0	24.3	31.0	21.5	16.5	47.7	7.7	10.5
Quintile 2	20.0	4.1	14.0	28.0	28.7	26.3	27.6	17.9	10.1	24.6	20.1	22.0	11.3
Quintile 3	20.0	6.4	19.0	22.7	22.9	24.0	21.9	20.2	18.7	18.6	13.3	25.5	27.9
Quintile 4	20.0	22.6	21.7	23.1	19.5	14.9	16.7	20.3	30.5	24.6	10.1	26.2	20.0
Quintile 5	20.0	66.7	33.1	15.0	5.4	3.9	9.5	10.5	19.2	15.6	8.8	18.7	30.3
Number of households	3,808	168	969	151	319	481	670	257	140	157	226	182	88
Household size	4.8	6.3	5.0	5.0	3.7	4.3	4.7	4.6	5.6	5.9	4.6	5.2	4.5
Poverty rate (%)	54.4	53.6	51.0	53.2	65.1	57.8	45.1	59.0	40.8	33.8	86.5	61.7	81.2
Share of poor (%)	100.0	5.7	24.7	4.0	7.8	12.0	14.2	7.1	3.2	3.1	9.1	5.9	3.2
Harvest area (1000 ha)	3,211	-	-	353	420	572	453	265	243	305	266	254	78
Average farm land (ha)	1.20	-	-	2.34	1.32	1.19	0.68	1.03	1.74	1.94	1.18	1.40	0.89
Maize	0.35	-	-	0.71	0.35	0.15	0.15	0.49	0.84	0.54	0.32	0.65	0.20
Other cereals	0.25	-	-	0.99	0.32	0.30	0.08	0.04	0.25	0.96	0.04	0.01	0.00
Root crops	0.26	-	-	0.13	0.28	0.37	0.34	0.06	0.22	0.09	0.28	0.24	0.11
Pulses	0.13	-	-	0.17	0.10	0.18	0.03	0.12	0.13	0.08	0.29	0.26	0.22
Horticulture	0.09	-	-	0.17	0.06	0.06	0.03	0.09	0.09	0.06	0.24	0.24	0.08
Tobacco	0.02	-	-	0.13	0.00	0.01	0.01	0.08	0.01	0.00	0.00	0.00	-
Cotton	0.06	-	-	0.00	0.15	0.07	0.02	0.10	0.06	0.14	0.00	-	-
Other crops	0.05	-	-	0.03	0.05	0.05	0.01	0.05	0.14	0.07	0.00	0.00	0.28
Crop yields (mt/ha)													
Maize	0.83	-	-	1.24	0.70	0.68	0.82	1.09	0.93	0.75	0.28	0.68	0.71
Other cereals	0.48	-	-	0.33	0.47	0.52	0.43	0.11	0.51	0.67	0.23	0.17	1.64
Root crops	3.68	-	-	2.64	2.53	2.89	5.56	4.31	3.23	3.79	2.41	1.95	3.28
Pulses	0.39	-	-	0.49	0.32	0.56	0.30	0.26	0.27	0.25	0.27	0.27	0.77
Tobacco	1.27	-	-	1.11	2.44	1.00	1.48	1.49	0.12	0.12	1.70	0.08	-

Source: Own calculations using 2006 agricultural production data (TIA) and the 2002/03 household survey (IAF).
Note: 'Poverty rate' is the poverty headcount based on provincial poverty lines.

Table 3. Crop land distribution across urban households and rural farm households

	National	Niassa	Cabo Delg.	Nam-pula	Zam-bezia	Tete	Manica	Sofala	Inham-bane	Gaza	Maputo prov.
All crops	3,028	336	406	555	422	249	235	295	230	226	74
Maize	934	108	111	72	104	127	118	85	73	119	18
Rice	24	0	1	0	20	0	0	3	0	0	0
Other cereals	610	149	101	143	17	10	34	145	8	2	0
Cassava	630	12	89	177	213	5	23	12	63	29	7
Other roots	64	7	1	2	14	10	8	2	1	15	3
Pulses	216	23	18	24	16	21	12	8	49	39	6
Groundnuts	94	3	12	40	6	10	6	4	10	1	2
Cashews	50	1	1	23	0	0	0	0	7	7	12
Vegetables	21	2	2	2	2	2	1	1	5	4	1
Fruits	58	6	5	6	4	6	3	2	13	10	2
Tea	6	0	0	0	0	0	6	0	0	0	0
Tobacco	53	20	1	4	7	19	2	0	0	0	0
Sugarcane	27	0	0	0	0	0	0	3	0	0	24
Cotton	152	0	48	34	13	27	8	22	0	0	0
Other crops	88	5	17	26	5	12	14	9	0	0	0
All crops	100.0	11.1	13.4	18.3	13.9	8.2	7.8	9.8	7.6	7.5	2.4
Maize	100.0	11.5	11.9	7.7	11.1	13.6	12.7	9.1	7.8	12.7	1.9
Rice	100.0	0.1	2.6	0.8	82.1	0.0	0.0	14.2	0.0	0.0	0.2
Other cereals	100.0	24.5	16.6	23.5	2.8	1.6	5.6	23.8	1.3	0.3	0.0
Cassava	100.0	1.9	14.2	28.1	33.8	0.8	3.7	1.9	10.0	4.6	1.1
Other roots	100.0	11.5	1.7	3.3	22.2	16.2	12.5	2.6	1.6	24.1	4.3
Pulses	100.0	10.5	8.4	11.1	7.6	9.7	5.4	3.8	22.8	17.9	2.8
Groundnuts	100.0	2.8	12.5	43.0	6.2	10.4	6.8	4.1	10.9	1.4	2.0
Cashews	100.0	1.3	1.3	46.6	0.4	0.0	0.0	0.4	13.5	13.5	23.0
Vegetables	100.0	10.5	8.4	11.1	7.6	9.7	5.4	3.8	22.8	17.9	2.8
Fruits	100.0	10.5	8.4	11.1	7.6	9.7	5.4	3.8	22.8	17.9	2.8
Tea	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Tobacco	100.0	37.9	1.0	7.7	13.6	36.2	3.1	0.2	0.2	0.0	0.0
Sugarcane	100.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	90.0
Cotton	100.0	0.3	31.9	22.0	8.8	17.8	5.1	14.1	0.0	0.0	0.0
Other crops	100.0	5.9	19.2	29.2	5.7	14.2	15.6	10.1	0.1	0.0	0.1

Source: Own calculations using 2006 agricultural production data (TIA) and the 2002/03 household survey (IAF).

Data

The data used to calibrate the base year of the model is drawn from a variety of data sources. The core dataset underlying the CGE model is a new 2003 social accounting matrix (SAM). This SAM was constructed using 2003 national accounts and supply-use tables from the Instituto Nacional de Estatística (INE). Province-level agricultural production and area data was taken from the 2006 national agricultural survey (Trabalho de Inquerito Agricola) (TIA) from the Ministry of Agriculture (MOA). The CGE model is thus consistent with recent agricultural production levels and yields at the provincial level. Nonagricultural production and employment data was compiled from the 2002/03 national household survey (Inquérito ao Agregado Familar sobre Orçamento Familiar) (IAF) and national accounts. On the demand-side, information on industrial technologies (i.e., intermediate and factor demand) was taken from earlier SAMs for Mozambique (Arndt et al., 1998; Thurlow et al., 2006), while the income and expenditure patterns for the various household groups were taken from IAF. The CGE model is therefore based on the most recent available data for Mozambique.

III. Poverty reduction under Mozambique's current growth path

In this section we use the CGE and micro-simulation model to examine the impact of Mozambique'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. Mozambique experienced rapid growth during 1996-2003, with national GDP growing at almost 9 percent per year (INE, 2007). During this same period the agricultural sector also experienced rapid growth of six percent per year. However, agricultural growth has taken place from a low base, with most of the growth associated with a 'bounce-back' after civil war. For example, while maize production has grown since the mid-1990s, much of this growth has been driven by land expansion, with national average maize yields still at 0.83 tons per hectare by 2006 (TIA). Given the possible slowdown in agricultural growth, the baseline scenario assumes that agricultural GDP will maintain a slower but steady agricultural growth rate of around 4 percent per year during 2006-2015 (see Table 5).

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

	Initial value of GDP (MTn mil.) 2003	Percentage share of total (%)		Average annual growth rate (%)	
		Total GDP 2003	Agricultural GDP 2003	Baseline scenario 2006-15	CAADP scenario 2006-15
Total GDP	66,727	100.0		6.3	7.0
Agricultural sub-sectors	17,299	25.9	100.0	4.2	6.6
Cereals	3,564	5.3	20.6	3.5	4.7
Maize	2,356	3.5	13.6	3.6	5.0
Rice	480	0.7	2.8	4.1	5.3
Other cereals	728	1.1	4.2	2.5	3.0
Root crops	4,795	7.2	27.7	4.7	5.2
Cassava	4,654	7.0	26.9	4.7	5.2
Other roots	141	0.2	0.8	4.3	4.7
Pulses and nuts	1,544	2.3	8.9	3.6	4.3
Pulses & oils	641	1.0	3.7	3.9	4.5
Groundnuts	606	0.9	3.5	4.2	5.3
Cashew nuts	297	0.4	1.7	1.5	1.0
Horticulture	2,217	3.3	12.8	4.3	5.7
Vegetables	1,145	1.7	6.6	4.3	5.3
Fruits	1,072	1.6	6.2	4.3	5.2
Export-oriented crops	705	1.1	4.1	4.7	6.1
Tobacco	216	0.3	1.2	1.5	3.5
Cotton	191	0.3	1.1	8.3	8.3
Sugarcane	51	0.1	0.3	7.5	7.5
Tea	2	0.0	0.0	4.0	5.4
Other crops	245	0.4	1.4	2.0	5.4
New crops	0	0.0	0.0	0.0	765.0
Bananas	0	0.0	0.0	0.0	577.5
Sugarcane (ethanol)	0	0.0	0.0	0.0	717.4
Jatropha (biodiesel)	0	0.0	0.0	0.0	837.9
Livestock	1,106	1.7	6.4	5.2	6.0
Cattle	223	0.3	1.3	6.1	6.7
Poultry	538	0.8	3.1	4.9	5.8
Other livestock	345	0.5	2.0	5.0	5.7
Fisheries	1,534	2.3	8.9	2.0	3.6
Forestry	1,834	2.7	10.6	5.3	6.0
Manufacturing	9,125	13.7		5.9	7.2
Other industry	6,319	9.5		10.0	8.5
Services	33,984	50.9		6.5	6.9

Source: 2003 Mozambique social accounting matrix and Mozambique CGE and microsimulation model.

Moreover, one-third of the growth during 1996-2006 was through area expansion, with the rest driven by rising yields (FAO, 2007). In the Baseline scenario, we assume that land expansion will continue at this pace, with a third of production increases driven by area expansion. This is equivalent to an increase in harvested land by 2 percent per year during 2006-2015, and is equal to the population growth rate of 2.0 percent. As shown in Table 4, the non-agricultural sectors

are expected to maintain a stronger performance over the coming decade, with manufacturing and service sectors growing more rapidly than agriculture at 7.2 and 6.9 percent respectively.

The 4.2 percent agricultural growth rate in the Baseline scenario is based on more detailed assumptions for different agricultural sub-sectors. Table 5 shows the assumptions made about each sub-sector's yield growth. We initially adopt the maize yield that was observed in 2006 and then assume that maize yields grow at 1.9 percent such that Mozambique achieves a sustained maize yield of 0.98 tons per hectare by 2015. While this is below the yields reported for certain seasons over the last decade (FAO, 2007), it is consistent with Mozambique's long term trend of around one ton per hectare (i.e., 1996-2006), and thus reflects expected fluctuations in the performance of the maize sector over the next decade.[2] Similarly, for rice and other cereals, we assume initial yields remain closer to longer-term trends at 0.39 and 0.46 tons per hectare respectively, and that these yields rise modestly to 0.53 and 0.58 tons per hectare by 2015.

Since population growth is lower that cereals production growth, there is growing excess supply for these food crops, which encourages a slightly smaller allocation of land towards maize, rice and other cereals. Thus, even though total agricultural land is growing at two percent per year, a smaller share of land is allocated to cereals by 2015.[3] Despite smaller land allocations, production of cereal crops still grows at around 3.5 percent per year during 2006-2015. Since cereals production growth is higher than population growth, annual average per capita cereals consumption increases under the Baseline scenario.

Based on the recent performance of root crops, we assume that these crops' yields will grow as fast as maize yields over the coming decade. Based on average annual yield growth rates since 1996, cassava and other root crop yields in the Baseline scenario grow at 1.9 and 2.5 percent per year respectively (see Table 5). Overall, root crop production is expected to continue growing at about 4.5 percent per year.

[2] There is considerable debate in Mozambique about an appropriate time-series for agricultural production. In this paper we draw on both FAO and TIA data, given the need for both time-series and cross-sectoral structural analysis.

[3] 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 both on 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 IAF).

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

	Crop yields (exogenous: imposed on the model)				Production quantity (endogenous: results from the model)				Harvested area (endogenous: results from the model)			
	Initial level	Baseline growth rate	CAADP target level	CAADP growth rate	Initial level	Baseline growth rate	CAADP target level	CAADP growth rate	Initial level	Initial share	Baseline share	CAADP share
	mt/ha	%	mt/ha	%	1000 mt	%	1000 mt	%	1000 ha	%	%	%
	2006	2006-15	2015	2006-15	2006	2006-15	2015	2006-15	2006	2006	2015	2015
Cereals												
Maize	0.83	1.9	1.06	2.8	772	3.6	1,185	4.9	934	29.1	28.5	23.3
Rice	0.42	2.4	0.58	3.6	20	4.1	32	5.4	48	1.5	1.4	1.2
Other cereals	0.49	1.9	0.61	2.4	297	2.6	390	3.1	610	19.0	17.1	13.4
Root crops												
Cassava	3.65	1.9	4.43	2.2	2,298	4.7	3,661	5.3	630	19.6	21.2	17.2
Other roots	3.98	2.5	5.11	2.8	254	4.2	386	4.8	64	2.0	1.9	1.6
Pulses and nuts												
Pulses & oils	0.23	2.6	0.30	2.7	51	3.9	75	4.4	216	6.7	6.4	5.2
Groundnuts	0.33	1.9	0.42	2.7	31	4.1	49	5.3	94	2.9	3.0	2.4
Cashew nuts	1.16	5.2	1.63	3.8	58	1.5	64	1.0	50	1.6	0.9	0.8
Horticulture												
Vegetables	5.50	1.8	6.75	2.3	350	4.2	551	5.2	64	2.0	2.1	1.7
Fruits	5.73	2.6	7.83	3.5	1,004	4.2	1,580	5.2	175	5.5	5.3	4.2
Export crops												
Tobacco	1.27	2.2	1.76	3.7	68	1.4	93	3.5	53	1.7	1.3	1.1
Cotton	0.82	1.3	1.19	4.2	125	8.3	256	8.3	152	4.7	7.3	4.5
Sugarcane	14.71	2.2	22.23	4.7	397	7.5	760	7.5	27	0.8	1.1	0.7
Tea	1.86	3.0	2.62	3.9	11	4.0	17	5.3	6	0.2	0.2	0.1
Other crops	0.30	2.3	0.42	3.8	26	2.0	43	5.4	88	2.7	2.2	2.1
New export crops												
Bananas	3.50	0.0	3.50	0.0	0	0.0	126	577.5	0	0.0	0.0	0.7
Sugarcane	14.71	0.0	14.71	0.0	0	0.0	2,943	717.4	0	0.0	0.0	4.2
Jatropha	3.00	0.0	3.00	0.0	0	0.0	2,250	837.9	0	0.0	0.0	15.6

Source: Yield, area and production estimates from 2006 agricultural production data (TIA).

Other food crops, such as groundnuts and horticulture, have grown fairly well over the last decade. To capture these recent trends, the Baseline scenario assumes that pulses and groundnut yields will grow at 2.6 and 1.9 percent per year during 2006-2015 (see Table 5). By 2015 it is expected that groundnut yields will have risen slightly to 0.39 tons per hectare. Bean yields will increase from 0.22 to 0.29 tons per hectare by 2015 under the Baseline scenario.

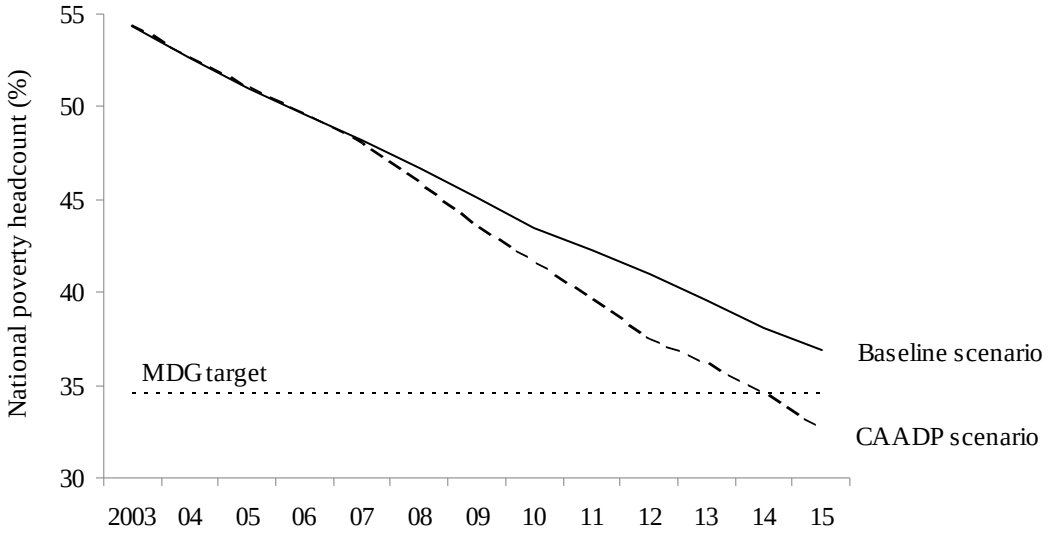
Export crops have also performed well since the mid-1990s. Tobacco and sugarcane production rose during 1996-2006. The Baseline scenario assumes that these export-oriented crops will continue to have higher growth potential than food crops. Cotton and sugarcane are expected to grow faster than agriculture as a whole at 8.3 and 7.5 percent per year (see Table 4). These export crop assumptions do not include the emerging opportunities for new export crops, such as sugarcane for ethanol and jatropha for biodiesel, which are assumed to remain unchanged under the Baseline scenario.

Livestock is another important agricultural sub-sector generating 6.4 percent of agricultural GDP in 2003 (see Table 4). The Baseline scenario assumes that livestock GDP will expand until 2015 at a rate of 5.2 percent per year. This also assumes more rapid growth in poultry GDP, and slower growth in other livestock, such as pigs and sheep. Fisheries and forestry are also key agricultural sub-sectors, together generating almost 20 percent of total agricultural GDP in 2003. The Baseline scenario assumes that fisheries GDP will grow at 2.0 percent per year during 2005-2015. This captures reasonable expectations about sustainable growth potentials. For the forestry sub-sector, the Baseline scenario assumes that value-added in this sub-sector will grow more rapidly 5.3 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 6.3 percent during 2006-2015. This is below the average GDP growth rate of 7.5 percent experienced during 2002-2005 (World Bank, 2007), thus reflecting a potential slowdown in the economic growth over the coming decade. However, with population growth at about 2.0 percent per year, this means that per capita GDP grows rapidly at 4.3 percent. With rising per capita incomes, the CGE model indicates that poverty will decline.

Moreover, this decline in poverty will be significant with national poverty falling from 54.4 percent in 2003 to 36.9 percent in 2015 (see Figure 2). With this rapid poverty reduction, and despite an expanding population, the absolute number of poor people in Mozambique would decline from 9.95 million in 2003 to 8.55 million by 2015. Relatively balanced growth across both agricultural and non-agricultural sectors means that national income growth is fairly evenly distributed across rural and urban areas. Accordingly, urban poverty falls from 51.5 to 36.5 percent by 2015, while rural poverty declines from 55.7 to 37.0 percent during the same period. However, poverty reduction under the Baseline scenario is insufficient to reach the first Millennium Development Goal of halving poverty by 2015 (first measured in 1996 at 69.1 percent) (see Figure 2).

Figure 2. National poverty rate under alternative agricultural growth scenarios



Source: Results from the Mozambique 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 Mozambique's current growth path on poverty reduction. In this section we examine the potential contribution of different agricultural sub-sectors in helping Mozambique 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. It is therefore not expected that Mozambique will achieve and sustain the high yields predicted under the more ideal conditions of controlled field trials conducted within-country.

Taking maize as an example, under the Baseline scenario we assumed that average yields for the next ten years would remain relatively constant between 0.83 and 0.98 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 1.9 percent per year to 2.8 percent per year (see Table 5). This implies that national average maize yields will rise consistently over the next ten years to reach 1.1 tons per hectare by 2015. This is well below the maximum potential yields identified by Mozambican field trials. However, it is similar to the 2.7 percent per year yield improvement achieved by India during the 1970s (FAO, 2007).

Table 6 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 increase total factor productivity (TFP) for the maize crop so as to achieve the yield target shown in Table 5. In the non-crop scenarios, such as 'livestock-led growth', we also increase TFP to achieve the targeted GDP growth rates. In the final Scenario 11, or '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 6. Model growth scenarios

	Maize-led	Cereals-led	Root-led	Pulses-led	Hort-iculture-led	Export-crop-led	Live-stock-led	Fisheries-led	Forestry-led	New-crop-led	CAADP scenario
	1	2	3	4	5	6	7	8	9	10	11
Maize	×										×
Rice		×									×
Other cereals		×									×
Cassava			×								×
Other roots			×								×
Pulses & oils				×							×
Groundnuts				×							×
Cashew nuts				×							×
Vegetables					×						×
Fruits					×						×
Tobacco						×					×
Cotton						×					×
Sugarcane						×					×
Tea						×					×
Other crops						×					×
Bananas										×	×
Sugarcane										×	×
Jatropha										×	×
Cattle							×				×
Poultry							×				×
Other livestock							×				×
Fisheries								×			×
Forestry									×		×

In the 'new export crop' growth scenario we model an expansion of new land allocated to currently nonexistent export crops, such as bio-fuels.[4] Based on existing investment requests, we assume that the land allocated to sugarcane for ethanol production rises to 200 000 hectares by 2015, while jatropha for biodiesel production grows to 500 000 hectares. Finally, export banana production is assumed to rise to 36 000 hectares. We currently assume that this new investment takes place evenly across the ten provinces in Mozambique.

Agriculture's current strong performance means that achieving the CAADP target of six percent growth poses a reasonable or surmountable challenge. Based on the crop yield and agricultural productivity targets identified at the sub-sectoral level, the CGE model indicates that Mozambique could reach an average agricultural growth rate of 6.6 percent during 2006-2015 (see Table 4). However, since agriculture is only a quarter of the economy, this acceleration of agricultural growth increases the national GDP growth rate from its current 6.3 percent to 7.0 percent per year. Faster agricultural growth also stimulates additional growth in the non-agricultural sectors, by raising 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 manufacturing sector increases from 5.9 percent under the Baseline scenario to 7.2 percent per year. Achieving the CAADP agricultural growth target therefore has strong economy-wide growth-linkage effects for non-agriculture.

Impact on poverty

The acceleration of agricultural growth to over six percent per year and the spillover effects into non-agriculture causes poverty to decline by a further 4.2 percentage points. This is shown in Figure 2, where the share of Mozambique's population under the poverty line is 32.6 percent by 2015 under the CAADP scenario compared to 36.9 percent under the Baseline scenario. Thus, taking population growth into account, achieving the CAADP growth target lifts an additional 0.98 million people above the poverty line by 2015, and is sufficient to halve the 1996 poverty rate, thus achieving the first MDG.

[4] The 'new export crop' scenario draws on ongoing collaborative work between the Ministries of Agriculture and Planning to investigate the impact of large-scale commercial crop development in Mozambique.

Faster agricultural growth benefits a majority of households. However, not all households in all provinces benefit equally from achieving the crop yields and sub-sector growth rates targeted under the CAADP growth scenario. Table 9 shows changes in poverty rates for different farm household groups in the model. Within urban areas, it is households outside of Maputo City (i.e., in the provincial urban centers) that benefit more from faster agricultural growth. This is because these urban economies are more heavily engaged in agriculture-related activities, and thus are more likely to benefit than households in metropolitan Maputo.

Table 7. Poverty headcount in the model

	Initial poverty rate (%)	Final poverty rate under…		Additional poverty reduction
		Baseline scenario	CAADP scenario	
	2003	2015	2015	2015
National	54.4	36.9	32.6	-4.2
Urban	51.5	36.5	32.3	-4.3
Maputo City	53.6	39.1	35.8	-3.3
Other urban	51.0	36.0	31.5	-4.5
Rural	55.7	37.0	32.8	-4.2
Niassa	53.2	27.3	21.1	-6.2
Cabo Delgado	65.1	43.9	36.7	-7.1
Nampula	57.8	37.6	33.4	-4.2
Zambezia	45.1	24.7	21.9	-2.8
Tete	59.0	45.5	41.0	-4.4
Manica	40.8	26.0	23.3	-2.7
Sofala	33.8	16.9	13.7	-3.2
Inhambane	86.5	75.4	72.4	-2.9
Gaza	61.7	37.5	31.2	-6.3
Maputo province	81.2	69.4	63.6	-5.9

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

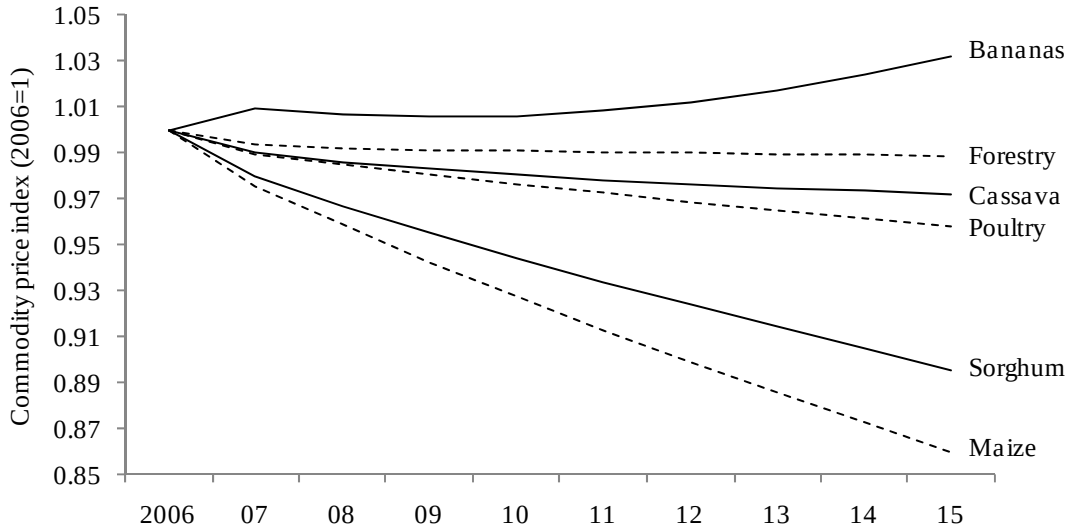
As indicated in Tables 2 and 3, higher-value export-oriented crops are grown more intensively in certain provinces. For example, tobacco production is most important in Niassa province, whereas cotton production is more heavily concentrated in Cabo Delgado and Sofala. As such, it is representative farmers in these provinces that benefit the most from export crop production under the CAADP scenario. These crops are assumed to have higher growth potential than other food crops. Poverty declines by more in these provinces than in less export-oriented provinces, such as Manica or Zambezia.

Poverty declines for all representative households. However, the sources of additional incomes vary across representative farms. Not surprisingly, households that already depend more 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 effects farm incomes since it increases 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. Thus it is important to note that, while we model maize-led growth by increasing maize yields, 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.

Figure 3 shows the importance of taking demand constraints and relative price changes into account. Maize and sorghum face domestic demand constraints and have weaker linkages to upstream food processing and foreign markets. 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. By contrast, poultry has stronger linkages to food processing, which means that, while prices do decline under the CAADP scenario, they fall by less than for maize crops. Finally, under the small-country assumption, we assume that world prices are unaffected by domestic trade decisions. Thus, export-oriented crops face elastic demand at a fixed price, which only adjusts in response to changes in the real exchange rate.

Figure 3. Relative producer price changes under the CAADP scenario



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

In summary, the CGE model results indicate that it is possible for Mozambique to reach the CAADP target of six percent agricultural growth. This is supported by the current strong performance of the agricultural sector, thus requiring less additional growth in crops and agricultural sub-sectors. 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 livestock sub-sectors also contribute significantly 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 highlighted the potential contributions of different crops and sub-sectors in increasing agricultural growth and poverty reduction. However, the different sizes of these sub-sectors made 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 certain households have better opportunities to produce higher-value crops, and are thus better positioned to benefit from export-led agricultural growth. However, export-crop-producing households are typically less poor than other rural households (see Table 7). Thus, agricultural growth driven by export crops may have less of an impact on poverty, especially amongst the poorest households. By 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 one percent increase in agricultural GDP per capita. Table 8 shows the calculated poverty-growth elasticities under the different growth scenarios. The results indicate that agricultural growth driven by maize and other cereal crops are more effective at reducing poverty than growth in export crops, although the new export crops have greater poverty reducing potential than existing export crops.[5] For example, a one percent increase in maize GDP causes the national poverty headcount rate (P0) to decline by 0.73 percent, while growth in existing export crops, such as tea and sugarcane, causes the poverty rate to decline by 0.29 percent. This emphasizes the importance of cereals for poorer households in Mozambique, both as a source of income and as an item in households' consumption baskets. Although root crops and pulses are less effective at reducing the incidence of poverty, they are more effective at reducing the severity of poverty amongst Mozambique's poorest households, as

[5] 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. traction during land preparation). Rather the model treats livestock as producers of final products, such as meat and dairy. The elasticities for forestry and fisheries are overestimated in the current model framework, due primarily to a lack of data to calibrate these sectors in the model. Their elasticities are removed from Table 8 until new data becomes available.

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 captured in the elasticities reported in the table. This arises because maize growth reduces urban poverty by reducing urban food prices, which is captured within the economy-wide model.

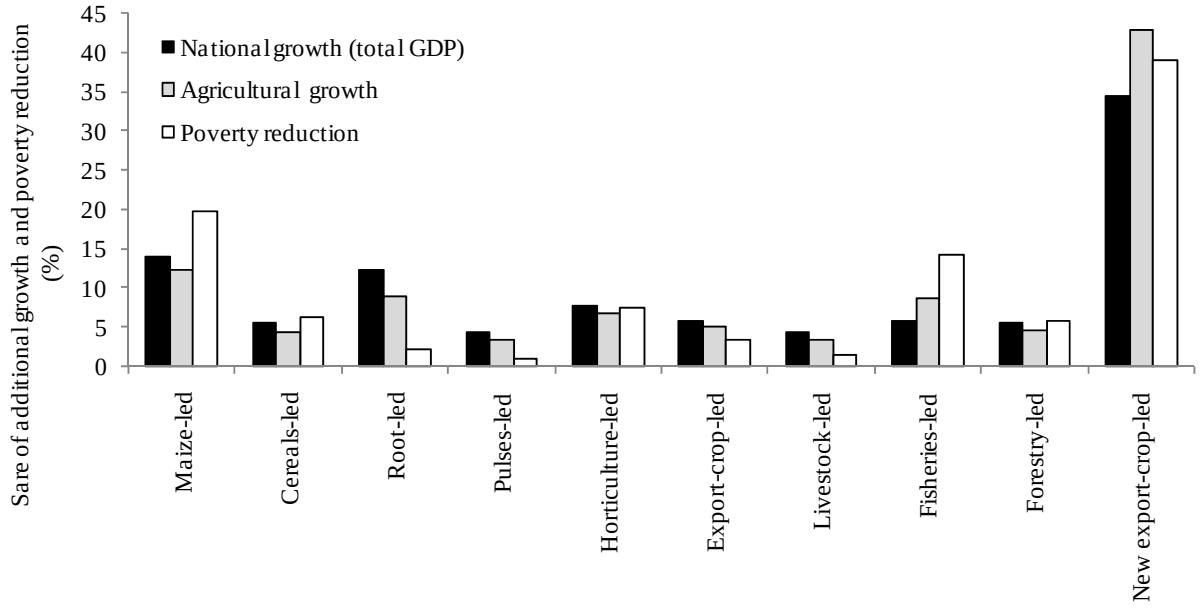
Table 8. Poverty-reduction-growth elasticities under alternative agricultural growth scenarios

	Percentage change in poverty rate caused by one percent growth in agricultural GDP led by the following crops and sub-sectors…		
	Incidence P0	Depth P1	Severity P2
Maize-led growth	-0.730	-0.914	-0.987
Cereals-led growth	-0.648	-0.931	-1.103
Root-led growth	-0.106	-0.533	-0.798
Pulses-led growth	-0.117	-0.745	-0.923
Horticulture-led growth	-0.481	-0.582	-0.749
Export-crop-led growth	-0.294	-0.455	-0.497
Livestock growth	-0.180	-0.343	-0.383
New export-crop-led growth	-0.429	-0.407	-0.444
CAADP growth scenario	-0.537	-0.680	-0.801

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

An alternative representation of poverty-growth linkages is shown in Figure 6, which compares each sectoral scenario's contribution to agricultural growth and poverty reduction. The higher-than-average poverty-growth elasticities of maize and other cereals growth can be seen by the fact that these sectors contribute more to poverty reduction under the CAADP scenario than they do to growth. However, Mozambique 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 new export crops have lower poverty-growth elasticities than maize, the rapid growth potential of these sectors means that they could account for most of the overall poverty reduction under the CAADP scenario. Conversely, a growth strategy should not overly rely on high growth potential sectors without taking into the account their potential contribution to the national economy.

Figure 6. Share of additional growth and poverty reduction for CAADP sectoral scenarios



Source: Results from the Mozambique 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 9 measures agriculture's growth-linkage-effects at the sub-sector-level. For example, the maize-led growth scenario causes agricultural GDP to increase by MTn 866 million (see column five). However, total GDP increases by more than this amount due to backward and forward production and consumption linkages. For example, increasing maize production stimulates growth in food processing within the manufacturing sector, while also reducing food prices and increasing real incomes that are then spent on non-agricultural commodities. Overall GDP increases by MTn 1227 million, which means that for every MTn 1 increase in agricultural GDP driven by maize-led growth there is an additional MTn 42 increase in non-agricultural GDP (i.e., a growth-linkage ratio of 1.42). Comparing these ratios across model scenarios suggests that, even through livestock-led growth contributes less to agricultural growth under the CAADP scenario (see Figure 6), it is more effective at stimulating non-agricultural growth than new export-crop-led growth. The latter has weaker economy-wide growth-linkages because most of export crop sectors are exported directly as raw agricultural materials and do not generate many employment opportunities in upstream production before being exported.

Table 9. Agriculture's economy-wide growth-linkage effect

	Sector's initial value-added	Sectoral growth rates (%)		Additional GDP relative to baseline (2003 mil. MTn)		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	2,356	3.6	5.1	1,227	866	1.42
Cereals-led	1,208	3.2	3.6	494	306	1.61
Root-led	4,795	4.7	5.1	1,091	636	1.71
Pulses-led	1,544	3.6	4.2	381	236	1.62
Horticulture-led	2,217	4.3	5.3	689	485	1.42
Export-crop-led	705	4.7	8.7	519	350	1.48
Livestock	1,106	5.2	5.8	377	230	1.64
New export- led	0	0.0	765.0	513	616	0.83
Fisheries-led	1,534	2.0	5.6	498	318	1.57
Forestry-led	1,834	5.3	6.1	3,041	3,026	1.01
CAADP scenario	17,299	4.2	6.6	8,563	6,538	1.31

Source: Results from the Mozambique CGE and microsimulation model.

The previous section concluded that to increase agricultural growth and reach the CAADP growth and MDG poverty targets it will be necessary to encourage growth in a number of agricultural sub-sectors. On the one hand, the poverty-growth elasticities, sectoral growth potentials, and size- and linkage-effects presented in this section suggest that improving maize and other cereals yields should be afforded high priority. This is because maize is a large sector, with high poverty-growth elasticities, and which stimulates economy-wide growth. On the other hand, maize and other food crop sectors are unlikely to generate large-scale agricultural growth and poverty reduction in isolation of accelerated growth in export crops. Here the potential for new export crops provides opportunities to encourage faster pro-poor growth in Mozambique.

V. Summary of major findings

A dynamic CGE model was developed and used to examine the contribution of accelerating growth in alterative agricultural crops and sub-sectors and to assess how Mozambique can achieve the CAADP target of six percent agricultural growth. The impact of agricultural growth at the macro- and microeconomic levels, as well as on poverty, was estimated. The major conclusions of this study are summarized below.

Six percent agricultural growth is achievable and sufficient to meet MDG1

The CGE model results indicated that if Mozambique can achieve reasonable improvements in crop yield targets and sub-sector growth rates, then it should be possible to achieve the CAADP target of six percent agricultural growth during 2006-2015. By focusing additional growth in agriculture, agricultural growth at 6.6 percent per year would increase overall GDP growth from 6.3 to 7.0 percent per year. This higher growth rate would reduce national poverty to 32.6 percent by 2015, which is lower than the 36.9 percent poverty rate that would have been achieved without additional agricultural growth. This means that the higher growth under the CAADP scenario would lift an additional 0.98 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, some regions growing higher-value export-oriented crops, such as tobacco and cotton, stand to gain more than households in other regions. Furthermore, poverty amongst households in some regions will remain high, despite faster agricultural growth. Finally, both rural and urban households benefit equally from faster agricultural growth. This is because agricultural commodities are an important part of the consumption baskets of both urban and rural households. As such, while rural poverty falls by an additional 4.2 percentage points, urban poverty also falls by a similar amount.

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 and other cereal crops has larger impacts on poverty reduction than similar growth in more export-oriented crops. This is because yield improvements in these crops not only benefit households directly, by increasing incomes from agricultural production, but also by allowing farmers to diversify their land

allocation towards higher-value crops. Cereals are already an important sector in Mozambique and have strong growth-linkages to non-agriculture, which stimulates broader economy-wide growth and poverty reduction. Thus, high priority should be afforded to improving yields amongst maize and other cereal crops.

There are two major challenges to food crop development. First, increasing food crop yields will require substantial improvements in research, extension and irrigation, which are inadequate in many parts of the country. Overcoming these constraints will require greater engagement in public-private partnerships where the public sector lacks capacity, such as credit and input provision. Secondly, while targeting specific food crops may support urban and rural poverty reduction, production increases will be offset by significant price declines. This underlines the importance of local and regional market development, in part through investment in rural roads, especially in less densely populated roads.

Given the above constraints, it is clear from the model results that efforts to achieve Mozambique's growth and poverty reduction goals would be greatly strengthened by the establishment of new commercial export crops, such as bio-fuels, which produce clear pro-poor outcomes and permit greater diversification in rural employment options. The higher growth potential of these export crops relative to that of food crops means that export-led growth will still account for a large share of overall poverty reduction under the CAADP scenario, despite these sectors lower poverty-growth elasticities. Finally, the varying importance of different crops in different parts of the country highlights the need to design development strategies at the sub-national level. Thus, in revising its new agricultural strategy, it is important that Mozambique take into account how sectoral growth priorities vary at the provincial level, and how they interact and contribute to national development objectives.

References

Arndt, C., Cruz, A., Jensen, H.T., Robinson, S. and Tarp, F. 1998. "Social Accounting Matrices for Mozambique, 1994 and 1995", Trade and Macroeconomics Discussion Paper No. 28, IFPRI, Washington D.C.

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

FAO (Food and Agriculture Organization of the United Nations). 2006. FAOSTAT database. <http://faostat.fao.org/> last accessed in October 2007.

Lofgren, H., Harris, R. and Robinson, S. 2002. "A standard computable general equilibrium (CGE) model", IFPRI, Washington DC.

Thurlow, J. 2003. "A recursive dynamic computable general equilibrium model of South Africa", Trade and Industrial Policy Strategies, Johannesburg, South Africa.

Thurlow, J. 2006. "A 2002/03 poverty-focused social accounting matrix for Mozambique", IFPRI, Washington D.C.

World Bank. 2006. *World development indicators.* Last accessed in October 2007**.**

Appendix: 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 2003 social accounting matrix (SAM) that provides information on demand and production for 56 detailed sectors (see Table 1). The model further disaggregates agricultural activities across provinces using agricultural survey data (see Section 2). Nonagricultural production is also 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 unpaid agricultural workers, unskilled and semi-skilled workers working in both agriculture and non-agriculture, and skilled non-agricultural workers. Skills are based on worker education levels. Information on employment and wages by sector and region is taken from the 2002/03 household survey (IAF).

Workers in the model can migrate between sectors, although unpaid family labor remains within agriculture. 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 labor mobility from working on smallholder farmers' own land to finding employment opportunities through the labor market. Capital moves freely within regions and within the broad agricultural and non-agriculture sectors, and accumulation of capital is through investment 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 IAF. This 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, and therefore, how changes in Mozambique's structure of growth influences its distribution of incomes.

The growth-poverty relationship is examined by combining a CGE and micro-simulation model. An important factor determining the contribution of agriculture to overall economic growth is its linkages with the rest of the economy. Agriculture's proponents argue that agriculture has strong

growth-linkages. The model captures production linkages by explicitly defining a set of nested constant elasticity of substitution (CES) production functions 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 IAF. As with production, households are defined at the regional level, and within each region, by income quintiles. Metropolitan Maputo and other urban centers are treated as separate groups given their unique role as nonagricultural 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 IAF. 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 IAF. 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 have to generate export earnings in order to pay for imported goods and services. While this assumption realistically limits the degree of import competition in the domestic market, it also underlines the importance of the agricultural and industrial export sectors. For the government account, tax rates and real consumption 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 recursive dynamic, which means that some exogenous stock variables in the models are updated each period based on inter-temporal behavior and results from previous periods. The model is run over the period 2003-2015, with each equilibrium period representing a single year. The model also exogenously captures demographic and technological change, including population, labor supply, human capital and factor-specific productivity. Capital accumulation occurs through endogenous linkages with previous-period investment. Although the allocation of newly invested capital is influenced by each sector's initial share of 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 models 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	
$QINT_{ca} = ica_{ca} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}-1}$	(4)
$QF_{fa} = \alpha_{fa}^{van} \cdot \left(\sum_{f' \in F} \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}} \right)^{-\frac{1}{\rho_{fa}^{van}}}$	(5)
$W_{f'} \cdot WFDIST_{f'a} = W_f \cdot WFDIST_{fa} \cdot QF_{fa} \cdot \left(\sum_{f'' \in F} \delta_{ff''a}^{van} \cdot QF_{f''a}^{-\rho_{fa}^{van}} \right)^{-1} \cdot \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}-1}$	(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)
$QXAC_{ac} = \theta_{ac} \cdot QA_a$	(10)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(11)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(12)
$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1}$	(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)
$QT_c = \sum_{c' \in C'} (icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'})$	(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)
$YIF_{if} = shif_{if} \cdot [YF_f - trnsfr_{row\,f} \cdot EXR]$	(29)
$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$	(30)
$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'}$	(31)
$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih}\right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h$	(32)
$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right)$	(33)
$QINV_c = IADJ \cdot \overline{qinv}_c$	(34)
$QG_c = \overline{GADJ} \cdot \overline{qg}_c$	(35)

Table A3. CGE Model Equations (continued)

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

ReSAKSS
Regional Strategic Analysis and Knowledge Support System
Africa Wide

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