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Agricultural Growth and Poverty in Mozambique:

Technical Analysis in Support of the Comprehensive Africa Agriculture Development Program (CAADP)

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ABSTRACT

In any economy there are important economic linkages and trade-offs that need to be considered when designing policies or assessing their impacts. Various policy analysis tools can help policymakers understand these linkages and trade-offs. One such tool is an economywide computable general equilibrium (CGE) model. In this study we calibrate a CGE model to Mozambique's newest social accounting matrix (SAM) to consider economywide growth, poverty, and nutrition impacts under alternative agricultural growth scenarios. Scenarios are compared over the period 2009–2019, which coincides with the implementation period of the *Strategic Plan for Agricultural Development* (PEDSA), Mozambique's embodiment of the *Comprehensive Africa Agriculture Development Program* (CAADP). The "baseline scenario" assumes a continuation of Mozambique's recent experience of low agricultural productivity and slow progress in the fight against poverty. Although national accounts estimates suggest that agricultural GDP expanded at around 7.4 percent per annum during 2003–2007, this figure has been widely questioned. In our baseline scenario, which carefully replicates historic crop production trends from official statistics, agricultural GDP only expands at 3.2 percent per annum during 2009–2019, while the economy as a whole expands at 5.7 percent per annum. The poverty headcount rate declines from 54.6 in 2008/09 (the official estimate) to 46.8 percent by 2019. The biggest decline in poverty occurs in the southern region where, following recent trends, agricultural productivity increases more rapidly off a very low base compared to other regions. The share of caloric deficient people declines from 57.1 percent in the base to 50.1 percent by 2019.

Under an accelerated agricultural growth scenario or "CAADP scenario", agricultural growth is more broad-based and reaches the seven percent target set by PEDSA. Even though Mozambique's GDP growth strategy largely focuses on the development of extractive industries, the agricultural sector's importance is demonstrated in this scenario, with national GDP growth rising by 1.2 percentage points relative to the baseline growth rate (i.e., to 6.9 percent). The central and northern regions are prioritized under PEDSA due to a superior agricultural potential. After a decade of stagnation the north is regarded as a priority region with very high potential for rapid growth; hence, agricultural GDP expands by 9.3 in this region. The central region, which has already outperformed its neighboring regions during the past decade, continues to be considered a priority. We assume a continued strong performance, with the agricultural sector expanding at a rate of 5.8 percent per annum. Finally, agriculture in the southern region, although not a priority under PEDSA, grows at a respectable 4.9 percent off a low base. Under this accelerated growth scenario national poverty reaches 44.9 percent by 2014, which is higher than the *Poverty Reduction Plan's* optimistic target of 42 percent by 2014, and 35.8 percent by 2019. The rapid increase in per capita (staple) food production in the CAADP scenario further causes the calorie deficiency rate to decline by 13.3 percentage points relative to the baseline scenario. As expected, poverty and calorie deficiency reduction is not as rapid in the southern region. However, even our reported rates of decline may be an overestimate given the assumption of common prices across a national commodity market. Further analysis is required to determine to what extent weak market linkages between the south and the rest of the country may actually prevent the southern region from benefiting from price declines and food supply associated with enhanced productivity in the central and northern regions.

Key words: Mozambique, CGE, SAM, CAADP, agricultural productivity, poverty reduction, agricultural growth.

INTRODUCTION

Mozambique has experienced rapid economic growth over the last decade. National accounts estimates put the GDP growth from 2003–2007 at 8.4 percent per annum, with strong growth across all subsectors in the economy, including agriculture (7.4 percent), industry (8.0 percent), and services (9.3 percent) (see Table 3.1 further below). Drought condition in 2008 and a spike in world prices had a negative effect on the economy, leading to a slowdown in GDP growth during 2007–2009 (6.3 percent). However, preliminary estimates point at a recovery during 2009–2010. Although never an outright priority in terms of the country's development strategy, the agricultural sector has always played an important role in the Mozambican economy. During the 1990s, strong growth in the agricultural sector, which accounts for roughly one-quarter of GDP and employs 80 percent of the adult population, contributed to the great strides made in the fight against poverty (Thurlow 2012). The official poverty headcount rate fell from 69.4 percent in 1996/97 to around 54.1 percent in 2002/03. The latest estimate, however, suggests that poverty had in fact increased marginally to 54.7 percent in 2008/09 (DNEAP 2010) (Table 4.4 reports detailed poverty statistics).

In the context of apparent rapid agricultural GDP growth, the poverty outcome came as a surprise to many. This raised questions over the reliability of the crop production statistics underlying the national accounts estimates, with some suggesting instead that the official statistics produced by the Ministry of Agriculture (Trabalho de Inquerito Agricola or TIA) painted a much more realistic yet somber picture of the agricultural growth performance during 2003–2009 (see Arndt et al. 2011). TIA data suggest that yields of most staple foods remained stagnant or declined during the period. This stagnation has been identified as one of major reasons why poverty reduction was so sluggish (Arndt et al. 2011). There were also some other factors that played a role. Using a CGE model Arndt et al. (2011) demonstrate how external price shocks and region-specific weather shocks caused poverty to spike at the time the 2008/09 survey was being conducted. Mozambique's high import intensity meant the impact of the 2008 world food price shocks had a very pronounced impact on domestic prices. These effects were compounded by the fact that fuel prices in 2008 were nearly five times the average levels during 2002. A drought in 2008 affected many farming households in the central region, which explains the sharp increase in poverty there despite the region's agricultural sector being one of the better performing ones during 2002–2008.

Mozambique recently launched its *Strategic Plan for Agricultural Development* (PEDSA) (Ministry of Agriculture 2011). The document spells out the country's vision of transforming the agricultural sector from being predominantly a subsistence farming industry to becoming a competitive and sustainable sector that would contribute to food security and raise incomes of rural households. Agriculture is still a vital source of income for the majority of the population. Although its relative importance as an exporting sector is declining in the face of rapid industrialization and export growth in mining and industrial sectors, the sector still contributes around one-tenth to export revenues. The sector further provides key inputs for agro-processing sectors, which contribute a further 6.5 percent to national GDP. In parallel to PEDSA, the New Partnership for Africa's Development (NEPAD) is implementing the *Comprehensive Africa Agriculture Development Program* (CAADP) in partnership with various African governments, including Mozambique. CAADP supports the identification of an integrated framework of development priorities aimed at restoring agricultural growth, rural development and food security in the African region. Although the main target of CAADP is achieving six percent agricultural growth per year, Mozambique's PEDSA document sets this target at seven percent.

Since there are choices involved within the agricultural sector, both for the sector as a whole and across sub-sectors, many of the investment and policy interventions under PEDSA are being designed at the sub-sector level. However, strong inter-linkages exist 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 analysis framework is needed to synergize growth projections for different sub-sectors and evaluate their combined effects on economic growth, poverty reduction, and caloric availability. Moreover, agricultural production growth is often constrained by demand in both domestic and export markets. 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 economywide impact of agricultural growth.

Thus, to summarize, this study uses an economywide computable general equilibrium (CGE) model for Mozambique to analyze the linkages and trade-offs between economic growth, poverty reduction, and caloric availability at both macro- and micro-economic levels. As such the study builds on earlier analysis by James Thurlow, which was recently published in an IFPRI book entitled *Strategies and Priorities for African Agriculture: Economywide Perspectives from Country Studies* (Thurlow 2012), with some important additions and updates. First, the CGE model is calibrated to a new social accounting matrix (SAM) for Mozambique with base year 2007 (Pauw and Thurlow 2012) (the previous study used a 2003 SAM). Second, whereas the initial analysis intended to guide debate in prioritizing the contribution of different subsectors in helping Mozambique achieve its broader development objectives, the analysis here also introduces a regional focus. Specifically, we consider the role of regional agricultural growth targets and policy interventions on patterns of subsector, regional, and national growth. Finally, in addition to the familiar "poverty module", the CGE model now includes a "nutrition module" that estimates changes in caloric availability at the household level based on food consumption results for different representative households in the model. This model adaptation follows the approach first developed by Pauw and Thurlow (2011) for Tanzania.

The paper is structured as follows. The following section provides background information on the data, the CGE model, and the two microsimulation components for estimating poverty and caloric availability changes, with additional technical detail provided in Appendix A. We then evaluate Mozambique's recent agricultural growth performance, and specifically analyse yield performance of key staple crops at the national and regional level. Next, we present and discuss model results from our baseline and CAADP scenarios. The baseline scenario is calibrated under the assumption that Mozambique's agricultural sector will continue along the same low-productivity growth path over the simulation period (2009–2019) as was observed during the preceding decade. The CAADP scenario, on the other hand, assumes more broad-based growth across all agricultural subsectors and attainment of the seven percent agricultural growth target. Finally, the conclusion highlights policy implications from the analysis.

MODELING AGRICULTURAL GROWTH AND POVERTY REDUCTION

Computable General Equilibrium Model

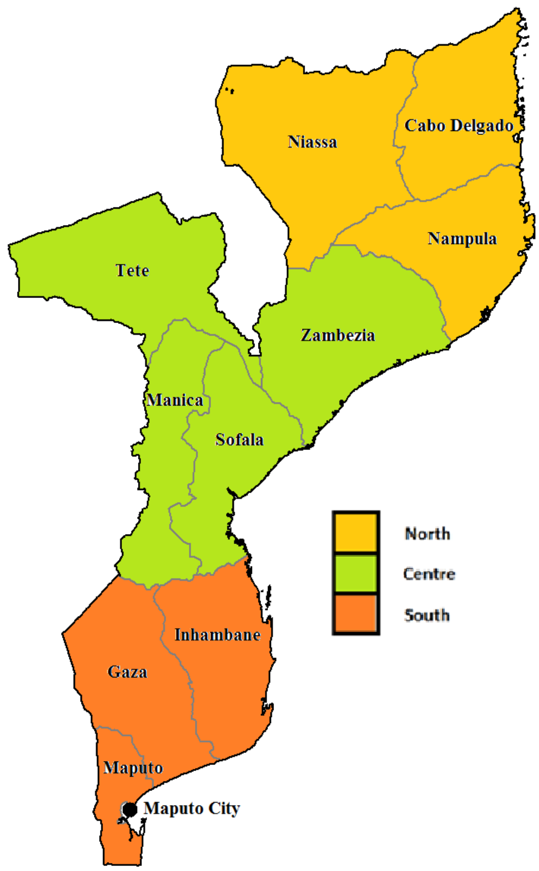
For this analysis we calibrate a standard recursive-dynamic CGE model with a newly developed 2007 SAM for Mozambique (Pauw and Thurlow 2012). Model simulations capture trade-offs and synergies from accelerating growth in agricultural subsectors, as well as the economic inter-linkages between agriculture and the rest of the economy. Although this particular study focuses on the agricultural sector, the CGE model also contains information on the non-agricultural sectors. This is particularly relevant in Mozambique where non-agricultural growth—particularly in extractive industries and such as coal and natural gas—has been an important driver of national growth in recent times. The model version used here identifies 54 subsectors, 22 of which are in the agriculture, forestry, and fisheries sector. A listing of main activity/commodity accounts appears in Table A.1 (Appendix A).

Agricultural crops fall into five broad groups: (i) cereal crops, which include maize, sorghum and millet, rice, and wheat; (ii) root crops, which include cassava and other roots (e.g., sweet potatoes); (iii) pulses, nuts, and oilseeds, which includes beans and pulses, groundnuts, cashew nuts, and oilseeds; (iv) horticulture, which includes vegetables and fruits; and (v) higher-value export-oriented cash crops, which include leaf tea, tobacco, sugarcane, cotton, and other export crops. The CGE model also identifies three livestock sub-sectors, including cattle, poultry, and other livestock (i.e., sheep, goats, and pigs). All the crops and livestock sectors are spatially disaggregated across the three regions in Mozambique (see Figure 2.1), which permits a regional assessment of agricultural growth and policy impacts. A national forestry sector and a fisheries sector complete the agricultural sector.

Agricultural commodities can be exported, consumed directly by households, or used as intermediate inputs in agro-processing activities. Processing activities identified in the model include meat and fish processing; grain milling; sugar refining; other food processing; beverages; tobacco processing; cotton ginneries; textiles; leather; wood processing; and paper products. Various other "heavy" manufacturing sectors are also included in the model. These are fuels; chemicals; non-metal minerals; metals; and machinery. Other industrial sectors (water, electricity, and construction), as well as various private and government services subsectors make up the remainder of the non-agricultural sectors in the model. In addition to the forward linkages that exist between agriculture and the agro-processing sectors in particular, the model also captures important backward linkages from industrial and services sectors to the agricultural sector (e.g., demand for intermediate inputs such as chemicals or trade and transport services).

The high level of details in the agricultural sector is particularly useful in a study of this nature. The CGE model captures the initial cropping patterns for each subsector in each of the three regions. This includes information on initial land use, production levels, and crop yields (these data are obtained from the TIA and supplemented with data from FAOSTAT), as well as demand for other inputs. The representative farmer in each province responds to changes in production technology (e.g., total factor productivity gains associated with agricultural policy interventions), commodity demand (due to household income changes), and changing market prices (due to changes in demand and supply) by reallocating land and other resources across different crops in order to maximize incomes. Farm households may also reallocate labor and capital away from farm activities 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 economywide model with regional agricultural production models. The Mozambique CGE model is therefore an ideal tool for capturing the growth linkages and income-and price-effects resulting from accelerating growth in different agricultural sectors.

Figure 2.1. Regions in the CGE model



Microsimulation Poverty and Nutrition Modules

The CGE model endogenously estimates the impact of growth on household incomes. There are 30 representative household groups in the model, disaggregated across three regions, five income quintiles (based on per capita expenditure levels), and location (urban and rural). An analysis of changes in average disposable income levels within each of these representative household groups provides some information on welfare changes. However, CGE models disregard the distribution of income within each household group; hence, the microsimulation component of the model specifically looks at impacts at the level of the individual household within each household group.

The microsimulation model links each household in the 2008/09 household survey (IOF) directly to a corresponding representative household in the CGE model. The fact that the household income and expenditure data in the model is drawn from the IOF 2008/09 facilitates this matching. Changes in representative households' consumption and prices in the CGE model are then passed down to the 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 (DNEAP 2010), and standard poverty measures and their changes from the base are calculated. We use official regional-specific poverty lines and consumption figures so that measured poverty rates for 2009 in our microsimulation model are consistent with official estimates.

A new addition to the Mozambican model is a nutrition module, which follows the approach by Pauw and Thurlow (2011). The nutrition module operates similarly to the poverty module in that consumption changes in the CGE model are linked top-down to the survey-based microsimulation model. The nutrition module, however, only considers changes in the consumption quantities of food products from which calories are obtained by households. The nutrition module allows us to measure changes in caloric availability at the household level. These changes are calculated on the basis of caloric contents of different food items (i.e., similar to those used by DNEAP 2010 in the estimation of Mozambique's official poverty lines) and the changes in quantities of these foods consumed as observed in the CGE model. Each household's total caloric availability is adjusted for the size and demographic structure of the household (i.e., age and gender composition) before it is compared against a measure of the daily energy requirement. A household that fails to meet this requirement—a "calorie deficiency line" of 2,150 kilocalories per adult equivalent per day is used in this study—is deemed calorie deficient.

MOZAMBIQUE'S HISTORICAL AGRICULTURAL GROWTH PATH AND GROWTH POTENTIAL: A REGIONAL PERSPECTIVE

GDP growth: official estimates

The Mozambican economy has been one of the fastest growing economies in Sub-Saharan Africa for several years. During 2003–2007 (the latter is the base year of our CGE model) national GDP grew at a rapid 8.4 percent per annum, with strong growth across all subsectors (see Table 3.1). Although the agricultural growth statistics have been questioned—there was a marked downward adjustment in 2009–2010 to more accurately reflect the slower output growth reported in official crop statistics (TIA)—much of the national growth originated from within nonagricultural sectors. The period 2007–2009, which coincided with international commodity price shocks, a global recession, and drought domestically, was characterized by a slowdown in economic growth, but growth in most nonagricultural sectors recovered again in 2009–2010.

Table 3.1. Historical GDP (value added) growth by sector (2003-2010)

	2003-2007	2007-2009	2009-2010*
National GDP growth	8.4	6.3	6.8
Agriculture	7.4	7.5	4.9
Crops	8.6	9.3	5.2
Livestock	4.1	3.8	4.4
Forestry	3.7	2.4	2.4
Fishing	4.4	-1.9	5.6
Industry	8.0	3.5	3.6
Mining	27.4	5.0	5.1
Manufacturing	5.2	3.6	2.8
Electricity and water	13.7	-0.4	5.6
Construction	6.8	9.1	3.6
Services	9.3	7.0	9.4
Trade	12.2	6.6	10.9
Accommodation & restaurants	10.4	6.7	7.6
Transport and storage	9.4	11.6	13.7
Financial	20.5	6.5	10.5
Business	2.0	1.4	2.5
Government	9.3	8.2	8.3
Other services	2.4	2.4	2.4

Note: (*) GDP estimates for 2010 are provisional
Source: INE, Mozambique national accounts (2011)

Agricultural sector performance

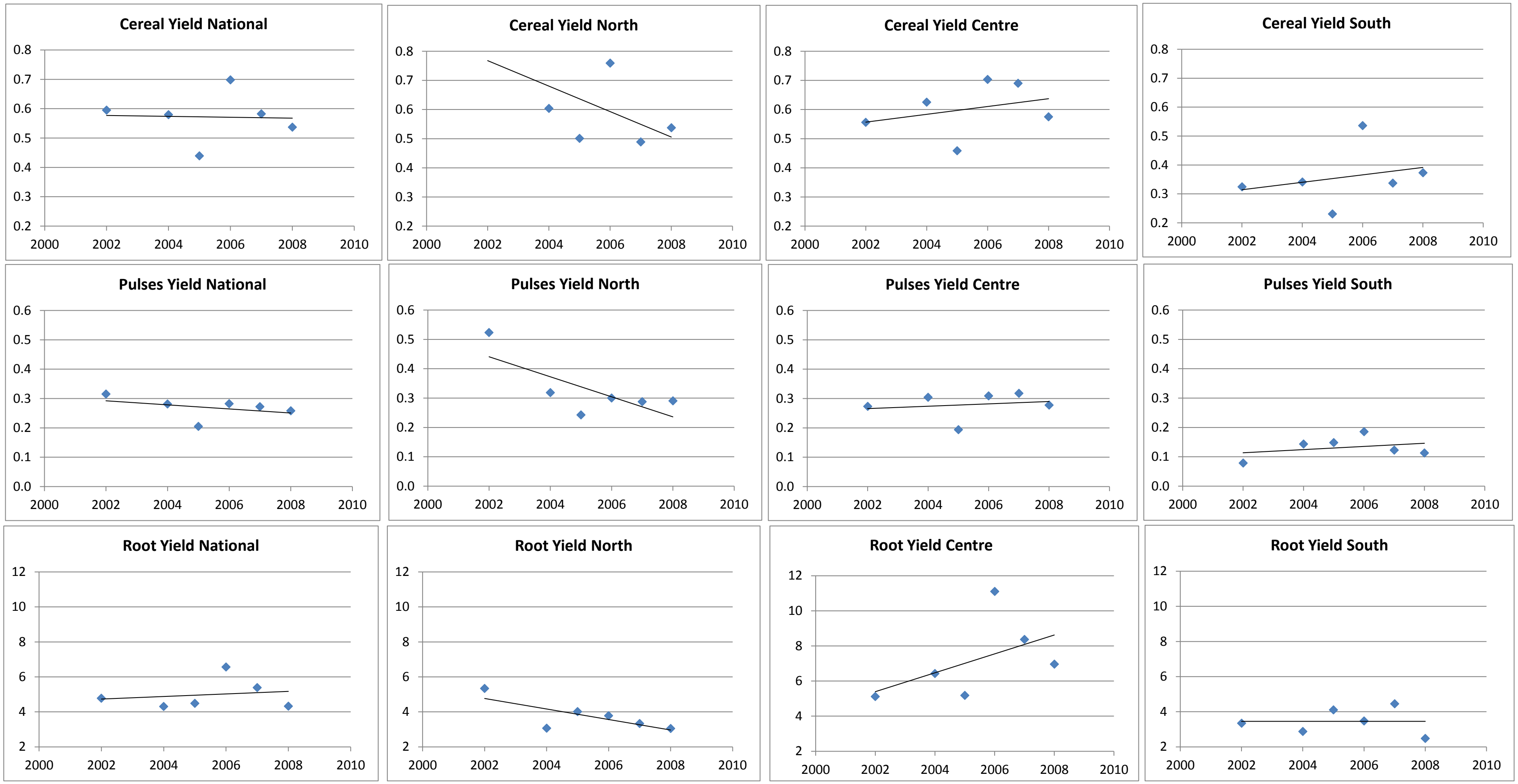
Of particular interest is the performance of the agricultural sector and its subsectors. Figure 3.1 plots yield outcomes for key staple crop groups, namely cereals, pulses, and root crops. A trend line is fitted to each graph. It must firstly be noted that yield outcomes are widely dispersed over the years, which means the trend lines do not fit the data particularly very well. The dispersion of yields around the trend line may point at actual variability due to (say) weather conditions or errors in measurement. The variation becomes more pronounced at the regional level where sample sizes are smaller. Land area measurement appears to be somewhat problematic in the TIA data. Cultivated land areas for different crops vary widely from one year to the next, which is contrary to expectation. Also, aggregate land sizes in the TIA and their changes over time are very different from what are reported in the FAO statistics for Mozambique (FAOSTAT 2012). These factors may explain at least part of the yield variation observed over time.

Most crops analyzed here have performed disappointingly during 2000–2008. In some ways this period resembles the post-war recovery period of 1993–1998, which saw growth in agricultural output driven largely by land expansion and not so much by productivity growth (Gemo 2011). Mucavele (2009) notes that rising population density has forced many farming households to increasingly cultivate marginal lands, with the result that average yields have declined. The northern region is a prime example of this. The TIA suggests that land expanded at over six percent per annum during the analysis period, yet yields declined sharply for all the major crops. Cereals and root crops, in particular cassava, dominate agricultural GDP in the northern region with (31.6 and 26.8 percent GDP shares respectively; see Table 4.2). Most of the region forms part of a tropical high-rainfall climatic zone, which means expected yields for this region are high compared to the other regions. This was certainly true earlier in the 2000s, but the sharp decline in yields means that the region no longer enjoys a yield advantage over other regions in Mozambique. However, its size, favorable agro-ecological conditions, agricultural potential, and prospects of further development along the major Nacala trade route suggest the northern region has the potential to become an important contributor to agricultural growth. It is not surprising that many of the PEDSA development initiatives specifically target the north. The region also boasts some of the lowest poverty rates in the country (see Table 4.4).

Mozambique's central region is also its largest in terms of area. Agro-ecologically speaking it is quite diversified. The mostly arid province of Tete is found in the north-west, to the east lie the tropical and wet coastal provinces of Zambezia and Sofala, while more inland the Manica province has a cooler climate given its high altitude. Although the region spans several distinct agro-ecological zones, agricultural conditions are generally favorable, while its strategic location around the Beira corridor, a major trade route linking Zimbabwe with the port city of Beira, implies equally great potential for continued growth in agricultural trade. The region contributes 57.6 percent of national crops and livestock GDP. Cereals are important, contributing 40.3 percent to regional agricultural GDP. Although historically households in the central region have faced low levels of poverty (see Table 4.4), the drought of 2008 had a severe impact on household incomes. TIA data suggests that cereals and root crop yields dropped by 16–17 percent in that year alone, causing poverty to rise sharply. Despite this misfortune, Figure 3.1 shows that the region still outperformed the other regions over the period 2002–2008 in terms of yield growth. Agricultural land expansion also marginally exceeded the population growth rate.

The southern region clearly lags behind the other regions in terms of average crop yields. The region, which includes Imhambane, Gaza, and Maputo provinces, is mostly dry, with small semi-arid pockets along the eastern border and a wetter coastal strip. On average it has the lowest precipitation levels of all the regions (Mucavele 2009). As shown in Table 4.2, pulses, nuts, and oilseeds (this includes the important coconuts subsector) are important crops, contributing 21.7 percent of regional agricultural GDP. Horticulture, however, contributes one-third of regional GDP. In contrast to the other regions, cereals and root crops are less important in terms of GDP contribution. The region as a whole is prone to drought, has a high population density, and only contributes 16.5 percent to national agricultural GDP. It is therefore also highly impoverished and suffers high levels of caloric deficiency due to persistent food deficits (see Table 4.4). Its proximity to South Africa has led to a situation where the region (and Maputo city in particular) imports large amounts of food from its neighbor. This means the southern region is vulnerable to international price shocks. Land expansion in the southern region was only about half the population growth rate during 2002–2008, which together with the slow or even negative yield growth of many crops contributes to the region's import-dependency.

Figure 3.1. Yield growth by region and key staple crops (2002–2008)



Source: TIA (2002–2008)

In summary, the period 2002–2008 was generally a disappointing one for Mozambique as far as agricultural growth and development is concerned. Stagnant crop yields and evidence that staple crop production did not keep up with population growth (i.e., in per capita terms, production declined) are worrying trends (see Arndt et al. 2011). These results are clearly inconsistent with the 7.4 percent average annual agricultural GDP growth rate reported in the national accounts. The central region is the only highlight in an otherwise gloomy picture painted by our yield analysis. Although some subsectors in the south performed adequately, productivity in northern region deteriorated over time despite the purported potential of the region.

Box 3.1. Developing policies versus developing agriculture: Mozambique's lost decade

A cynical view of the Mozambican agricultural experience is that the 2000s was all about developing policies and not so much about developing agriculture. There is evidence that public service delivery was severely hampered by internal problems within the Ministry of Agriculture relating to its internal restructuring process (Gemo 2011), while a lot of energy went into the development of a plethora of policies, also at the expense of service delivery. During 1999–2004 the first National Agricultural Development Program (PROAGRI I) dominated agricultural policy and development. Its proposed successor, PROAGRI II was developed during 2003–2004 with the intention of implementing it during 2005–2009. However, implementation delays led to PROAGRI I being extended until 2006. PROAGRI I was commended for improving institutional capacity in the Ministry of Agriculture (e.g., progress on decentralization and the transfer of decision-making powers to the local level; improvements in internal dialogue between provincial and national governments; improved administration, financial management, and operational capacity), but was criticized widely in the media for failing to address agricultural production constraints in Mozambique (Gemo 2011). Government's defense to such allegations was that production support was always planned for phase II, which could only commence after institutional capacity strengthening was completed during phase I.

PROAGRI II was never approved and thus never adopted. Sadly, the period 2007–2010 was characterized yet again by "intensive policy and strategy formulation" (Gemo 2011) with little attention given to production support. An Agriculture Sector Priorities document was released in 2006. The National Irrigation Strategy, the Agrarian Intensification and Diversification Program, and the Green Revolution Strategy (GRS) were all developed in 2007. In 2008 the Action Plan for Food Production (PAPA) was released for implementation during 2008–2011. PEDSA formulation started at around the same time (i.e., 2007–2008) but was temporarily suspended as GRS and PAPA received higher priority and political support at the time (Gemo 2011). Development of PEDSA commenced during 2008–2010, and was formally approved in 2011. As recently remarked by prominent economist Firmino Mucavele during a Radio Mozambique interview [†] in reference to the state of agriculture, "Mozambique was good at drawing up plans [for agricultural development], but [many of these plans] were never implemented".

[†] Excerpts from the interview transcript can be accessed here: http://allafrica.com/stories/printable/201205071400.html

Future agricultural growth potential

Mozambique's agricultural sector is in need for a revival if is to once again become an engine of growth for the rural economy. The sector has for a long time been neglected in favor of an overt focus on mining and industrial development. While the discovery of vast amounts of natural resources in Mozambique in recent years is potentially good for overall economic growth, the adverse implications of the so-called "resource curse"—most notably Dutch disease effects—will pose a significant challenge to the agricultural sector, which has to compete in an unfavorable environment created by a strong domestic currency (see Biggs 2012). However, considering the opportunities in Mozambique and potential for agricultural growth, there is much to be optimistic about. Agricultural techniques are for the large part still fairly primitive and adoption of modern inputs is low. This implies room for raising agricultural productivity through better extension services and input provision. Ongoing infrastructural development, especially along Mozambique's development or trade corridors, could also generate positive spillover effects for agriculture. If managed, supported, and developed appropriately, the agricultural sector can still play an important role in the development process, provided producers are able to effectively close existing yield gaps and achieve yield targets.

Table 3.2, compiled from various sources, shows data on current and potential yields for a select number of crops in Mozambique. In the table "PEDSA" refers to yield data reported in the agricultural strategy, while "PNISA" refers to yield data in draft agricultural investment plan for PEDSA (see note below the table). Based on historical performance, current yield levels, yield gaps, and priority afforded under PEDSA/PNISA, we subjectively rate the future yield growth potential for select crops for which data was available using a simple five-point scale: *low*, *medium-low*, *medium*, *medium-high*, and *high*.

Table 3.2. Current yields and yield potential: selected crops

	CGE model yield (2009)	Mucavele (2009) (†)		PEDSA (‡)		PNISA (§)		Verdict
		Current yield	Yield potential	Current yield	Yield potential	Current yield	Yield potential	
Selected crops								
Maize	0.87	0.9	5.0 to 6.5	0.7 to 1.3	> 4.5	1.2	1.8 to 2.5	*Medium-high*
Sorghum	0.60	0.6	0.8 to 2.0	0.5 to 0.7	> 1.5	-	-	*Medium-low*
Rice	1.05	1.1	2.5 to 6.0	0.6 to 1.0	> 4.5	1.1	1.6 to 2.7	*High*
Wheat	-	-	-	-	-	-	1.5 to 2.7	*Medium*
Cassava	8.45	5.5	5.0 to 10	-	-	-	-	*Medium-high*
Other roots	9.71	-	-	-	-	-	18.0	*Medium-high*
Beans and pulses	0.66	0.45	0.5 to 2.5	0.3 to 0.6	> 1.0	0.5	0.9	*Medium-low*
Groundnuts	0.35	0.5	1.0 to 3.0	-	-	-	-	*Medium*
Oilseeds (*)	1.21	-	1.0 to 2.0	1.5 to 2.5	> 2.5	-	-	*Medium-low*
Cotton	0.47	-	-	0.5 to 0.8	> 1.5	-	-	*Medium-high*

Notes: (†) Mucavele's (2009) source is cited as Ministry of Agriculture (2008). (‡) PEDSA current yields are based on TIA 2007 data, while the basis on which yield potential is estimated is not explained. (§) PNISA is the draft investment plan for PEDSA. The source of existing yields is not reported, while yield potential here means yields that are expected to be obtained by farmers benefiting from receiving proposed "technology packages" consisting of modern inputs being proposed under PNISA. (*) "Oilseeds" is the collective noun for several crops grouped together in the CGE model. Mucavele's yields and yield targets for "oilseeds" refer to coconuts in particular. Similarly, the PEDSA yields and yield targets listed here under "oilseeds" are specifically for commercially grown soya beans.

Maize yields, as discussed, have been stagnant during 2002–2008, with yields in the north declining rapidly. There was some growth in center and south, but average yields remain very low nationally (i.e., between 0.7 and 1.3 according to PEDSA). We consider this crop to have fairly strong potential for a two- to threefold increase in yields, although this wouldrequire rapid expansion of modern input adoption among smallholder subsistence farmers who cultivate the bulk of maize in the country. We therefore deem the yield growth potential for maize to be medium-high

Other cereals include sorghum, rice, and wheat. Sorghum yields were also stagnant nationally during 2002–2008, with very similar regional yield growth patterns to maize. There was strong growth in sorghum yields in the south, although this was off a very low base. Although data on yield potential is limited, there is some potential for yield growth, although the fact that sorghum is apparently not a focus crop under PEDSA means we consider it to have medium-low potential. Rice experienced only slight yield growth (less than one percent) during 2002–2008. This growth was driven entirely by strong growth in the center amid rapid yield declines in the north and south. Rice, however, has high potential for further yield growth: not only is it a PEDSA focus crop, but rice also benefits from an established domestic consumer market which currently relies heavily on imports to satisfy demand. These imports can be displaced rapidly by more productive domestic suppliers. The same is true for wheat, another product that is largely imported. The wheat sector, however, is still in its infancy and may require more time to establish itself. Both these crops may also struggle to compete against imported substitutes if the exchange rate moves to unfavorable levels due to Dutch disease effects. We consider rice to have high potential and wheat is classified as having medium-high potential.

Among the root crops cassava yields were also stagnant at the national level during 2002–2008, although there was relatively strong growth in the center region where yields are also highest on average. Yields are very low in the south and the north, but the national average yield is already within the potential yield range of 5–10mt/ha. Although further yield growth potential is limited in the center, we consider the north in particular to have large potential; hence the cassava subsector as a whole is considered to have medium-high potential for yield growth. Other roots include potatoes and sweet potatoes. Evidence shows that yields of other crops in fact doubled during 2002–2008, with very large yield gains in the center. Maintaining yield growth in center will be challenging on the back of this past performance, although PNISA targets are even double current yields. The north, a focus area of PEDSA interventions, therefore has strong growth potential for roots where yield growth has been disappointing recently. The other roots sector as a whole is therefore considered to have medium-high potential for further growth.

The performance of beans and pulses was very weak during 2002–2008. While some priority is afforded to beans in the PNISA document, the reported yield target (0.9mt/ha) is not very optimistic and not much above current yields. Yields could potentially go beyond that or even double considering the weak historical performance, but it is probably fair to assume beans and pulses at this stage only have medium-low potential for future yield growth. Groundnuts experienced a sharp decline in yields in recent years. Although groundnuts are not officially a priority, current low yields and the fact that groundnuts form an important part of the diet in some regions suggests significant room for growth. We therefore judge groundnuts to have *medium* priority for yield growth. Oilseeds yields already appear to be within or close to the range of potential yields, although we only have very limited data. Also, oilseeds include a wide variety of crops so a more in-depth analysis is required for making strong conclusions. Considering the crop, broadly speaking, has some room for moderate improvement, we afford it a *medium-low* potential classification.

The final crop analyzed is cotton, Mozambique's most important cash crop (Mucavele 2009). Cotton yields more or less doubled in recent years. Based on reported PEDSA yields there is room for further improvement (possibly even a two- or threefold increase) in yields. However, as an export sector, cotton will have to overcome the challenges posed by a strong domestic currency, which may ultimately deflect investments away from the sector. The sector therefore has *medium-high* potential for further yield growth.

Our yield potential analysis here is admittedly crude, but it is a useful example of the kind of exercise that is required for a better understanding of where the potential lies and where agricultural development and production support efforts should be targeted. This analysis would of course be complemented (and results potentially even altered) by more scientific and in-depth crop-specific assessments within each of Mozambique's agro-ecological zones, something which is beyond the scope of this exercise and the expertise of the authors. In the next section we look in more depth at the growth-linkages and poverty or nutritional effects of agricultural productivity growth, which will further shape our ideas around the prioritization of crops or agricultural subsectors for accelerated agricultural growth in Mozambique.

MOZAMBIQUE'S FUTURE GROWTH SCENARIOS: MODEL RESULTS

Baseline scenario: continuing on a low-productivity growth path

The economywide implications of a continuation of Mozambique's current growth path over the period 2009–2019 are explored in our "baseline scenario". Specifically, the CGE model is set up to replicate the level and patterns of growth observed during the four or five years prior to 2007. Although the model base year is 2007, we specifically compare and analyze growth, poverty, and nutritional outcomes over the period 2009–2019. This period is broken down into two sub-periods (2009–2014 and 2015–2019) to coincide with the two PEDSA implementation periods. Particular features we attempt to replicate include: (1) slow or declining productivity in the northern region coupled with rapid land expansion; (2) strong productivity growth in the central region, especially for cereals (e.g., rice in particular) and root crops; (3) and a relatively strong performance of the cereals sector in the southern region, but an otherwise weak agricultural performance and slow land expansion well below the population growth rate of 2.6 percent. At the national level land expansion matches the population growth rate. For non-agricultural sectors we assume a continuation of the strong growth performance as reported in national statistics.

Table 4.1 shows the average annual GDP growth rates in our modeled baseline scenario. The GDP estimates are measured at factor costs. Results for GDP at market prices are shown in Table B.1 (Appendix B). Agricultural GDP averages about 3.2 percent over both sub-periods, which is similar to the "revised" growth rate modeled by Arndt et al. (2011) in their analysis of the growth-poverty-inequality triangle in Mozambique during 2003–2009. As also argued by those authors, an agricultural growth rate in the region of 3–4 percent probably represents a more realistic picture of the actual growth performance of the sector as opposed to the high growth rates reported in national accounts. At the subsector level there are few crops that stand out apart from perhaps the sorghum, rice, and oilseeds sectors and selected export crops, all of which grow at a slightly higher than average rate.

Table 4.1. National and sectoral GDP growth rates in the baseline and CAADP scenarios

	National GDP shares (2009)	Agricultural GDP shares (2009)	Average annual growth rates (%)				Avg. annual %-point difference: CAADP and Baseline
			Baseline scenario		CAADP scenario		
Total GDP	100.00		5.51	5.89	6.65	7.08	1.16
Agricultural sub-sectors	26.66	100.00	3.26	3.24	6.50	7.04	3.52
Cereals	7.52	28.20	3.96	4.02	8.34	8.71	4.53
Maize	5.66	21.23	2.85	2.79	7.14	7.61	4.55
Sorghum	0.68	2.56	6.28	6.47	7.58	7.56	1.19
Rice	1.17	4.41	7.55	7.08	13.84	12.72	5.96
Root crops	5.30	19.87	3.12	3.26	5.29	6.04	2.47
Cassava	4.89	18.34	3.06	3.22	5.09	5.91	2.35
Other roots	0.41	1.53	3.79	3.72	7.56	7.39	3.72
Pulses, nuts, and oilseeds	3.16	11.87	3.49	3.53	5.35	5.66	1.99
Beans and pulses	1.20	4.49	3.26	3.53	4.69	5.01	1.46
Groundnuts	0.81	3.06	3.35	3.33	4.97	4.92	1.61
Cashew nuts	0.67	2.51	3.43	3.04	7.15	7.63	4.16
Oilseeds	0.48	1.81	4.36	4.47	4.99	5.32	0.74
Horticulture	2.58	9.67	2.06	2.05	3.57	3.57	1.52
Vegetables	2.19	8.21	2.31	2.26	3.45	3.49	1.19
Fruits	0.39	1.46	0.60	0.70	4.24	3.97	3.46
Export-oriented crops	1.17	4.41	2.89	1.94	5.78	5.00	2.97
Tea	0.05	0.20	7.44	7.38	7.85	7.67	0.35
Tobacco	0.31	1.17	2.04	-1.20	-1.03	-5.57	-3.73
Sugarcane	0.26	0.98	6.08	6.09	7.52	7.82	1.58
Cotton	0.20	0.75	5.91	3.99	11.96	11.80	6.94
Other crops	0.35	1.31	-1.91	-3.68	5.49	1.50	6.28
Livestock	1.95	7.30	3.12	3.13	7.64	8.08	4.73
Cattle	0.19	0.70	4.88	4.95	6.81	7.11	2.05
Poultry	1.25	4.70	2.73	2.73	7.55	8.07	5.08
Other livestock	0.51	1.90	3.42	3.33	8.15	8.41	4.91
Forestry	3.22	12.07	2.83	2.73	6.14	7.00	3.79
Fisheries	1.76	6.62	3.11	2.58	7.78	8.29	5.19
Industry	26.11		5.13	5.46	5.48	5.82	0.36
Mining	1.62		7.33	8.41	7.08	7.96	-0.35
Manufacturing	15.25		4.02	4.10	4.66	4.92	0.73
Other industry	7.15		5.56	5.34	7.04	6.98	1.56
Services	9.25		6.48	6.81	6.50	6.75	-0.02
Private services	47.23		6.90	7.27	7.36	7.71	0.45
Government services	35.77		7.23	7.67	7.80	8.18	0.54

Source: Mozambique CGE and microsimulation model.

At the regional level we see much more variation in subsector growth rates (see Table 4.2). Here we assume a continued weak growth performance in agriculture in the southern region (2.4 percent), and even slower growth in the northern region (2.1 percent) during 2009–2019. Agriculture in the central region, which grows at 4.1 percent on average, is the driver of national agricultural GDP growth. This table also allows us to evaluate potential sources of regional growth in our baseline scenario. For example, horticulture and export-oriented crops drive growth in the north; cereals and root crops are responsible for most of the growth in the central region; and cereals, pulses and oilseeds account for most of the growth in the southern region. It is worth noting that negative GDP growth in a subsector is not necessarily a result of negative productivity growth. Root crops in the south, for example, experience slow but positive productivity growth in our baseline scenario.

However, since farmers reallocate land and human resources away from root crops to other better performing crops such as maize, pulses and oilseeds, sectoral output declines over time despite increased productivity.

Table 4.2. Regional agricultural GDP growth rates in the baseline and CAADP scenarios

	Agricultural GDP shares by region (2009)	Within-region agricultural GDP shares (2009)	Average annual growth rates (%)				Avg. annual %-point difference: CAADP and Baseline
			Baseline scenario		CAADP scenario		
	(%)	(%)	2009-2014	2014-2019	2009-2014	2014-2019	2009-2019
Crops & livestock GDP	100.00		3.33	3.36	6.44	6.94	3.34
Northern region	26.61	100.00	2.22	2.07	9.03	9.48	7.11
Cereals	8.33	31.32	1.72	1.71	11.26	11.33	9.58
Root crops	7.69	28.90	1.52	1.24	11.68	11.46	10.19
Pulses, nuts, and oilseeds	5.38	20.20	1.57	1.05	4.01	3.82	2.61
Horticulture	1.50	5.62	5.81	6.09	2.67	2.72	-3.26
Export-oriented crops	1.35	5.06	5.67	4.44	5.44	5.62	0.48
Livestock	2.37	8.90	3.08	3.09	7.66	8.10	4.79
Central region	56.83	100.00	4.14	4.12	5.60	6.00	1.67
Cereals	23.62	41.56	4.65	4.69	7.93	8.18	3.38
Root crops	14.04	24.70	5.15	4.98	1.79	1.48	-3.43
Pulses, nuts, and oilseeds	5.79	10.18	2.76	2.88	4.28	4.64	1.64
Horticulture	4.93	8.68	2.91	3.03	3.29	3.70	0.53
Export-oriented crops	4.00	7.04	1.87	0.83	5.86	4.73	3.94
Livestock	4.45	7.84	3.14	3.14	7.63	8.07	4.71
Southern region	16.57	100.00	2.26	2.47	4.87	4.91	2.52
Cereals	2.73	16.45	4.50	4.01	1.62	0.30	-3.29
Root crops	2.71	16.37	-4.49	-5.49	1.46	-0.18	5.63
Pulses, nuts, and oilseeds	3.44	20.76	7.28	6.97	8.89	9.00	1.82
Horticulture	5.47	32.99	0.09	-0.71	4.05	3.67	4.17
Export-oriented crops	0.07	0.44	4.04	3.27	7.96	7.99	4.32
Livestock	2.15	13.00	3.14	3.15	7.62	8.06	4.70

Source: Mozambique CGE and microsimulation model.

Crop yield changes therefore ultimately depend on the interplay between productivity and the amount of resources (particularly land) allocated to a particular sector. Regional land supply growth rates are exogenously applied in our model; for example, based on historical land growth rates, we assume land expands by 3.5 percent in the north, 2.5 percent in the center, and 1.5 percent in the south, such that the overall area of cultivated land expands at the same rate as the population (i.e., roughly 2.6 percent per annum). Regional yield outcomes are reported in Table 4.3. Crop yields in the northern region, for example, decline across the board in the baseline scenario, which is due to a combination of weak agricultural productivity growth and rapid land expansion. Although higher levels of productivity growth are modeled for the central region, the relatively rapid land expansion here still means that yield gains are small. Yields improve slightly in the south where land expansion is slow, which implies intensification in the use of inputs.

Table 4.3. Crop yields (mt/ha) by region under baseline and CAADP scenarios

	Northern region			Central region			Southern region			National average		
	Initial yield (2009)	Final yield (2019)		Initial yield (2009)	Final yield (2019)		Initial yield (2009)	Final yield (2019)		Initial yield (2009)	Final yield (2019)	
		Baseline	CAADP		Baseline	CAADP		Baseline	CAADP		Baseline	CAADP
Cereals												
Maize	0.84	0.73	1.47	1.00	1.05	1.58	0.50	0.67	0.73	0.88	0.89	1.45
Sorghum	0.45	0.41	0.61	0.68	0.87	0.90	0.34	0.49	0.42	0.60	0.81	0.81
Rice	0.99	0.92	1.54	1.05	1.29	1.57	1.05	1.35	1.37	1.04	1.24	1.56
Root crops												
Cassava	5.69	5.28	9.96	11.86	13.70	17.54	6.60	8.62	9.54	8.14	9.25	11.61
Other roots	4.03	3.88	7.48	10.99	12.78	19.42	3.91	5.30	6.28	9.01	11.17	17.04
Pulses and nuts												
Beans & pulses	0.74	0.63	0.91	0.76	0.76	0.89	0.32	0.44	0.40	0.66	0.61	0.71
Groundnuts	0.42	0.35	0.56	0.31	0.33	0.39	0.19	0.24	0.24	0.34	0.33	0.44
Cashew nuts	0.81	0.74	1.09	0.85	0.94	1.08	0.88	1.26	1.13	0.85	0.99	1.10
Oilseeds	1.10	0.97	1.46	1.16	1.28	1.45	1.21	1.83	1.65	1.19	1.72	1.62
Horticulture												
Vegetables	4.76	3.81	6.16	4.96	4.65	6.07	5.08	5.81	6.08	4.98	4.76	6.09
Fruits	5.41	4.48	7.19	5.62	5.40	7.09	5.75	6.65	7.10	5.69	5.86	7.10
Export-oriented crops												
Tea	-	-	-	1.92	2.45	2.50	-	-	-	1.92	2.45	2.50
Tobacco	1.02	0.99	1.13	1.04	1.08	1.12	-	-	-	1.03	1.04	1.13
Sugarcane	11.80	8.80	12.57	12.34	10.94	12.39	12.66	13.90	12.41	12.14	9.99	12.46
Cotton	0.45	0.40	0.63	0.47	0.48	0.63	-	-	-	0.47	0.44	0.63
Other crops	-	-	-	0.17	0.18	0.19	-	-	-	0.17	0.18	0.19

Source: Mozambique CGE and microsimulation model.

Poverty and calorie deficiency outcomes are reported in Table 4.4. It is clear that a continuation of the current low productivity growth path will ultimately fail to achieve poverty targets as outlined in the *Poverty Reduction Strategy* (PARP 2011–2014). An earlier version of this strategy set the poverty target for 2009 at 45 percent. Arndt et al. (2011) show that this may have not been too unrealistic given the assumption made at the time based on the data that were available; for example, no one could foresee the slow growth in agricultural productivity, nor the international commodity price shocks or the drought of 2008, all of which contributed to a disappointing poverty outcome in 2008/09. The PARP also sets a target of 42 percent by 2014, which is missed in our baseline scenario. National poverty is 51.1 percent in 2014 and reaches 46.8 percent in 2019. Urban poverty declines more rapidly than rural poverty in relative and absolute terms (i.e., by 9.2 percentage points compared to 7.1 percentage points).

At the regional level the decline in poverty ranges from seven percentage points in the north (off a relatively low base) and 9.7 percentage points in the south (off a relatively high base). Despite relatively rapid agricultural growth in the central region, the decline in poverty here is relatively small. This relates to the fact that agricultural producer prices decline in real terms, which also means farmers' profit margins decline. This has a significant impact on household incomes, especially in the central region where agriculture is an important source of household income. This highlights a common implication of rapid agricultural productivity growth, namely that net consumers often end up benefiting more from agricultural productivity growth associated with price declines than net producers.

Our results on caloric availability show a fairly rapid decline in the calorie deficiency rate (i.e., by seven percentage points in the baseline scenario). Interestingly, in this instance the north experiences the greatest decline in calorie deficiency (7.7 percentage points) and the south the least (6.2 percentage points). This reflects regional variations in diets and the fact that different food types have different caloric contents (see Pauw and Thurlow 2011).

CAADP scenario: reaching the accelerated agricultural growth target

The previous section reported results obtained under a low-productivity growth path that closely resembles the recent experience of the agricultural sector and the broader economy. In this section we compare the outcome under an accelerated agricultural growth scenario as envisioned under PEDSA/CAADP. The "CAADP scenario" assumes a more broad-based or balanced agricultural growth trajectory during 2009–2019. Sector- and region-specific total factor productivity growth rates are applied such that reasonable yield targets are achieved by 2019 based on earlier assessments of yield potential and sector prioritization under PEDSA (see Table 3.2). Given the potential for rapid growth in the maize, rice, cassava, and other roots sectors, we assume relatively rapid total factor productivity growth in these sectors. Also, the prioritization of agriculture in the central and northern regions also means that productivity growth is generally assumed to be more rapid in these regions compared to the south. Agricultural land expansion is slightly higher compared to the baseline, based on the assumption that by 2019 each farmer will cultivate 25 percent more land than in 2007. We maintain an assumption of more rapid land expansion in the central and northern region than in the southern region.

Table 4.1 shows that the seven percent agricultural growth target stipulated by PEDSA is achieved during the second half of the simulation period (i.e., 2015–2019), while the average growth over the whole period is 6.8 percent. This growth rate is 3.5 percentage points higher than in the baseline (see final column). Cereals grow rapidly (average 8.5 percent). The domestic rice sector, which currently competes with imported rice, benefits from a weaker exchange rate, which pushes consumers to switch to locally produced rice. Other export crops such as tea and sugarcane also benefit from the weaker exchange rate. The exception is tobacco, which we restrict from expanding too rapidly given the reality of declining world prices and reductions in tobacco production in many southern African countries. The livestock sector in Mozambique has historically faced many challenges and growth has been weak. However, as one of the priority sectors under PEDSA we assume both rapid growth in livestock stocks and total factor productivity in the production of livestock products. This sector therefore also performs strongly and contributes significantly to agricultural GDP growth. Its contribution is nevertheless very likely to be underestimated; for example, the use value of animal draft power is not typically accounted for in agricultural production accounts.

At the regional level (Table 4.2) we now see a much improved performance in the north, which grows at 9.3 percent off a very low base. The central region, another focal point of PEDSA, grows slightly less (5.8 percent), which reflects the diminished potential in the region for sustained rapid yield improvements from a relatively high base. The southern region lags behind with a growth rate of around 4.9 percent.

Table 4.3 shows the regional crop yields required to reach the modeled agricultural growth levels. As far as key crops are concerned, we note maize yields improve by around 66 percent to reach 1.45mt/ha; rice yields improve 51 percent to 1.56mt/ha; and cassava and other roots continue to improve on the back of strong growth in the baseline (e.g., yields of other root crops increase significantly by 89 percent to reach 17.0mt/ha by 2019). PEDSA rather vaguely sets a target of "doubling agricultural yields" over the next decade. It is clear that such vast improvements nationally are not required to the meet the seven percent growth target; in fact, fairly moderate and achievable yield improvements would probably be sufficient under our assumed land expansion and rates.

The draft PEDSA investment document (PNISA) identifies more specific yield targets for those farmers that are set to benefit from so-called "technology packages" consisting of seed, fertilizer, and irrigation development programs. Depending on the mix of technologies received, maize farmer beneficiaries should achieve yields of 1.8–2.5mt/ha; rice farmer beneficiaries should achieve yields of 1.6–2.7mt/ha; beans farmer beneficiaries should achieve yields of around 0.85mt/ha; and potato yields should reach about 18mt/ha (see Table 3.2). The modeled yield outcomes here are mostly below these yield targets, but reflect the average across all farmers and not only those that may benefit from agricultural interventions. It is, for example, not clear how widely these technology packages would be targeted; hence it is difficult to translate them into national or regional average yield targets.

As in many developing countries, the vast majority of Mozambique's large rural population is linked to the agricultural sector. Rural agricultural households also face very high levels of poverty. Rapid agricultural growth therefore has the potential to have a meaningful impact on poverty. The pace of poverty reduction increases significantly when agricultural growth increases, as is evident when comparing the CAADP scenario results against those from the baseline scenario (Table 4.4). For example, under the CAADP scenario national poverty declines to 44.9 percent by 2014 and 35.8 percent by 2019, which is 11 percentage points below the rate achieved in the baseline scenario. Rural poverty reduction is much more rapid than urban poverty reduction. In fact, whereas the gap between rural and urban poverty widened under the baseline scenario, the gap now narrows. Results for the poverty gap and poverty gap squared are shown in Table B.2 (Appendix B).

Table 4.4. Poverty and calorie deficiency rates under the baseline and CAADP scenarios

	Official survey-based poverty estimates		Baseline scenario		CAADP scenario		%-point difference: CAADP and Baseline (2019)
	2002/03	2008/09	2014	2019	2014	2019	
National poverty rate (%)	54.1	54.6	51.1	46.8	44.9	35.8	-11.0
By location							
Urban	51.5	49.5	45.6	40.4	40.7	32.6	-7.8
Rural	55.3	56.8	53.5	49.7	46.8	37.3	-12.4
By region							
North	55.3	46.3	42.7	39.3	36.2	25.8	-13.5
Center	45.5	59.7	56.6	52.4	49.9	41.9	-10.5
South	66.5	56.8	52.6	47.1	47.9	38.6	-8.5
National caloric deficiency (%)	n/a	57.1	53.9	50.1	47.2	36.8	-13.3
By location							
Urban	-	67.1	63.6	60.0	59.7	51.1	-8.9
Rural	-	52.7	49.7	45.7	41.8	30.5	-15.2
By region							
North	-	45.8	42.3	38.1	35.1	24.2	-13.9
Center	-	57.0	53.9	50.2	46.0	34.9	-15.3
South	-	72.6	70.0	66.4	66.2	57.5	-8.9

Source: Mozambique CGE and microsimulation model.

We also note vast improvements in the caloric deficiency rates under the CAADP scenario vis-à-vis the baseline scenario. One interesting result is the relatively slow decline in the urban calorie deficiency rate, which at 51.1 percent by 2019 remains high. Generally, it is not uncommon for urban households to have higher caloric deficiencies compared to their rural counterparts. This relates to differences in diets or difficulties in accounting for all sources of calories obtained (e.g., urban households often consume prepared meals at restaurants, the caloric contents of which are difficult to determine or often unaccounted for completely). When data is available, it is also appropriate to adjust minimum caloric requirements for the type of work someone performs (e.g., urban households are less likely to do strenuous work such as farm labor and therefore require fewer calories). The implication is that measurement error may explain part of the difference in rural and urban calorie deficiency rates.

Identifying priority agricultural subsectors

The final part of this study considers the effectiveness of growth in different agricultural subsectors in contributing to overall growth and reducing poverty or under-nutrition. Growth within different agricultural subsectors can have different impacts on development outcomes for various reasons (see Pauw and Thurlow 2011). First, sectors differ in terms of their relative factor intensities. Growth in sectors that intensively employ the factors of production typically owned by poor households is more likely to reduce poverty. Secondly, some subsectors produce products that poorer households consume more intensively. Where rapid growth in these sectors is associated with lower prices, the poor will benefit disproportionately. Similarly, some subsectors produce products that are particularly important for households' nutritional status, such as those that represent low-cost sources of calories or are consumed intensively by calorie-deficient households. The structure of growth may therefore also determine the impact of growth on undernourishment. A third factor relates to linkages across economic sectors. Some sectors, due to their downstream production and consumption linkages, can have a greater impact on overall growth (i.e., through multiplier effects). We consider these criteria when we identify agricultural subsectors that are potentially more effective at contributing to growth and reductions in poverty in undernourishment in Mozambique.

For the purpose of the analysis we group agricultural subsectors into seven groups, namely: maize; other cereals (sorghum and rice); roots (cassava and potatoes); pulses and oilseeds (beans, legumes, groundnuts, etc.); horticulture (fruits and vegetables); export crops; and livestock. We do not explicitly assess the fisheries or forestry sectors given limited information on how these sectors are prioritized under PEDSA/PNISA or how much growth is anticipated. The individual growth effects of these groups of subsectors are then evaluated by applying technical change shocks from the CAADP simulations to the selected crop groups while maintaining the technical change shocks from the baseline scenarios for the remaining sectors.

Table 4.5 shows some key results on sectoral growth and the contribution of such growth to national growth (columns 1–4). Poverty (column 5) and caloric deficiency or under-nutrition rates (column 6) are also shown. The first two columns show the additional GDP and agricultural GDP generated by growth in a specific group. For example, the maize-led growth scenario causes agricultural GDP to increase by MT10.8 billion. Total GDP, in turn, increases by MT12.1 billion, which is higher than the agricultural GDP impact because of backward and forward production and consumption linkages. For example, to use the example in Thurlow (2012), increasing maize production stimulates growth in downstream food processing sectors, while lower maize prices raise disposable incomes and leads to increased spending also on non-maize or non-agricultural commodities.

Our first indicator is the *growth multiplier* (see Table 4.6), which is defined as the total GDP impact divided by the agricultural GDP effects (i.e., columns 1 and 2 in Table 4.5). The maize multiplier is 1.12, which means for every MT1.00 increase in agricultural GDP driven by maize-led growth, there is an additional MT0.12 increase in non-agricultural GDP due to inter-sectoral linkages. The ranking analysis in Table 4.6 shows that maize ranks sixth out of the seven groups of subsectors, suggesting relatively weak downstream processing linkages. Other than producing maize flour, much of which is done at the home and possibly unaccounted for in estimates of value addition, maize is not processed much. Livestock (processed in meat and other food processing sectors, animal feed sectors, or leather sector), horticulture (food processing) and root crops are ranked highest of the sector groups analyzed.

Table 4.5. Sectoral scenarios: key growth and poverty outcomes

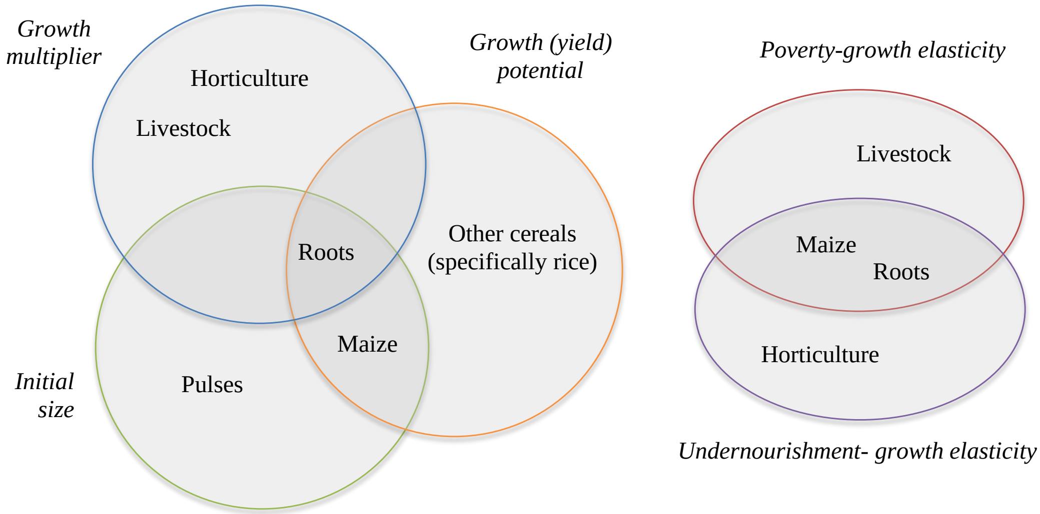
	Additional GDP relative to baseline in 2019 (MT millions)		Average annual *sector* growth rate, 2009-2019 (%)	Avg. annual agric. GDP growth, 2009-2019 (%)	National poverty rate (2019)	Caloric deficiency rate (2019)
	Total GDP	Agric. GDP				
	(1)	(2)	(3)	(4)	(5)	(6)
Maize-led growth	12,133	10,828	7.55	4.61	42.7	43.5
Other cereals-led growth	5,338	5,295	11.85	3.93	45.7	48.9
Root crops-led growth	8,357	6,254	5.84	4.05	44.5	45.5
Pulses-led growth	5,163	4,257	6.05	3.80	45.5	48.4
Horticulture-led growth	4,379	2,959	3.55	3.64	45.7	48.7
Export crops-led growth	2,149	1,652	5.17	3.47	46.0	49.6
Livestock-led growth	6,726	4,295	7.54	3.81	45.1	49.0
Combined (CAADP scenario)	42,486	30,832	-	6.77	35.8	36.8

Source: Mozambique CGE and microsimulation model.

Our second indicator is the *initial size* indicator, which is simply the group of subsectors' initial contribution to GDP measured at factor cost (i.e., value added). For large, established sectors, even little growth can have large impacts on household incomes. Here the maize, root crops, and pulses sectors rank highest. Our third is a more subjective indicator of *growth (yield) potential*. This follows the earlier assessment in Table 3.2, where we identified maize, other cereals (rice in particular), and root crops as high potential crops. No specific ranking is assumed among these three groups of crops.

The left-hand panel in Figure 4.1 provides a summary of our main findings relating to the growth contribution and growth potential of sectors. Within each circle we list the three highest ranked groups. At the intersection of the growth potential and initial size circles is the maize sector, while roots appears at the intersection of all three indicators (i.e., also including growth multiplier effects). These two crops, with the latter in particular, therefore emerge as priority crops.

Figure 4.1. Summary of priority sectors



There are other socio-economic considerations as well. We analyze the potential of subsectors to reduce poverty or the caloric deficiency rate. Given multipliers, size, and growth potential, not all sectors contribute equally to poverty or undernutrition reduction *in aggregate*; however, it useful to understand the *relative contribution per unit* of agricultural growth. In column 3 of Table 4.5 we show, for each separate scenario, the growth in the group being analyzed. For example, in the maize-led scenario the maize sector grows 7.6 percent; in the other cereals scenario other cereals crops grow 11.9 percent; in the root crops-led growth scenario root crops grow 5.8 percent, and so on. These growth rates can be compared against the sector growth rates for the CAADP scenario in Table 4.1 (they will be slightly smaller due to smaller interaction effects in the sector scenarios). In column 4 of Table 4.5 we show the impact on agricultural GDP growth. Finally, we also have poverty and calorie deficiency rates by 2019 under each of the sector scenarios.

Two growth elasticities, namely the poverty growth elasticity (PGE) and the undernourishment growth elasticity (UGE) are now calculated. These elasticities respectively represent is the percentage changes in poverty and undernourishment (i.e., between 2019 and 2009; see columns 5 and 6 and the baseline results in Table 4.4) divided by the percentage change in agricultural GDP (column 4 in Table 4.4). The UGE and PGE values are shown in Table 4.6, together with a ranking analysis. The right-hand panel in Figure 4.1 lists the top three sectors in each indicator. At the intersection of the PGE and UGE are, once again, maize and root crops, while the livestock sector has strong poverty-reducing effects and the horticulture sector has strong undernourishment-reducing effects. The latter result is somewhat surprising given the low caloric content of horticulture; hence, this outcome rather reflects the impact of horticultural growth (and price declines) on households' ability to allocate more of their income to calorie-laden food types rather than the nutritional characteristics of horticultural crops *per se*.

Table 4.6. Sectoral prioritization indicators

	Growth multiplier		Initial size		Growth potential		Poverty-growth elasticity		Undernourishment-growth elasticity	
	Measures strength of backward/forward linkages between agriculture and non-agriculture.		*Simple ranking of initial value added (GDP at factor cost) in 2009 (MT millions)*		*Subjective assessment of (yield) growth potential based on historical performance, yield gaps, and prioritization under PEDSA*		*Percentage change in poverty for a percentage change in agricultural GDP.*		*Percentage change in caloric deficiency for a percentage change in agricultural GDP.*	
	Value	**Rank**	**Value**	**Rank**	**Assessment**	**Rank**	**Value**	**Rank**	**Value**	**Rank**
Maize-led growth	1.12	[6]	11,945	[1]	Medium-high	[X]	-0.528	[1]	-0.582	[1]
Other cereals-led growth	1.01	[7]	3,917	[6]	Medium-low to high	[X]	-0.447	[7]	-0.391	[7]
Root crops-led growth	1.34	[3]	11,179	[2]	Medium-high	[X]	-0.499	[2]	-0.555	[2]
Pulses-led growth	1.21	[5]	6,678	[3]	Medium-low to medium		-0.474	[6]	-0.432	[4]
Horticulture-led growth	1.48	[2]	5,440	[4]	-		-0.484	[5]	-0.435	[3]
Export crops-led growth	1.30	[4]	2,479	[7]	Medium		-0.487	[4]	-0.403	[5]
Livestock-led growth	1.57	[1]	4,105	[5]	-		-0.497	[3]	-0.397	[6]

Source: Mozambique CGE and microsimulation model and authors' calculations.

SUMMARY OF MAJOR FINDINGS

This recursive-dynamic CGE modeling analysis examined the regional contribution of accelerating growth in alterative agricultural crops and subsectors. It also assessed the economywide spillover effects in terms of growth, poverty reduction, and caloric availability should Mozambique achieve the PEDSA target of seven percent agricultural growth, both at the national level and for the three regional economies. Under the modeled baseline scenario Mozambique fails to achieve the PEDSA agricultural growth target of seven percent due to the low levels of productivity in the agricultural sector. The CAADP scenario, on the other hand, shows that if the Mozambican economy revives its agriculture sector through diversification and broad-based agricultural growth, more rapid land expansion, a lesser reliance on selected crops or regions that have stood out as the drivers of growth in the past, and various other yield-enhancing initiatives, the PEDSA target of seven percent growth is within reach. The pace of poverty and calorie deficiency reduction is significantly raised by agricultural growth given the strong linkages between agricultural growth, poor households, and their nutritional status. Our sector analysis identifies maize and root crops as particularly important crops for contributing to growth but also alleviating poverty and reducing undernourishment.

However, if Mozambique is to achieve its targets, several important challenges have to be overcome. Firstly, the analysis here does not consider the so-called resource curse or Dutch disease implications of natural resource extraction. While Mozambique's recent discovery of coal and natural gas may unlock large investments and spur industrial development and growth, it is important to mitigate the negative impacts of an appreciating exchange rate on non-tradable agricultural subsectors in particular. Mozambique's growth experience during the 2000s has shown how damaging slow agricultural growth can be for poverty reduction efforts and food security. Secondly, increasing food crop yields will require substantial investments 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. An important area of research relates the extent and manner in which the agricultural sector might benefit from larger infrastructure investments such as dams, roads, or railways along the various "investment corridors" in Mozambique.

Finally, agricultural productivity gains are associated with increased availability of cheaper agricultural produce, which is either consumed by households or used as intermediate inputs in the economy. Through supply and price linkages the benefits of agricultural productivity gains ultimately translate into consumer welfare gains across the whole economy, even when agricultural productivity gains are restricted to specific regions. In the case of Mozambique, for example, we still see significant welfare gains in the southern region, even when most of the productivity gains occur in the central and northern regions which are being prioritized under PEDSA Thus, whereas central and northern region households benefit from increased sales *and* lower consumer prices, households in the south at least benefit from lower prices. However, this outcome is only plausible when local and regional markets function properly and market linkages are well-developed. Our CGE model assumes markets are perfectly linked and common consumer prices exist across the regions. The reality is that markets linkages are weak in Mozambique. The southern region's food import-dependency on South Africa is evidence of weak "north-south" transport linkages, which suggests that agricultural productivity growth might not spill over into the southern region as effectively as one might hope. Currently, a lot of attention is afforded to the "east-west" development corridors aimed at facilitating Mozambique's international trade. Development planners would do well not to neglect the important internal "north-south" trade routes if proposed agricultural development under PEDSA is to have an equitable outcome across the entire country.

APPENDIX A: CGE AND MICROSIMULATION MODEL SPECIFICATION

A computable general equilibrium (CGE) model was developed to assess sector-specific growth options and their poverty impacts. The model is calibrated to a 2007 social accounting matrix (SAM) that provides information on demand and production for 54 detailed sectors (see Table A.1). The model further disaggregates agricultural activities across regions using agricultural survey data. Forestry, fisheries, and non-agricultural production are specified at the national level. 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 based on their completed education levels (i.e., no primary, primary, secondary, and tertiary).

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

	AGRICULTURE			INDUSTRY			SERVICES	
A1	Cereals		I1 (23)	Mining and natural gas		S1	Private services	
	1	Maize	I2	Agro-processing			44	Trade services
	2	Sorghum and millet		24	Meat and fish		45	Hotels and catering
	3	Rice		25	Grain milling		46	Transport
	4	Wheat and barley		26	Sugar refining		47	Communications
A2	Root crops			27	Other foods		48	Financial services
	5	Cassava		28	Beverages		49	Real estate
	6	Potatoes		29	Tobacco		50	Business services
A3	Pulses, nuts, and oilseeds			30	Cotton ginning	S2	Social and administrative	
	7	Beans and pulses		31	Textiles and clothing		51	Public administration
	8	Groundnut		32	Leather products		52	Education
	9	Cashews		33	Wood products		53	Health
	10	Oilseeds		34	Paper and publishing		54	Other services
A4	Horticulture		I3	Other manufacturing				
	11	Vegetables		35	Fuel			
	12	Fruits		36	Chemicals			
A5	Export-oriented cash crops			37	Non-metal minerals			
	13	Leaf tea		38	Metal products			
	14	Tobacco		39	Machinery			
	15	Sugarcane	I4	Other industrial subsectors				
	16	Cotton		40	Other			
	17	Other crops		41	Electricity			
A6	Livestock			42	Water distribution			
	18	Cattle		43	Construction			
	19	Poultry						
	20	Other livestock						
A7 (21)	Forestry							
A8 (22)	Fisheries							

Workers in the model can migrate between sectors, including between agriculture and non-agriculture (previous model versions assumed the existence of unpaid family labor which was only employed in agriculture). 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 distribution patterns in the SAM. 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.

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.

Households groups include urban and rural households, disaggregated by national income quintiles, and further split across the three regions (north, center, and south). Each representative household in the model is an aggregation of a group of households in underlying survey data (IOF 2008/09). 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 the IOF 2008/09. 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. Similarly, a nutrition module calculates changes in caloric availability on the basis of observed changes in food consumption quantities. These are compared against a calorie deficiency line (i.e., minimum caloric requirement) to determine changes in the calorie deficiency rate at the national or subnational level.

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 2007–2019 (we only report changes during 2009–2019), 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.

APPENDIX B: ADDITIONAL RESULTS

Table B.1. National GDP at market prices: growth rates in the baseline and CAADP scenarios

	Initial value (MT millions) (2009)	Average annual growth rates (%)				Avg. annual %-point difference: CAADP and Baseline
		Baseline scenario		CAADP scenario		
		2009-2014	2014-2019	2009-2014	2014-2019	2009-2019
Domestic absorption	249,502	5.35	5.56	6.39	6.67	1.07
Private consumption	185,011	5.04	5.32	6.35	6.73	1.36
Fixed investment	38,624	6.90	6.78	7.34	7.26	0.46
Government consumption	-1,252	5.00	5.00	5.00	5.00	0.00
Trade balance	27,119					
Exports	68,002	4.92	5.52	5.57	6.20	0.67
Imports	-85,076	4.93	5.41	5.46	5.97	0.54
GDP at market prices	232,428	5.38	5.60	6.49	6.78	1.15
Net indirect taxes	21,398	4.05	2.26	4.85	3.35	0.94
GDP at factor costs	211,030	5.51	5.89	6.65	7.08	1.16

Source: Mozambique CGE and microsimulation model.

Table B.2. Poverty gap and poverty gap squared estimates

	Poverty gap (P_1)			Poverty gap squared (P_2)		
	2008/09	Baseline 2019	CAADP 2019	2008/09	Baseline 2019	CAADP 2019
National poverty	21.1	17.3	11.4	10.9	8.6	5.3
By location						
Urban	19.0	14.5	10.9	9.5	7.0	5.0
Rural	22.0	18.5	11.6	11.4	9.3	5.4
By region						
North	16.5	13.3	7.4	7.9	6.1	3.2
Center	24.1	20.4	13.8	12.9	10.6	6.5
South	22.0	17.1	12.5	11.3	8.5	5.9

Source: Mozambique CGE and microsimulation model.

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