Report 2.
Potential Consequences of Intra-Regional Trade in Short-Term Food Security Crises in Southeastern Africa

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAMP	African Agricultural Markets Programme
ACTESA	Alliance for Commodity Trade in Eastern and Southern Africa
COMESA	Common Market for Eastern and Southern Africa
CV	coefficient of variation
DRC	Democratic Republic of Congo
FAO	Food and Agriculture Organizaiton
MSU	Michigan State University
RATES	Regional Agricultural Trade Enhancement Support
SAFEX	South African Commodity Exchange
WFP	World Food Programme

1. INTRODUCTION

Staple foods trade regularly across national borders in Eastern and Southern Africa (Figure 1). Principal maize surplus areas lie in South Africa, Northern Mozambique, Southern Tanzania and Eastern Uganda and to a lesser extent in Northern Zambia and Northern Tanzania. Sourcing supplies from these surplus areas, local traders supply deficit markets in Southern Mozambique, Malawi and Kenya. Since the liberalization of maize markets in South Africa in the late 1990's, the emergence of major private trading companies and launching of the SAFEX commodity exchange there, South Africa has served as the largest regional supplier of maize. The SAFEX price likewise provides the price barometer against which regional millers and grain traders evaluate prospects for regional trade in maize (Traub and Jayne, 2004).

Cross-border trade flows can potentially help to reduce price volatility in staple food markets (see, for example, Timmer, Falcon and Pearson, 1983; Koester, 1986; Dorosh, 2001). The import parity price sets an upper bound, while export parity sets a floor below which prices will not fall, provided governments allow grain to flow freely across their borders. Because of high transport costs to some locations, the bands between import and export parity may be wide in some markets, but they nonetheless place bounds on price movements, limiting extreme price spikes in times of drought (Figure 2).

Yet many countries in Eastern and Southern Africa have, at various times, controlled cross-border traded through export and import bans, import tariffs and cumbersome customs procedures that increase transactions costs and reduce profitability of formal sector trade. The informal trade, which has emerged to avoid these barriers, often requires handling of small loads[1], extra handling in transferring grain from trucks to bicycles and back, and other increased transactions costs, which lower farmer prices in the export regions and raise consumer prices in the importing markets. High transactions costs and uncertainties about government import and pricing policies pose significant risks to traders and tend to discourage private sector food imports during times of food shortages which could be alleviated through trade flows from neighboring areas that are either less severely affected by the shocks or are better integrated to more stable international and regional markets. By increasing farmer incentives in surplus areas and dampening price spikes in deficit zones, the fluid functioning of staple food markets can contribute to both agricultural growth in the surplus zones and to food security throughout the region.

This paper aims to evaluate the potential impact of intra-regional trade in moderating food price shocks in south eastern Africa, in the market shed centered in Northern Mozambique, Malawi and Southeastern Zambia. To do so, the following analysis develops a spatially disaggregated model of maize and cassava markets in the region in order to evaluate the impact of supply shocks confronting the region, with and without cross-border trade.

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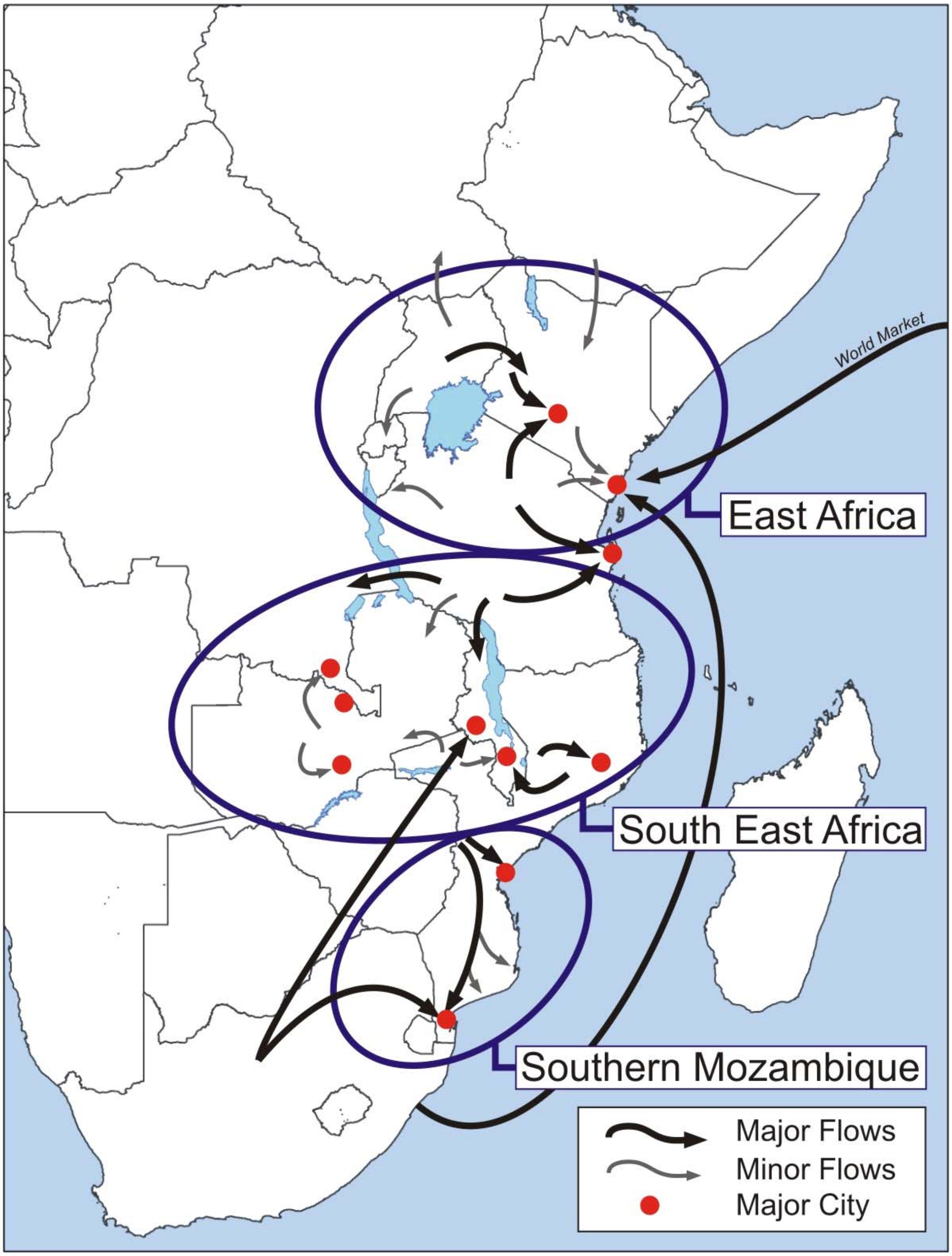
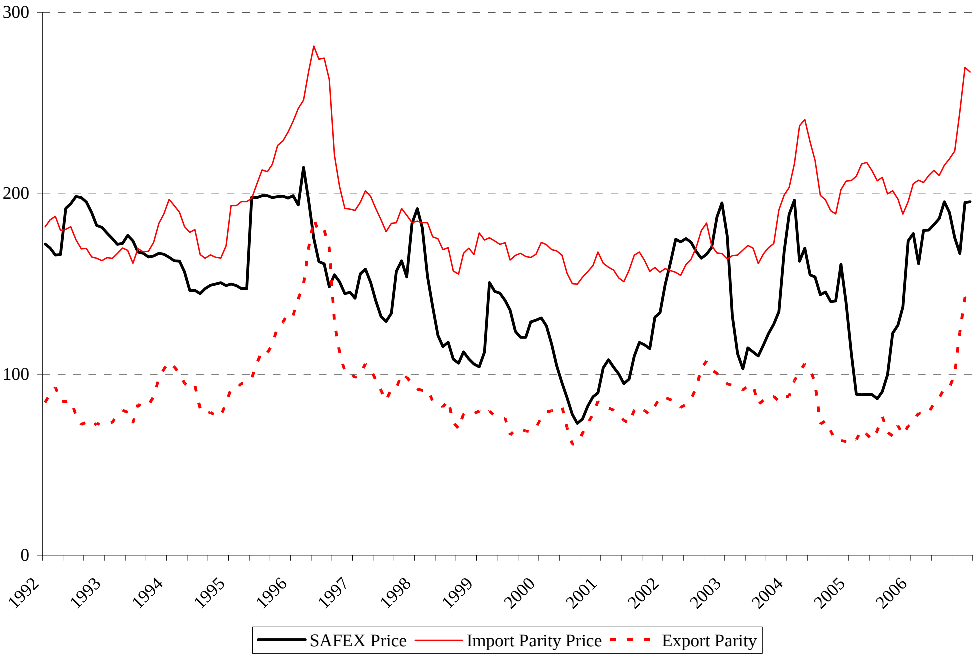
[1] See, for example, the cover photo of small maize traders bringing in maize from Northern Mozambique into Malawi.

Figure 1. Maize Marketing Flows in Southern and Eastern Africa

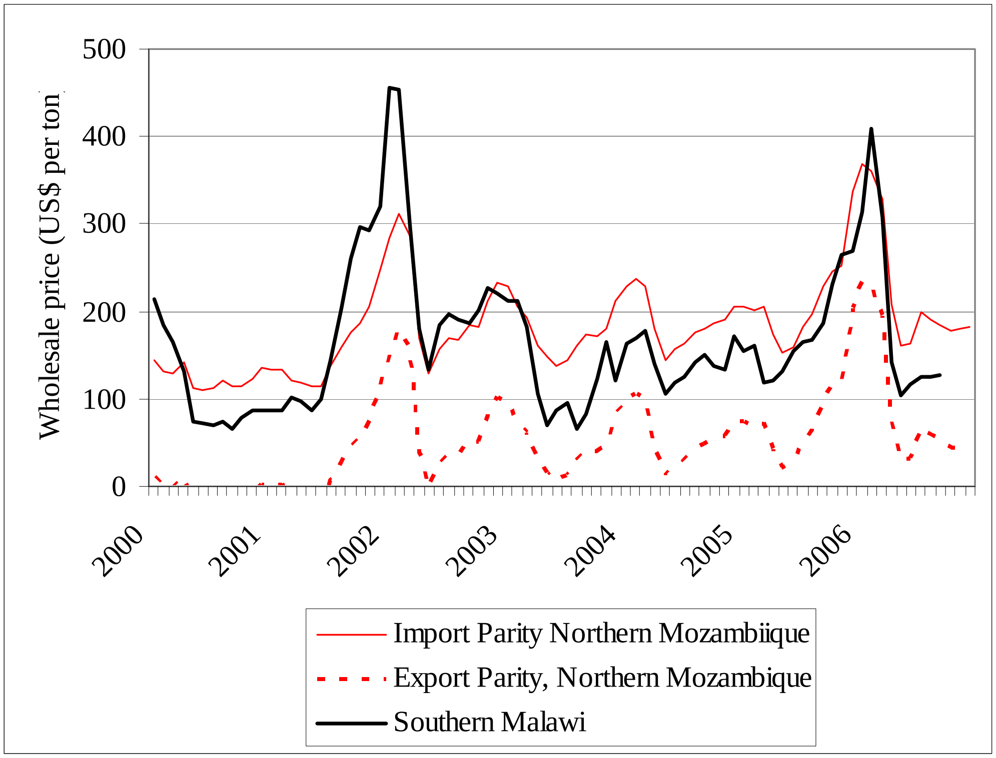


Source: Govereh, Haggblade and Nielson (2008).

Figure 2. Trends in Domestic and Border Prices for White Maize



a. White maize price, Randfontein, South Africa



b. White maize price, Southern Malawi
Source: Govereh et al (2008), Traub (2008).

2. FACTORS AFFECTING INTRA-REGIONAL TRADE IN FOOD STAPLES

2.1. Factors Favoring Trade in Food Staples

2.1.1. Political Boundaries Cut Across Natural Market Sheds

Highly arbitrary political boundaries throughout Africa cut across natural market sheds. Colonial borders, drawn in Berlin in 1885 and inherited by independent African states during the 1960's, remain in force, cutting across ethnic groups and natural movements of people and goods.

As a result, natural market movements frequently cut across national borders. Consider Katanga province of the DRC, which juts far into the middle of Zambia. Yet the rail line running north up through central Zambia continues on to Lubumbashi, in the heart of the Katanga copper belt. A good rail link, coupled with good roads in Northern Zambia, enable Zambians to export food staples such as maize, cassava, groundnuts and beans into DRC.

A similar situation arises in Mozambique, which the Zambezi River cuts in two. Despite regular maize surpluses north of the Zambezi and regular maize deficits in the south, these two parts of Mozambique rarely trade maize. Instead, geographic proximity links the major deficit cities of the south with the maize surpluses stocked in silos across the border in neighboring South Africa. Meanwhile, the highly productive northern parts of Mozambique link up with more naturally with markets in Malawi and Eastern Zambia. In this more northerly market shed, Northern Mozambique typically supplies to deficit Malawi and sometimes into Eastern Zambia.

As a result, the region's surplus maize producing zones must cross national borders in order to supply their most natural deficit markets. Hence, cross-border trade becomes necessary to ensure regular, low-cost food supplies in these deficit zones.

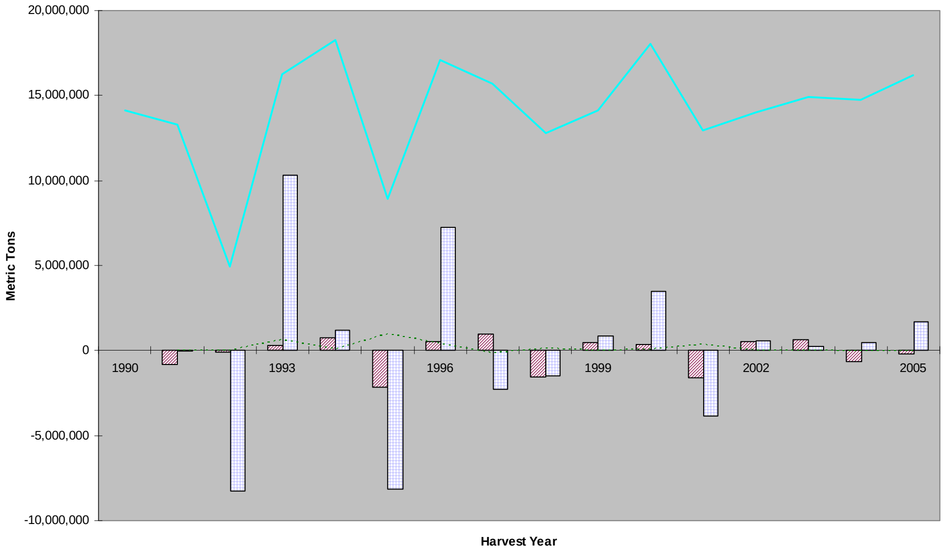
2.1.2. Differences in Regional Production Volatility

For trade to take place, surpluses in some locations must be available during times of deficit elsewhere. Thus, the question of the covariance of production across countries becomes important in assessing opportunities for trade.

Maize production in southern Africa is considered highly variable and highly covariant across countries. Official production data suggest that both perceptions are less true now than in the past. From 1990 to 1999, the median year-on-year change in production was nearly 20%, with changes exceeding 50% during four of the 10 years (Figure 3). Median year-on-year change from 1996 to 2005 was only 10%, and no single change exceeded 30%. Coefficients of variation in production fell during the second (overlapping) ten-year period in all countries except Zimbabwe; driven by South Africa, the overall coefficient of variation fell from 0.29 to 0.11. During the first period, changes in yield, driven largely by rainfall fluctuations, drove huge changes in production in 1992 (drought), 1993 (recovery), 1995 (drought) and 1996 (recovery). Changes in yield, driven largely by rainfall fluctuations, continued to be the prime cause of change during the second period, but did not have nearly the quantitative impact they did during the first period.

Production in the region was also far more covariant during the first period than the second (Table 1). From 1990 to 1999, correlation coefficients on production between South Africa, Zimbabwe, and Zambia were large, positive, and highly statistically significant. During the second period they were much lower and none were significant. Correlations between those three countries and Mozambique and Malawi were small and insignificant during both periods, with one exception: a large, significant, and *negative* correlation between Mozambique and Zimbabwe during the second period. Mozambique's lack of correlation with other countries[2] is driven by the predominance of the North in national production, and by the low correlation of weather patterns in this area with those in the rest of the region. For example, during the droughts of 1992 and 1995, production in northern Mozambique was largely unaffected. Since northern Mozambique regularly produces exportable maize surpluses, its lack of correlation with production in the region makes it a potentially important source of supply for both commercial and humanitarian responses to drought.

Figure 3. Maize Production Variability in Southern Africa, 1990-2005



Source: Tschirley and Jayne (2007).

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[2] The negative correlation with Zimbabwe is a special case, driven by the economic chaos in Zimbabwe contrasted with recovery from the civil war in Mozambique.

Table 1. Correlation Coefficients of Maize Production among Selected Southern African Countries, 1990-2005

		South Africa	Zambia	Zimbabwe	Mozambique	Malawi
South Africa	1990 - 1999		**0.66**	**0.93**	0.18	0.12
	1996 - 2005		0.36	0.51	0.04	-0.18
Zambia	1990 - 1999	**0.66**		**0.77**	-0.04	0.36
	1996 - 2005	0.36		0.27	-0.08	0.06
Zimbabwe	1990 - 1999	**0.93**	**0.77**		0.30	0.22
	1996 - 2005	0.05	0.27		**-0.88**	0.21
Mozambique	1990 - 1999	0.18	-0.04	-0.30		**0.65**
	1996 - 2005	0.04	-0.08	**-0.88**		-0.20
Malawi	1990 - 1999	0.12	0.36	0.22	**0.65**	
	1996 - 2005	-0.18	0.06	0.21	-0.20	

Note: coefficients in bold are statistically significant at the 5% level.

Source: Tschirley and Jayne (2007).

Overall, regional production varies less than production in each individual country. While the coefficient of variation (CV) of total regional production was 25% from 1990 to 2003, CVs in individual countries ranged from a low of 28% in South Africa to highs of 46% in Zimbabwe and 48% in Mozambique.[1] This suggests that, despite positive and large correlations in production across countries, there will be scope for intra-regional trade to cover some portion of national and sub-regional shortfalls in all but the worst drought years, such as 1992 (Tschirley et al., 2004). Since 1992, however, differences in production outcomes and the buffering capacity of the cassava belt zones have induced cross-border flows into they most heavily affected areas, particularly into Malawi, during deficit years.

2.1.3. Substitution Among Food Staples

Maize serves as the primary food staple in Africa, with cassava a close number two. Yet maize's vulnerability to moisture stress results in wide fluctuations in annual output and price. Hence the importance of a range of drought-tolerant secondary food staples, such as sorghum and millet in the temperate zones and cassava in the tropical zones. Estimates of cross price elasticities of demand in South Africa, for example, indicate strong substitution effects between maize and other cereals (Alderman and del Nino, 2002).

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[1] Mozambique's high variability is due primarily to steady increases in production since the drought and the ending of the civil war in 1992. The CV of production around a linear trend was only 19%, compared to 48% absolute variation over the same period.

Empirical work in Mozambique similarly shows high levels of cassava consumption as well as substitution between maize and cassava, in urban and rural areas, particularly in the north and especially during drought years (Rosling, 1986; Tschirley and Abdula, 2007). In Malawi and Zambia, substitution with cassava can also be strong when maize is in short supply. Data from Zambia illustrate how cassava's well-deserved reputation for drought-resistance translates into much lower production volatility for cassava than maize (Figure 4). As a result, increasing cassava production provides a growing buffer against drought-induced volatility in rainfed maize production.

Because households in northern zones of Mozambique, Malawi and Zambia consume both cassava and maize (see Figures 6 through 9), and because they can harvest cassava over several years, households can choose to consume more cassava and sell more maize during drought years, thus releasing maize for sale to deficit maize-belt households. In bad years, when nearby maize belt households face acute deficits, farmers from neighboring cassava and dual staple zones are able to harvest more of their perennial cassava crop and in turn free up more maize for export to deficit zones. These mixed and dual-staple zones, thus, serve as potentially important food security shock absorbers, enabling the release of maize to deficit areas in times of short supply, thereby moderating regional food shortages. Northern Mozambique provides an example of a maize-exporting dual-staple zone. While maize remains the key staple food in the region, , substitution with cassava and other drought-tolerate food staples offer important alternative foods when maize prices spike.

2.2. Factors Limiting Trade

Poor infrastructure, high transport costs, inconsistent product standards and inhibiting policies all contribute, in varying degrees, to diminished cross-border maize trade in Eastern and Southern Africa (RATES, 2003).

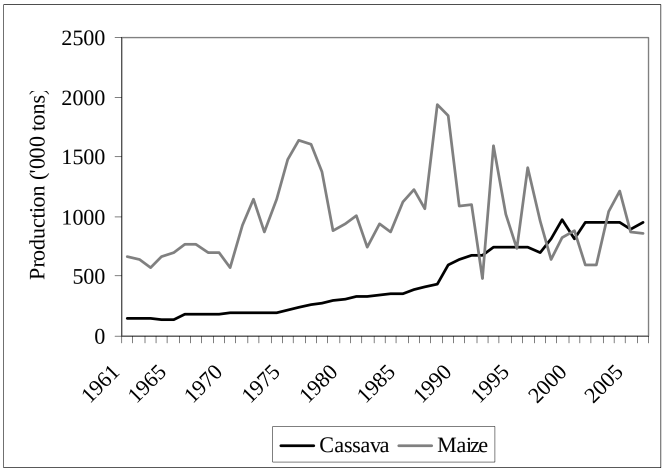
In general, policy restrictions – such as export bans, permit systems and tariffs – tend to drive cross-border trade from formal into informal channels. But because handling costs rise with small lots, and with truck to bicycle to truck transfers at borders, these policy limitations do, in fact, diminish trade flows by driving up transaction costs. Tracking informal maize trade from Southern Tanzania into Malawi, one study notes, "Costs fell in mid 2001, when the export ban was lifted and the traders no longer had to take the maize across the border by bicycle and canoe. This illustrates how lifting an export ban can tip the balance between profitable and unprofitable trade." (Whiteside, 2003, p.33). Tariffs and border controls between Uganda and Kenya imposed similar transaction costs by forcing bicycle transfers at border crossings, up until 2005 when signature of the East African Community (EAC) treaty diminished these controls (RATES, 2003; Ariga and Jayne, 2007; Jayne, Myers and Nyoro, 2005).

Policy reviews in Zambia and Malawi suggest that unpredictable and intermittently interventionist government policies – government procurement, direct import and subsidized sales – have tended to undercut private traders by raising risk and forcing many to exit the formal import market (Mwanaumo et al., 2005; Nijhoff et al. 2002 and

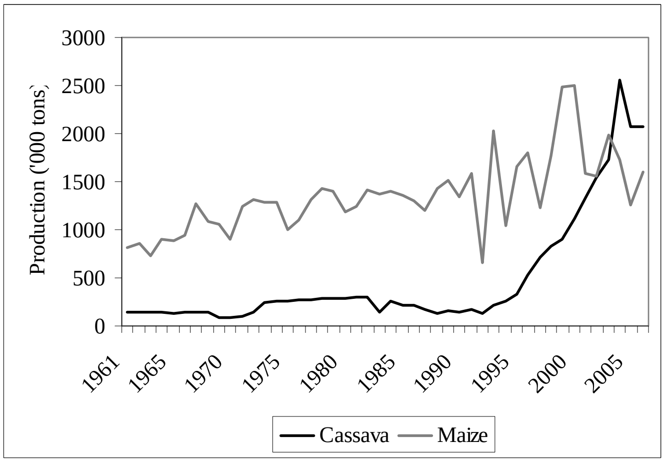
2003; Tschirley et al, 2004; Whiteside, 2003). In contrast, Mozambique has maintained generally open border policies since the end of the civil war in 1992. Northern Mozambique benefits from access to deficit markets in Malawi, while Southern Mozambique benefits from access to nearby imports from South Africa.

Farmers, too, pay a price for the increased volatility that results from closed borders. When production shortages one season lead to price spikes and expanded planting the following year, closed borders exacerbate spikes and well as price falls. Farmers from Northern Mozambique, who plant additional maize area in expectation of supplying Malawi become discouraged when deprived of these natural export markets. For this reason, many farmers in Tete Province of Northern Mozambique began switching to alternative cash crops such as tobacco following mis-timed public maize distribution at harvest time which triggered the Malawian price collapse of 2003 (Whiteside, 2003)

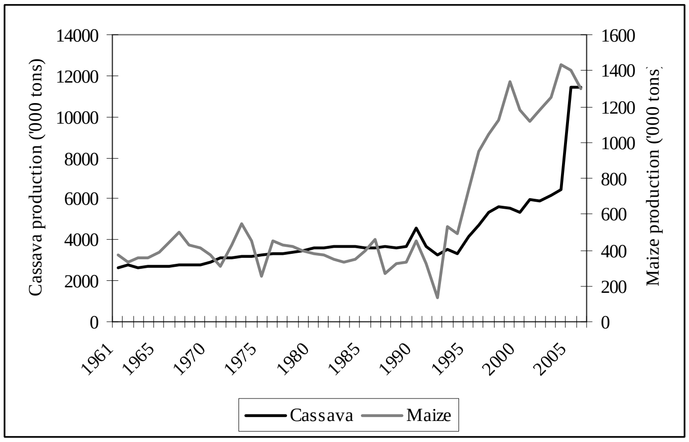
Figure 4. Trends in cassava and maize production in Zambia, Malawi and Mozambique



a. Production trends in Zambia



b. Production trends in Malawi



c. Production trends in Mozambique

Source: FAOSTAT.

3. DATA AND METHODS

3.1. Key Food Staples

This analysis focuses on cassava and maize, the two most important food staples in sub-Saharan Africa as well as in these three countries. At a continental level, maize provides the largest single source of calories in Sub-Sharan Africa, about 600 kcal per person per day, while cassava follows closely behind as the continent's number two food staples, supplying 500 kcal per person per day (FAO Food Balance Sheets).

In Zambia and Malawi, maize dominates the national food basket, providing just over half of all calories consumed, while cassava provides roughly 10%. However, in Mozambique the rankings are reversed. Cassava serves as the number one food staple there, supplying about one-third of total calories, while maize, the number two staple, furnishes about one-fourth (Table 2). Likewise in the cassava zones of northern Zambia and the northern lakeshore region of Malawi, cassava predominates.

Table 2. Average National Production and Consumption of Cassava and Maize, 2001-2004

	Cassava, fresh weight	Maize
Production (kg/capita)		
Malawi	138	158
Mozambique	314	64
Zambia	86	94
Consumption (g/person/day)		
Malawi	225	358
Mozambique	644	171
Zambia	231	351
Consumption (% kcal)		
Malawi	9%	53%
Mozambique	34%	24%
Zambia	13%	56%

Source: FAOSTAT.

3.2. Spatial Aggregations

Because existing market sheds do not coincide with national boundaries, our analysis requires subnational spatial disaggregation of food production and consumption patterns. To accommodate both spatial trade flows as well as geographic differences in staple food consumption and production patterns, we have broken down our three-country region into several levels of spatial disaggregation.

3.2.1. Food Staple Zones

Given regional differences in weather, soils and crop suitability, in tastes, consumption patterns, food substitutability and prices, we first defined homogeneous clusters according to the composition of staple food production and consumption. Using household-level survey data, we classify districts in each of the three countries into one of five homogeneous food consumption units: maize belt, maize-dominant mixed zones, dual staple zones, cassava-dominant mixed zones and cassava belt. The ensuing discussion describes how we have defined each of these food staple zones according to the relative importance of maize and cassava in regional food production(see Figures 6-9 below).

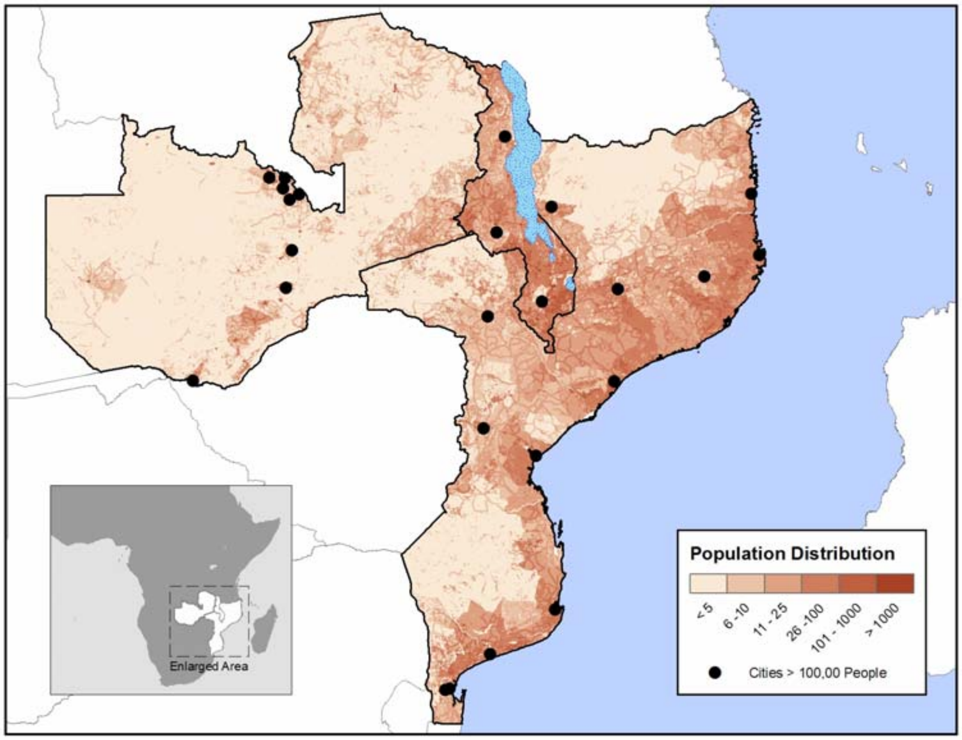
3.2.2. Market Sheds

We then cluster districts into larger groupings, called food staple regions, which we define as areas with homogeneous food consumption and production patterns (that is, they belong to one food staple zone) linked to the same major market. A market shed then is defined as a collection of food staple regions connected by trade.

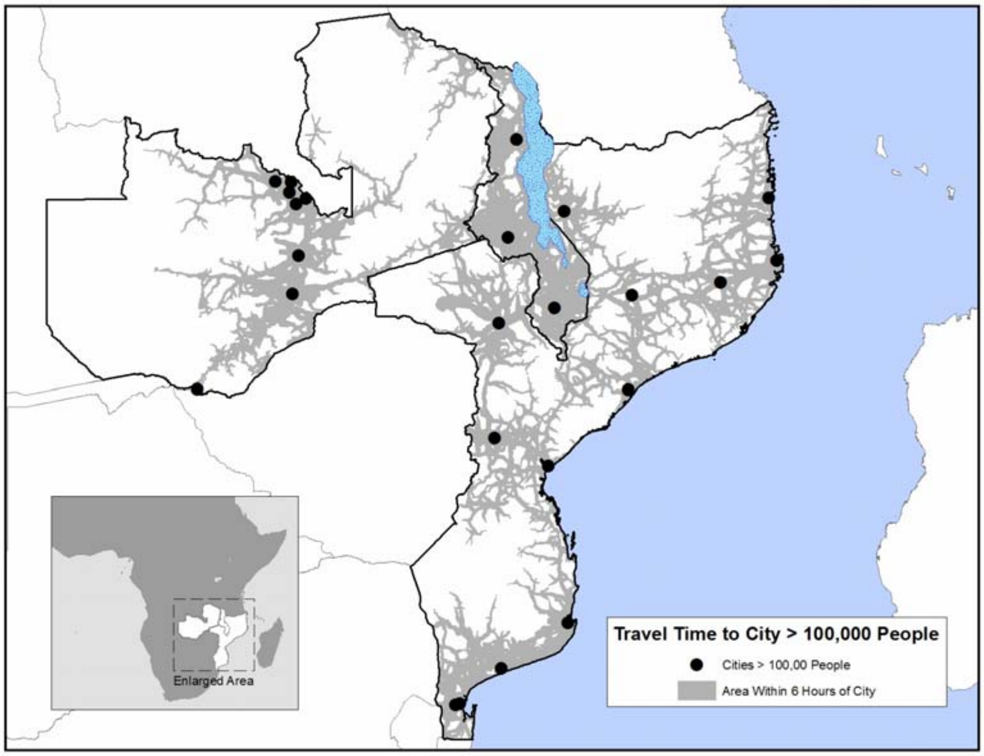
3.2.3. Urban proximity zones

Within each market shed, we recognize three levels of spatial dispersion: urban areas; rural areas and remote areas. For purposes of this work, we have defined remote as any area more than six hours of travel time from a city of over 100,000 people. Figure 5a maps the spatial distribution of population within the three countries, while Figure 3b defines the urban proximity zones.

Figure 5. Spatial Distribution of Population and Urban Areas



a. Population distribution



b. Urban proximity zones

3.3. Mapping Food Staple Zones

Because food production and consumption patterns vary across regions, and because tastes and relative prices differ as well, we have begun our spatial mapping efforts by delineating major food staple zones. For this purpose, we obtained nationally representative farm household survey data for each of the three countries for representative recent years. For Zambia, we have used the latest supplemental survey to the Central Statistical Office's Post-Harvest survey, the 2004 supplemental survey covering the crop year 2002/03. For Malawi, we have used the integrated rural household survey of 2004/05 and in Mozambique we have use the 2005/06 Ministry of Agriculture national household survey files.

3.3.1. Percent of households growing each crop

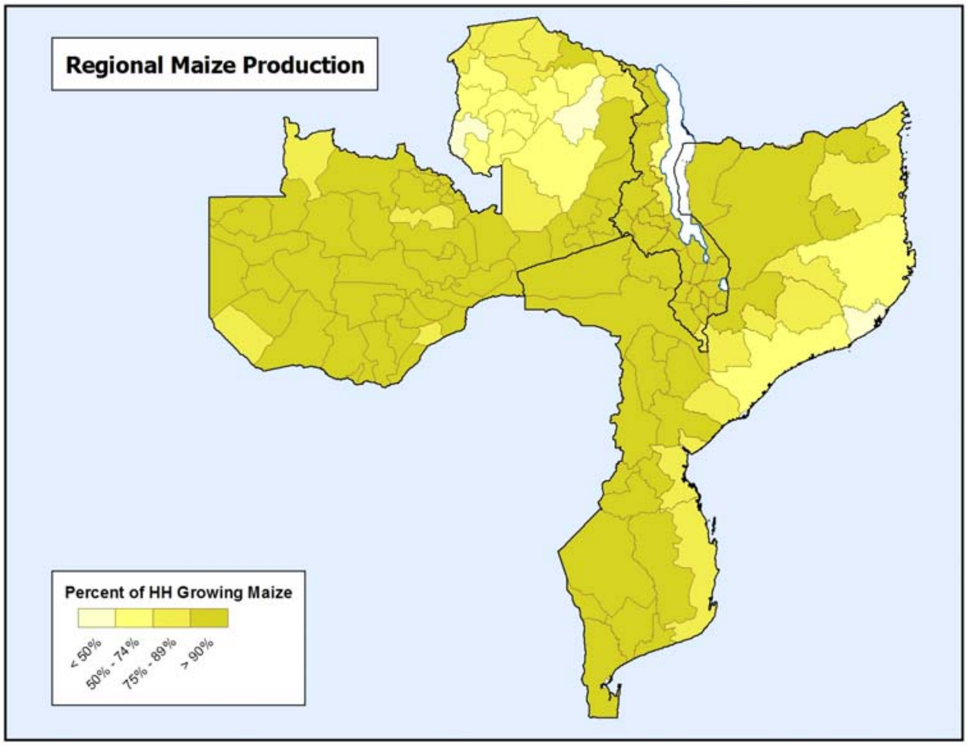
To provide an initial feel for the spatial distribution of food production and consumption, we have mapped the percentage of hoseholds growing each of these staple foods. Using progressively darker shades of yellow (for maize) and blue (for cassava), the maps in Figure 6 classify districts according to the percentage of households growing each of these two staple food crops. While maize predominates in the central part of the region, cassava production becomes significant in northern areas of all three countries as well as along the Mozambican coast.

3*.3.2. Production Quantities*

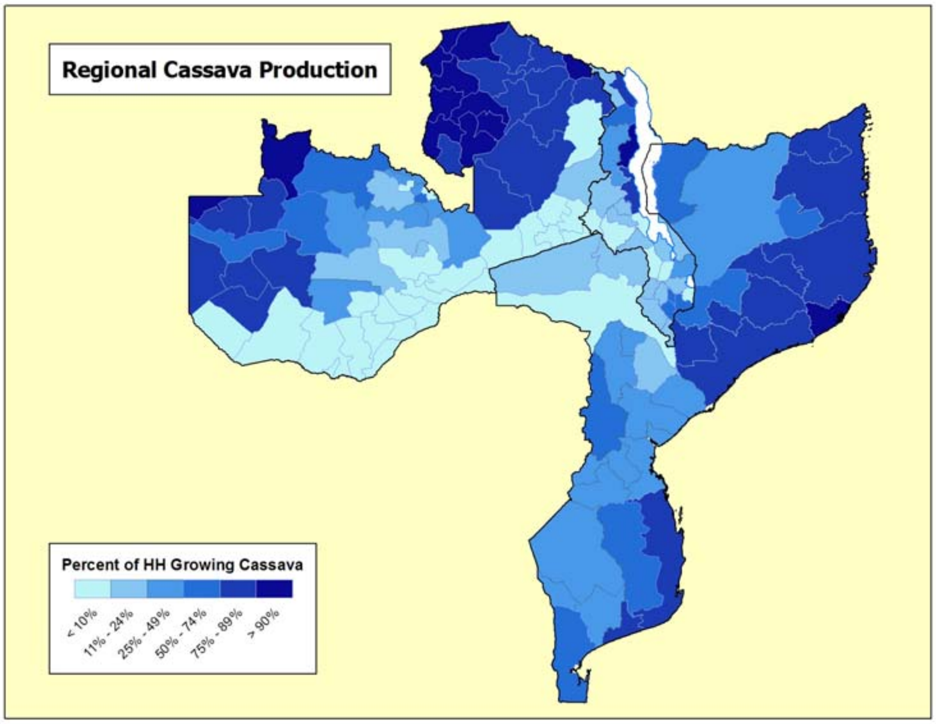
The absolute level of production depends not only on percentage of households but also on their absolute numbers. As Figure 5 indicates, population dispersion across the region is very uneven. Roughly 40% of Zambia's 11 million people live in urban areas, either in the mining towns of the Copperbelt or along the line of rail. Malawi, however, squeezes a slightly larger population of over 12 million people into a much tighter space, leading to much heavier population density. Given that less than 20%% of Malawi's population lives in urban areas, Malawi consists primarily of densely settled rural areas. Mozambique, the largest of the three countries geographically, also houses more people, roughly 19 million in 2005, with slightly over 60% living in rural areas. The northern districts of Mozambique nearly rival Malawi in population density, as does the central and southern coastal corridor (Figure 5).

The population distribution, from Figure 5, combined with the production patterns, from Figure 6, translate into spatial distribution of staple food production as described in Figure 7 below. This figure clearly shows the dense concentration of maize production in southern Malawi, Eastern Province of Zambia and along central Zambia's north-south line of rail, in central interior of Mozambique and scattered throughout the cassava zone of northern Mozambique.

Figure 6. Percentages of Households Growing Maize and Cassava in Zambia, Malawi and Mozambique



a. Regional maize production



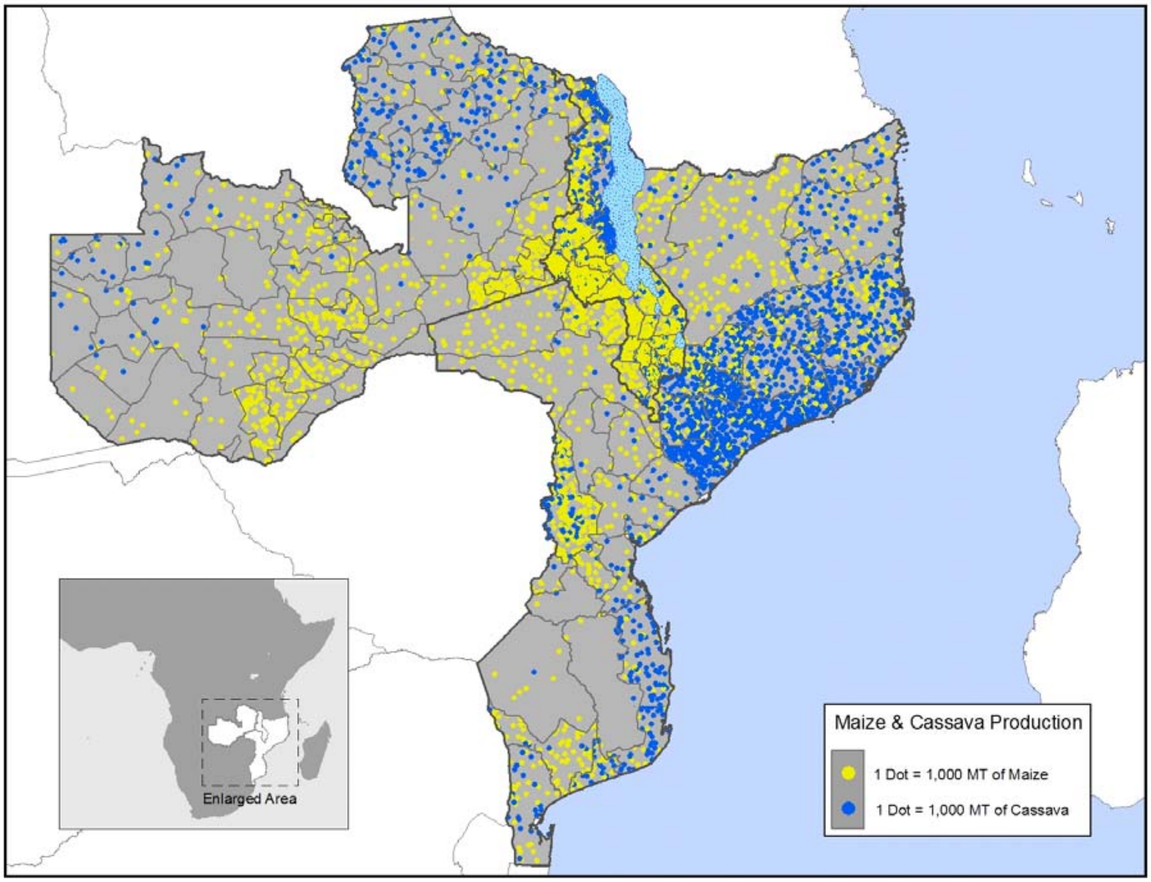
b. Regional cassava production
Source: produced from national farm household surveys in each country.

Production data, though the most useful for measuring levels of importance among food staples, are also the least reliable of the three measures of staple food prevalence: percentage of households growing each crop, hectares per household and kilograms produced. Production data, particularly for cassava, are subject to large measurement error because farm households typically harvest cassava year-round and over a period of several years. Aggregating up to annual production from daily small baskets produces wide variation in estimated cassava output.

3.3.3. Cropped Area per Household

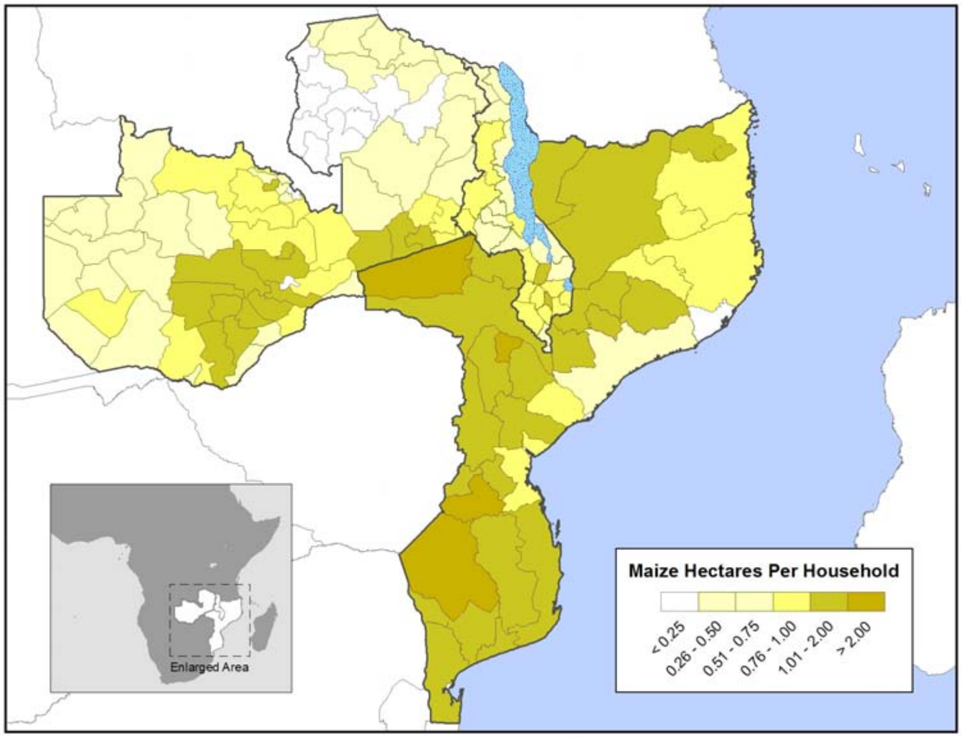
Area data prove more reliable than production, although even here confusion may arise since some surveys and some farmers report only area under mature cassava (those fields with plants over one year old and hence potentially available for harvest) while others report total area planted in cassava, including freshly planted first-year plots. Cropped area per household in each crop is displayed in Figure 8.

Figure 7. Spatial Distribution of Maize and Cassava Production

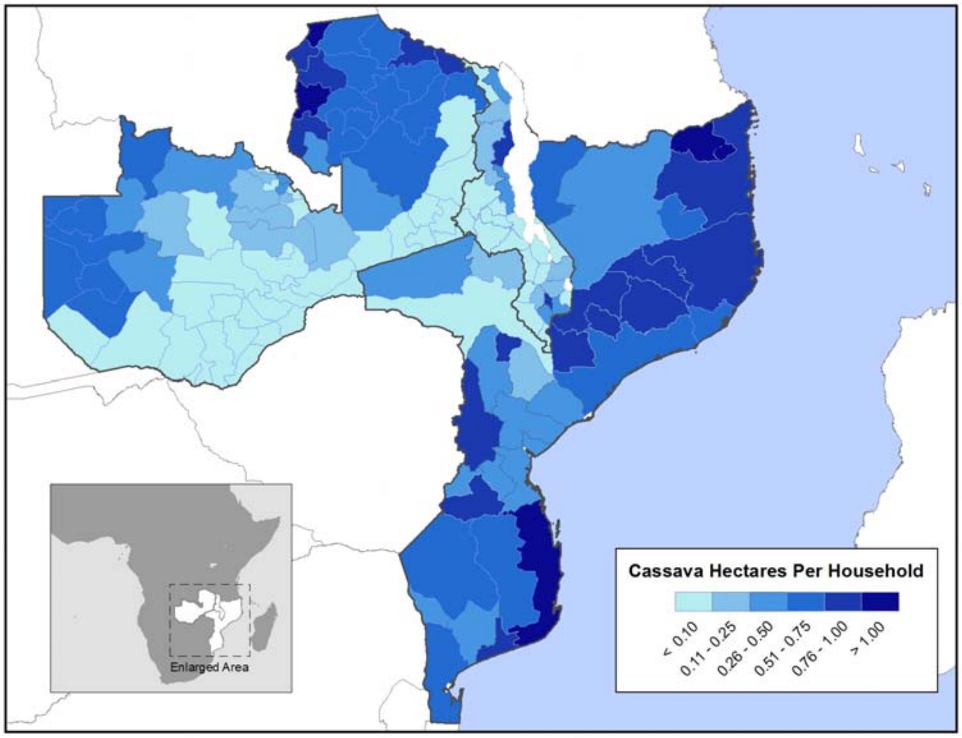


Source: produced from national farm household surveys in each country.

Figure 8. Area per Household Planted in Maize and Cassava



a. Maize area planted



b. Cassava area planted

Source: produced from national farm household surveys in each country.

3.3.4. Delineating Food Staple Zones

Because of the unreliability of district-level production data, particularly for cassava, we have focused on measures of relative staple food prevalence that relied on either area planted or on percentage of households growing each crop. The percent of households offers the simplest measure of crop prevalence. It likewise has the benefit of enabling researchers to classify new regions quickly, based on fairly inexpensive rapid reconnaissance visits.

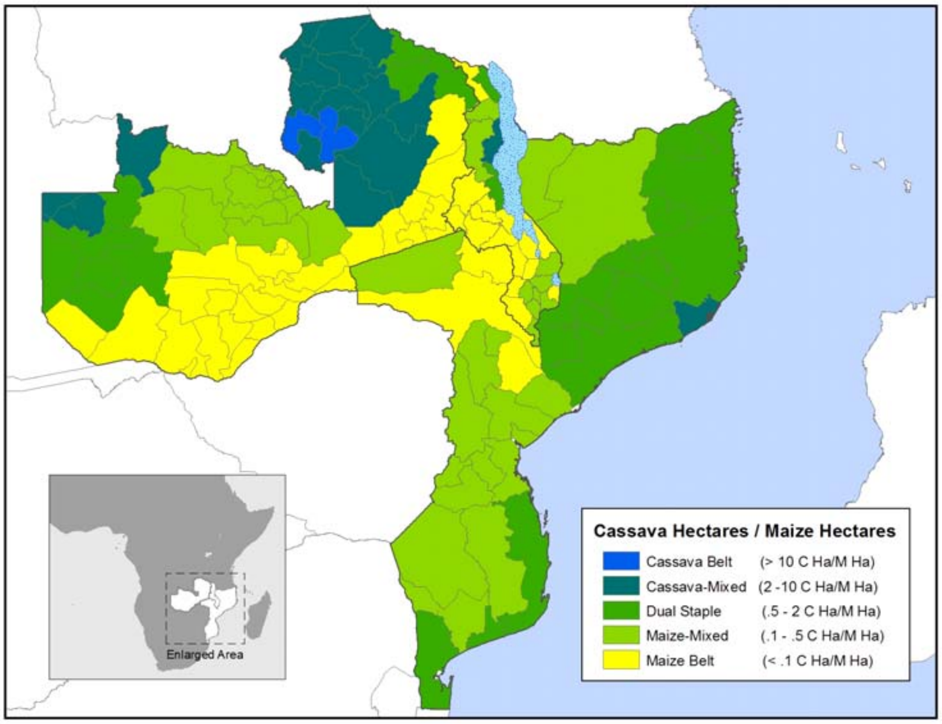
Area-based classification requires more careful, structured survey data. While area estimates based on farmer recall are also subject to considerable imprecision, we consider them more accurate measure of cassava stocks available in the ground than the estimates of harvested quantities derived from farmer recall of daily harvests that are then aggregated to an annual figure.

The two alternative measures – percent of households and area per household in each crop -- result in broadly similar classifications (Figure 9). Because the hectare-based measure offers a better sense of relative proportions of each crop, we have adopted the food staple zones as defined in Figure 9a for purposes of the following analysis. In this case, we have enjoyed access to detailed household survey data for each country. In future work, this may not be the case. So future circumstances may dictate reverting to zonal classification based on household percentages. For now, we have adopted the relative hectares under each crop as our classification tool.

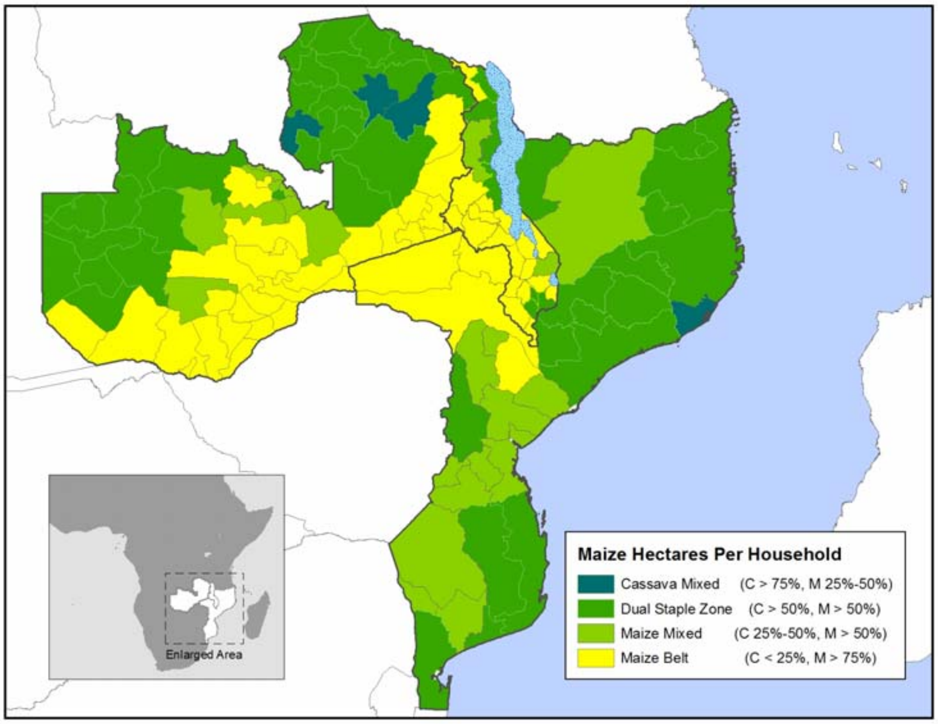
Table 3. Alternative Criteria for Defining Food Staple Zones

Food Staple Zone	a. Percent of Households Growing		b. Ratio of Cassava Hectares to Maize Hectares (C/M)
	Maize	Cassava	
Cassava belt	< 25%	> 75%	> 10
Cassava mixed	25-50%	> 75%	2 to10
Dual staple	> 50%	> 50%	0.5 to 1.9
Maize mixed	> 75%	25-50%	0.1 to 0.49
Maize belt	> 75%	< 25%	< 0.1

Figure 9. Food Staples Zones



a. Defined by relative area planted to maize and cassava



b. Defined by percent of households growing maize and cassava

Source: produced from national farm household surveys in each country.

3.4. The Multi-Market Model

3.4.1. Overview

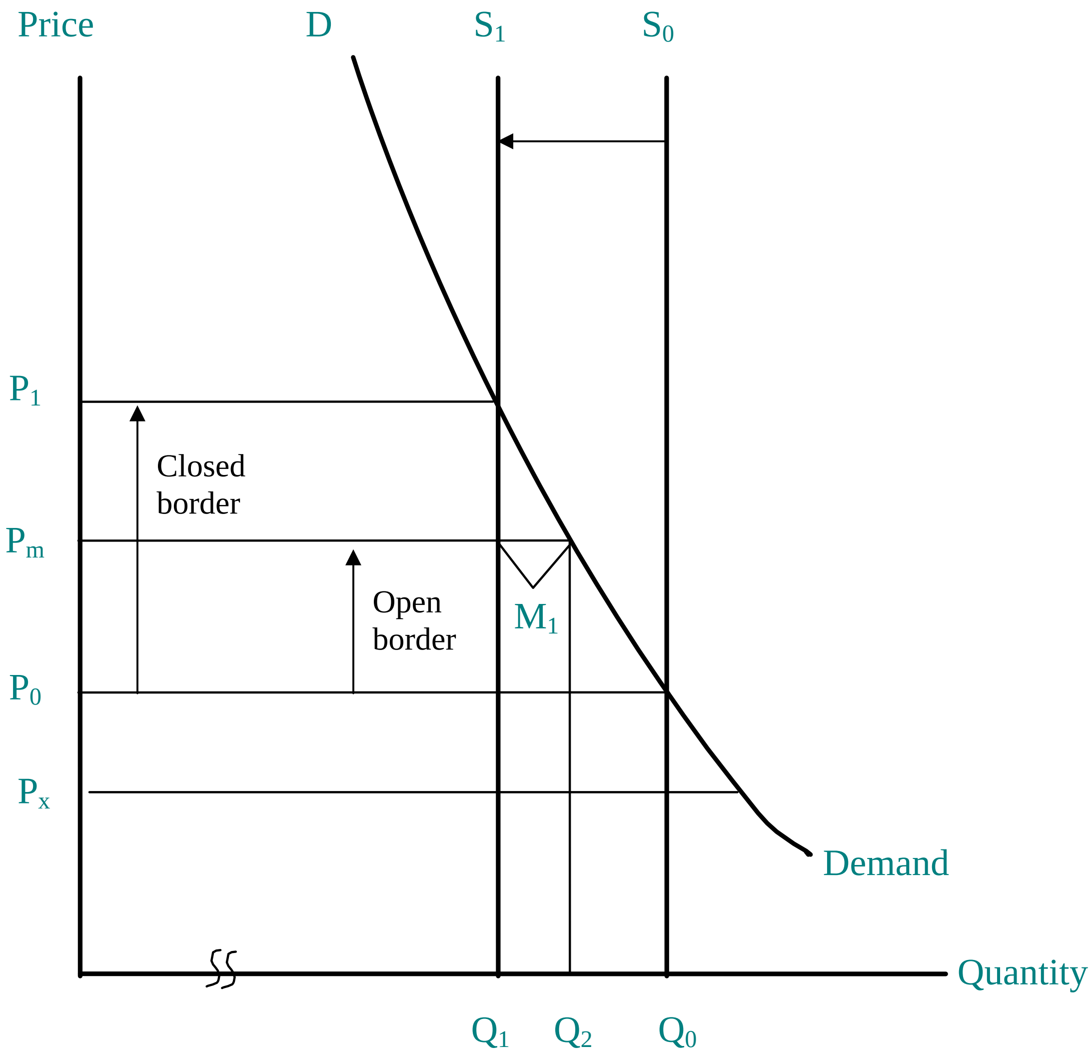
This paper develops and applies multi-market model designed to quantify the impact of production shocks on domestic food prices. In turn, the model assesses the impact of these changing prices on consumer, farmer and trader behavior. As an aid to policy makers and traders, the model likewise evaluates prospects for using trade policy, food aid or various government policy interventions to insulate consumers from production-induced shocks in staple food consumption. This work draws on and extends earlier multi-market models developed by Dorosh (2001), Dorosh and Haggblade (2002), Dorosh, Dradri and Haggblade (2007).

The model developed here explicitly models the market prices for key staple foods and the resulting impact of price changes on farm household income, food consumption by various household groups, staple food imports and exports, and next season's production. To anticipate these multiple outcomes, the framework incorporates price responses by three key groups: consumers, who reduce maize consumption and increase consumption of alternate staples as maize price rises; traders and millers, who import and export in response to differentials between domestic and border prices; and farmers, who alter planting decisions in response to changing prices. As exogenous variables, the model includes a range of potential instruments wielded by government and donors. These include trade quotas, tariffs, public imports, government exports, local procurement, government stockholding and sales, and targeted income transfers to vulnerable groups.

3.4.2. Model structure

At its core, the model estimates how much the domestic maize price will change following an exogenous shock – a drought, flood or pest infestation affecting farm production; a change in world prices; public food imports; food aid; or an array of government policy changes. Figure 10 illustrates by depicting the impact of a major supply shock, most frequently a drought, which causes maize production to decrease from S_0 to S_1. Changes in maize output (which falls from Q_0 to Q_1) and maize price (which increases from P_0 to P_1), in turn, affect the income of maize-producing households as well as consumption decisions of all household groups. With even a rudimentary knowledge of the price elasticity of demand (depicted in Figure 10 as the slope of the demand curve, D), the model is able to estimate approximate orders of magnitude for the resulting shift in market price, by tracing out movement along the aggregate demand curve (D) for maize.

Figure 10. Food Imports Moderate Price Shocks during a Drought



Source: Dorosh, Dradri and Haggblade (2007).

When the domestic maize price (P_0) lies between import parity (P_m) and export parity (P_x), no trade takes place and the domestic price (P_0) prevails. But when a drought or other supply shock causes the domestic maize price to rise, import parity (P_m) sets an upper limit on the price increase. In the absence of trade, the domestic maize price would spike to P_1 during a drought. But when governments allows imports, private traders import grain (an amount $M_1 = Q_2 - Q_1$) at the import parity price ($P_{m)}$, capping the domestic price increase at import parity. Conversely, in years of bumper maize harvest, when domestic prices plunge, the export parity price (P_x) sets a floor price below which the domestic price will not fall. Only when government policy limits imports or exports does domestic price move outside these import and export parity bands. The import and export flows modeled in this paper include both formal and informal trade.
To capture key consumption responses to a price shock, the model includes Zambia's two principal food staples, maize and cassava, as well as wheat, rice and other foods. In the event of a drought, the maize price rises and consumers reduce their consumption of maize. At the same time, they reorient consumption towards more readily available, typically more drought-tolerant staple foods such as cassava, sweet potatoes, millet and sorghum.

Consumption substitution among food staples occurs principally among households in the mixed and dual staple zones (see Figure 9), where people consume both cassava and maize. Because households in these zones consume both staple foods; and because they account for over 40% of maize consumption in each of the zones, slight changes in consumption patterns there can release significant quantities of maize for consumption in the maize belt (Table 4). Annex 1 describes the model formally, while Tables 4 and 5 detail the baseline data and model parameters.

When prices within a given market shed (or basin) increase up to import parity, imports become profitable and the market shed expands to include supply areas from neighboring zones. Similarly, when prices fall below export parity, export becomes possible and the surplus market shed expands its geographic scope to serve the adjacent, deficit basin. The model developed below includes five geographic units that fit together in different ways to form market sheds of different sizes depending on their relative price movements. The five building blocks include: Northern Mozambique, Malawi, Southern and Eastern Zambia, Northern Zambia and Southern Mozambique. In most years, the first four form the core of the South East African maize market shed, while Southern Mozambique remains linked more closely to South Africa.

3.5. Data

3.5.1. Quantities

The baseline data for this model come from a variety of sources. Production data come from a set of nationally representative farm household surveys, Zambia's 2004 supplemental survey to the Central Statistical Office's Post-Harvest survey, Malawi's integrated rural household survey of 2004/05, and Mozambique's 2005/06 national agricultural household survey file. Consumption data likewise have been computed from household data, the 2004/05 Malawi Integrated Household Survey, the Mozambican Integrated Household Survey of 2002/03 and Zambia's 1998 Living Conditions Monitoring Survey. Aggregate production and consumption data, as well as official trade flows, come from national food balance sheets produced by FAO.

Because household-level consumption and production data rarely match precisely, we have taken food balance sheet aggregates and partitioned consumption and production across food staple zones and households, using the shares computed from the household survey data.

3.5.2. Prices

Monthly market prices come from statistical offices in all three countries. Gaps in the data series, and shifts from retail to wholesale prices and from grain to flour in some series, have posed challenges in some instances. Where anomalies emerged, we have consulted with specialists and have commissioned a series of country baseline studies to help fill certain gaps. These studies are available in their entirety as annexes in a companion paper entitled "Market Sheds in Eastern and Southern Africa."

The relevant world price for this market shed are the prices listed on the SAFEX exchange in Johannesburg, which serve in computing import parity. The full set of monthly maize prices are listed in Annex 3 of this report.

3.5.3. Incomes

National income is taken from official World Bank estimates. We have partitioned these incomes among household groups using country social accounting matrices. In allocating agricultural income by commodity, we have relied on quantity breakdowns from our national farm household surveys. The results for our base year of 2004 are available in Table 4. We have selected 2004 as the base because it is the latest normal harvest year for which a full set of income and production data are available.

Table 4. Baseline Population and Income Data

	Population ('000)	Income (US$ millions)	Per Capita Income (US$/person)
Northern Mozambique	10,340	2,300	222
remote	1,967	311	158
rural	5,900	933	158
urban	2,473	1,056	427
Southern Mozambique	8,829	3,398	385
remote	1,059	359	339
rural	3,177	1,077	339
urban	4,593	1,962	427
Malawi	12,894	2,625	204
remote	1,068	145	135
rural	9,613	1,304	136
urban	2,212	1,177	532
Northern Zambia	5,338	2,385	447
remote	750	217	290
rural	2,251	653	290
urban	2,337	1,514	648
Southern Zambia	5,932	3,056	515
remote	1,039	309	298
rural	3,117	928	298
urban	1,776	1,819	1,024

Table 5. Baseline Production and Consumption Data

	Commodities						
	maize	cassava	rice	wheat	other ag	industry	services
Production ('000 tons)							
Northern Mozambique	685	5461	147	0	415	481	1033
Southern Mozambique	752	952	31	2	433	893	1919
Malawi	1733	1905	50	2	934	454	1167
Northern Zambia	390	945	6	48	518	672	1193
Southern Zambia	824	12	5	71	834	807	1433
Consumption ('000 tons)							
Northern Mozambique	451	4051	262	140	286	512	1145
Southern Mozambique	572	707	171	151	563	807	1807
Malawi	1472	1180	40	47	934	454	1167
Northern Zambia	367	832	10	45	455	574	1018
Southern Zambia	729	11	8	68	896	905	1607
Rural Prices (US$ per ton)							
Northern Mozambique	141	53	252	171	1,000	1,250	1,000
Southern Mozambique	155	58	277	232	1,000	1,250	1,000
Malawi	106	21	240	438	1	1	1
Northern Zambia	134	25	255	263	1	1	1
Southern Zambia	118	51	225	525	1	1	1
Urban Prices (US$ per ton)							
Northern Mozambique	168	63	300	137	1,250	1,000	1,000
Southern Mozambique	228	85	407	186	1,250	1,000	1,000
Malawi	133	27	300	350	1	1	1
Northern Zambia	168	32	319	210	1	1	1
Southern Zambia	148	63	281	420	1	1	1

Table 6.Model Parameters

	Elasticities with respect to						
	maize	cassava	rice	wheat	other ag	industry	services
a. Elasticity of supply							
maize	0.2	0	0	0	0	0	0
cassava	0	2.0	0	0	0	0	0
rice	0	0	0.3	0	0	0	0
wheat	0	0	0	0.3	0	0	0
other agriculture	0	0	0	0	0.3	0	0
b. income elasticity of demand							
remote households	0.5	0.1	0.7	0.8	1.0	1.2	1.0
rural households	0.5	0.1	0.7	0.8	1.0	1.2	1.0
urban households	0.5	0.1	0.7	0.8	1.0	1.2	1.0
c. price and cross-price elasticities of demand							
maize	-0.5	0.2	0	0	0	-0.3	-0.2
cassava	0.3	-0.2	0	0	0	-0.3	-0.2
rice	0.1	0	-0.8	0	0	-0.1	-0.2
wheat	0.1	0	0	-0.8	0	-0.1	-0.2
other agriculture	0.1	0	0	0	-0.8	-0.1	-0.2
industry	0	0	0	0	0	-1.0	-0.2
services	0	0	0	0	0	0	-1.0

4. SIMULATION RESULTS

This section illustrates the application of this model by reviewing results from a series of simulations across the South East Africa market shed. Discussion begins from the perspective of producers and consumers in Northern Mozambique, then moves counter-clockwise across to evaluate the probable impact of drought and various policy responses in Malawi and then in Zambia.

4.1. Northern Mozambique

Simulation 1. Drought in Northern Mozambique

The first simulation considers a scenario in which a regional drought reduces maize production by 10% below their expected base level. If this is the only shock to the system, given normal price elasticity of demand in the range of 0.2 to 0.3, the price of maize will rise sharply, by roughly 50% (Table 6, Column 1).

Cassava demand rises, due to cross-price effects, as consumers reduce their consumption of maize. Because farmers can harvest many varieties of cassava over a several year period, they are able to increase or decrease harvested quantities in any given year to accommodate surpluses or shortages of other food staples. Given a high supply elasticity, of 2.0, cassava quantities harvested increase by 8.8% to accommodate growing demand. Indeed, cassava consumption in rural areas increases by 13%, while maize consumption falls at a similar rate. The cassava price rises with growing demand, though only 4.3%, far lower than for maize, because of the high short-run supply elasticity.

In this simulation, which assume no knock-on effect on nonfarm incomes or other agricultural commodity production, real rural incomes actually rise because the maize price increases by more than production falls. However, real incomes in urban areas fall nearly 5% due to the sharp rise in maize price.

Simulation 2. Drought Affects All Rural Production

The second simulation models the consequences of a drought that affects not only maize but all other agricultural commodities, save for cassava, which remains unaffected. Unlike the prior scenario, rural nonfarm income also suffers a 10% fall, as a result of tight linkages to the agricultural economy.

In this situation, rural incomes are lower than in Scenario 1 because of the drop in rural nonfarm income and other agricultural production. Urban incomes likewise fall further because of the more broadly based price inflation in both maize and other agricultural products. Results in the cassava and maize markets remain similar to Scenario 1, however, because lower incomes are offset by cross-price effects of demand of other agriculture on maize and cassava demand, and hence price.

Table 7. Simulation Results: Northern Mozambique

	Simulation 1 Drought N Mozambique maize only	Simulation 2 Drought N Mozambique Rural nonfarm Income falls	Simulation 3 Normal Production Food Aid Procured WFP purchases 40,000 tons	Simulation 4 Drought Malawi Malawi imports 100,000 tons
Production				
Maize	-10.0%	-10.0%	0.0%	7.6%
Cassava	8.8%	8.7%	5.7%	8.1%
Price				
Maize	49.5%	48.7%	30.1%	44.0%
Cassava	4.3%	4.2%	2.8%	4.0%
Consumption				
Maize-Rural	-13.5%	-13.5%	-8.6%	-11.5%
Maize-Urban	-14.1%	-14.0%	-9.5%	12.2%
Cassava-Rural	13.3%	13.0%	8.6%	-12.9%
Cassava-Urban	0.6%	0.6%	0.3%	0.4%
Calories-Rural*	4.4%	4.2%	2.9%	-12.4%
Calories-Urban*	-3.2%	-3.1%	-2.2%	3.5%
Real Income				
Rural	3.8%	0.1%	3.15%	5.27%
Urban	-4.9%	-7.2%	-3.39%	-4.46%

* Calories from maize and cassava.

Simulation 3. Normal Harvest Year: 40,000 Tons of Food Aid Maize Procurement

Given regular surpluses of maize coming out of Northern Mozambique, food aid agencies have considered purchasing maize their for distribution to deficit households elsewhere in the region. This simulation, therefore, examines the likely impact of procuring 40,000 tons of maize, announced after planting so that short-run supply remains fixed at normal levels. The effect of this procurement is similar to a mild drought, in that it pulls supply off the local market. Most commonly such purchases take place in good harvest year and therefore serve to bolster farm price during bumper years.

Under these assumptions, procurement of 40,000 tons of maize will lead to a 30% increase in maize prices, given fixed output and increased demand. As before, consumers respond to the rising maize price by shifting consumption in favor of other staples. Because of its relatively elastic short-run supply, cassava harvesting increases to accommodate increased demand. Rural cassava consumption increases by 8.6%. Although rural maize consumption declines, calories available from maize and cassava increase slightly in rural areas due to the higher cassava consumption and the income effect of higher maize prices.

The tradeoff between rural and urban incomes becomes apparent in this scenario. Rural incomes rise by 3.2%, while urban incomes fall by a roughly similar magnitude.

Simulation 4. Cross-Border Trade to Malawi

If farmers in Northern Mozambique expect higher prices in Malawi during the coming season, as a result of bad weather or changes in government input supply programs, they respond by increasing production. Because of the long porous border between Malawi and the surrounding areas of Northern Mozambique, rising prices in Malawi trigger additional exports and higher maize price in Northern Mozambique. In a scenario where Malawi were to require imports of Mozambican maize 100,000 tons above normal, the maize price in Northern Mozambique would increase by 44%. This, in turn, would induce a 7.6% increase in maize production in Northern Mozambique. The combination of rising maize prices and increased output drives rural incomes up by 5.3% in Northern Mozambique. Urban incomes, however, fall in response to rising maize prices.

4.2. Malawi

Simulation 5. Drought in Malawi, Without Cross Border Trade

The previous simulation examined the consequences of a drought in Malawi, looking at the consequences from the perspective of farmers and consumers in Northern Mozambique. This simulation explores in greater detail the consequences of a Malawian drought, this time looking at circumstances from the Malawian side of the border.

Consider the impact of a drought in Malawi that results in a 20% reduction in maize production compared to the base year. These simulations assume that a sharp fall in maize production will also reduce related rural nonfarm income by 10%. As a result of this drought-induced reduction in maize output, the maize price rises sharply, by 62%, in the absence of opportunities for cross-border imports (Table 8). The cassava price rises as well, but by far less than the maize price since farmers can increase the supply of cassava can increase in the short run in response to price increases. Rural incomes fall due the reduced farm and nonfarm output, while urban real incomes fall due to the sharp rise in maize price.

As a result of reduced production and rising price, maize consumption falls in both rural and urban areas of Malawi. As a result, consumers diversify their consumption into alternative staples. Because farmers can harvest cassava over a period of several years, they are able to harvest additional volumes in droughts and reduce harvested quantities in years when the maize harvest is good. In this situation, cassava consumption grows by 14% in rural areas and by 2% in urban areas where sweet cassava has become a common snack food (Kambewa and Nyembe, 2007). In spite of the compensating substitution of cassava for maize, calorie consumption falls, by 6% in urban areas and by 8% in rural areas, because of the reduction in maize availability.

Table 8. Simulation Results: Malawi

	Simulation 5 **Drought Malawi** **Closed border**	**Simulation 6** **Drought Malawi** **Maize imports from N Mozambique**
Imports	0	100,000 tons
Production		
Maize	-20.0%	-20.0%
Cassava	8.3%	3.3%
Price		
Maize	62.2%	27.1%
Cassava	4.0%	1.7%
Consumption		
Maize-Rural	-22.2%	-15.6%
Maize-Urban	-16.1%	-8.7%
Cassava-Rural	14.2%	5.5%
Cassava-Urban	2.0%	1.7%
Calories-Rural*	-6.1%	-6.2%
Calories-Urban*	-7.8%	-4.0%
Real Income		
Rural	-11.4%	-16.2%
Urban	-21.3%	-7.6%

Simulation 6. Drought in Malawi, With Cross Border Imports from Northern Mozambique

The dual-staple zones of Northern Mozambique likewise respond to the sharp rise in maize price across the border in Malawi. Farmers in Northern Mozambique, who eat both cassava and maize, are able to harvest additional cassava and release additional maize for sale at the high price across the border in Malawi.

Simulation 6 examines the resulting impact of 100,000 tons of imports from Northern Mozambique into Malawi. This volume of imports -- well within the normal flows and significantly below the 200,000 to 300,000 tons exported to Malawi in 2003 – cuts the maize price rise in Malawi in half, from 62% to 27% (Table 8). The cassava price increase likewise falls roughly in half.

Urban consumers become the principal beneficiaries of this price containment. Their real income shock is moderated considerably, falling about 8% in the maize import scenario (Simulation 6) compared to a 21% fall without cross-border trade (Simulation 5). Caloric consumption, from cassava and maize, remains roughly similar in rural areas, while the reduced maize supply and price shock enables maize-preferring urban consumers to cut their calorie fall roughly in half, from 8% to 4%. Thus, farmers in

Northern Mozambique and urban consumers in Malawi both benefit from this cross border trade.

4.3. Zambia

Simulation 7. Impact of a Drought, No Trade

Simulation 7 examines the impact of a drought affecting 30% of the Zambian maize crop. If Zambia were to prevent imports in the face of a drought – by failing to issue import permits to the private sector, by announcing large volumes of subsidized public imports and then failing to provide adequate funding (as in 2001), or by some combination of disincentives (as happened in 2005), then domestic maize price would more than double.[3] Without the moderating impact of private imports, which when flowing unimpeded cap price increases at import parity levels, Zambia's maize price would increase by over 160 percent. Because poor households bear the brunt of this weather-induced compression in food availability, their maize consumption would fall by roughly 25% below normal (Table 9).

Simulation 8. Staple Food Substitution

Even in the unlikely event that government could maintain a completely closed economy in the presence of widespread informal trade flows, the worst-case scenario in Simulation 7 overstates the compression in food consumption by poor households, because Zambian consumers can fall back on alternative staple foods in situations where maize becomes scarce and the maize price spikes. Simulation 8 suggest a 160 percent increase in the maize price would induce Zambians to consume roughly 28% more cassava in the North and 21% more (from a nominal base) in the South, thus offsetting about 40% of the shortfall in maize availability. In the cassava-producing regions of northern Zambia, this substitution of cassava for maize would largely eliminate the vulnerable households' maize deficit, freeing up maize they would have otherwise consumed for sale in other zones where consumers have developed a more pronounced preference for maize. In calorie terms, the maize-equivalent consumption shortfall among poor households would fall from 15% to 2% in the heavy cassava-consuming areas of the North, though the impact in the South would be negligible because of the low levels of cassava consumption there (Table 9).

Both open borders and consumer substitution among food staples moderate maize production shocks, benefiting primarily low-income consumers. These results from Zambia suggest that, under an open trade regime, private imports together with increased cassava consumption could fill roughly two-thirds of the maize consumption shortfall facing vulnerable households during drought years.

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[3] For a review of recent Zambian government trade policy, see Dorosh, Dradri and Haggblade (2007) and Govereh, Jayne and Chapoto (2008).

Table 9. Simulation Results: Zambia

	Simulation 7 Drought S. Zambia	Simulation 8 Drought S. Zambia	Simulation 9 Drought S. Zambia	Simulation 10 Drought S. Zambia	Simulation 11 Drought S. Zambia	Simulation 12 Drought S. Zambia
Trade policy	import ban	import ban	free trade	free trade	free trade	traders scared away
Adjustments simulated						
market price of maize	yes	Yes	yes	yes	yes	yes
consumer substitution of cassava for maize		Yes	yes	yes	yes	yes
private imports			yes	yes	yes	small
Production						
Maize	-30.0%	-30.0%	-30.0%	-30.0%	-30.0%	-30.0%
Cassava	0.0%	24.3%	6.2%	6.2%	4.0%	19.4%
Price						
Maize	163%	163%	36%	36%	8%	115%
Consumption						
Maize-North	-29%	-29%	-12%	-12%	1%	-23%
Maize-South	-31%	-31%	-12%	-12%	-1%	-25%
Cassava-North	0%	28%	5%	5%	11%	24%
Cassava-South	0%	21%	5%	5%	4%	17%
Calorie consumption of poor households						
Poor northern households	-15%	-2%	-3%	-3%	3%	-1%
Poor southern households	-20%	-19%	-9%	-9%	3%	-15%
Maize supply response next season	34%	34%	10%	10%	2%	26%

Simulation 9. Drought, With Open Cross-Border Trade

More important to vulnerable households in the South are private imports of maize. With both private imports and consumer substitution of cassava for maize, national food security improves markedly, even during a serious drought. Compared to base levels, the private sector imports 155,000 tons of maize, capping the maize price increase at import parity, or 36 percent above normal lean-season levels. Although this price rise still triggers a reduction in maize consumption, even among households who prefer maize as their staple food, the resulting shortfall in staple food consumption by poor households falls to 3% in the North and 9% in the South (Table 9).

Simulation 10. Public Imports, Small Quantities

If food aid agencies or the Zambian government were to import small volumes of maize to sell domestically at market price -- where small is defined as any amount less than the 155,000 tons the private sector would bring in at import parity prices -- the results would be the same as under free trade. Thus the results of Simulation 10 are identical to those in Simulation 9. In this situation, public imports would simply displace an equivalent volume of private imports. For this combination of side-by-side public and private imports to occur, however, the private sector needs to have confidence that public food managers will operate under transparent, predictable decision rules governing quantities, timing and release prices. The private sector needs to believe that government will not sell imported grain at below-market prices, causing commercial losses for private importers. Government, likewise, needs to have confidence that private importers will not collude to artificially boost import prices above import parity. To develop this mutual trust will require good communications and good will on both sides.

Simulation 11. Public Imports, Large Quantities

If government or food aid agencies bring in maize volumes in excess of what consumers would purchase at import parity, these large-scale public imports will drive domestic prices down below import parity. In the present example, public imports of 255,000 tons (the maize supply gap projected under Simulation 7) would bring down prices below import parity, to only 8% above normal, even during a severe drought. However, these subsidized government imports would result in government trading losses of $64 per ton, amounting to a loss $16 million.

Simulation 12. Public Imports, Private Sector Impeded

Given late and unpredictable decision-making by Zambian authorities, many private firms have become wary of cross-border maize trade. Simulation 12 considers a scenario, similar to 2001, in which government announces that it will import large volumes of maize, thus scaring off the commercial private trade. Then, due to a shortage of funds or to management difficulties, government ends up bringing in less maize than they intended. If government were to announce they would import 255,000 tons of maize (as in Simulation 11), thus scaring away private traders, but then import only 50,000 tons, then maize prices would more than double and staple food consumption (of maize and cassava) by low-income consumers would fall 15% below normal levels in the South (Table 9). Given the predominance of cassava consumption in the North, poor households there remain largely insulated from the impact of the maize price increase.

4.4. Future Applications

These simulations illustrate the many potential applications possible with this geographically disaggregated multi-market simulation model. In the future, we aim to develop this model further, by adding in supply responses in the maize-surplus highlands of Southern Tanzania and by linking these various regions more formally to explore prospective opportunities for and consequences of cross-border trade in a variety of plausible future scenarios. Working with various trade policy groups at COMESA, our team will help to adapt and apply this model to serve in ongoing deliberations over regional trade policy in the region.

5. CONCLUSIONS

5.1. Importance of Food System Shock Absorbers

Maize production fluctuates widely in Southern and Eastern Africa given the region's heavy dependence on rainfed cultivation. When adjustments must take place within the confines of small national markets, this production volatility translates into wide swings in maize price and rapid compression in food consumption by vulnerable groups. Consumers confront the pressure of unexpected consumption shocks, while farmers face difficulties anticipating food prices in what can become self-reinforcing boom and bust production and pricing cycles.

Given current production volatility in maize, the development and expansion of available food system shock absorbers promises significant benefits in helping to buffer these shocks and thereby stimulate both agricultural production growth in surplus zones and improved food security in deficit zones. The data and analysis presented in this report suggest two import safety valves that can help to moderate consumption and price volatility in the presence of recurring maize production shocks.

5.2. Regional Trade in Food Staples

The first of these food system shock absorbers is regional trade in food staples. During the Malawian food crisis of 2002/03, informal traders from Northern Mozabmique, delivered on the order of 200,000 to 300,000 tons of maize into Malawi while farmers from southern Tananzia furnished further 100,000 tons (Whiteside, 2003). At these levels, total informal imports amounted to between 20% and 25% of normal consumption in Malawi. Our simulation results suggest that even more modest inflows -- of 100,000 tons of imports -- in response to a moderate drought, can cut price spikes by as much as 50%. Given these magnitudes, regional trade flows can clearly help to soften supply deficits.

The liberalization of maize trade in South Africa in 1995 and the subsequent launching of the SAFEX commodity exchange in 1996 provide a price and delivery mechanism on which traders and policy makers can build to help integrate regional markets and moderate supply shortfalls. As the Zimbabwean political situation unfolds, the regular maize deficits of recent years may revert to the prior norm as a significant surplus producer. Clearly, regional markets will continue to evolve. In the past decade more tools have become available for using this tool to help moderate price fluctuations and stimulate production growth in surplus zones while at the same time softening price shocks in deficit zones. Given small countries and arbitrary inherited political boundaries, cross-border trade in food staples will constitute an important pillar of improved regional food security.

5.3. Consumer Substitution among Food Staples

The second major shock absorber highlighted in this paper is consumer substitution among food staples. The results from Northern Zambia illustrate the importance of this consumer substitution. Even during a serious drought, reducing national maize production by 30%, poor households in the cassava-consuming north see calorie intake from cassava and maize fall by only 2%. Overall, this cassava substitution for maize compensates for about 40% of the national maize shortfall in these circumstances.

While discussion here has concentrated on cassava as a secondary food staple, these results should be considered illustrative of the broader opportunities for consumer substitution of a whole array of drought-tolerant alternative staples including sorghum, millet, and sweet potatoes. In urban areas, shifting consumption patterns and growing consumer preferences for rice and wheat products open further opportunities for substitution among food staples.

Livestock feed and livestock products, likewise, offer important substitution possibilities, particularly given growing demand for poultry, meat and other livestock products. Feed companies in Zambia are currently experimenting with the incorporation of cassava into their feed formulations. In years such as 2008, with sharply rising world cereal prices, the introduction of alternative local carbohydrate sources (such as cassava and sorghum) in feeds offers a second conduit for relieving pressure on maize demands. Although maize dominates many food policy discussions, a portfolio of drought-tolerant secondary staples offers important benefits in substituting for highly variable maize supplies.

These substitution possibilities help to moderate the food compression induced by maize supply shocks. Our simulations from Zambia suggest that, together, commercial maize imports plus consumer substitution of cassava for maize would fill roughly two-thirds of the maize consumption shortfall facing vulnerable households during a typical drought year, assuming open borders.

5.4. Future Priorities

The detailed data base and analytical tools developed for this paper provide a resource to be used in further work exploring the potential power of these two food system shock absorbers. Future work in this area will benefit from a focus on expanding analytical tools for linking market basins and expanding data collection to broaden their geographic reach. The maize surplus highlands of southern Tanzania, together with the surplus zones in northern Tanzania merit high priority, as these may provide the glue connecting the Eastern and Southeastern African maize market sheds. Thus, the data base and simulation model developed here provide a foundation for launching further forays into food staple markets and agricultural development in Africa.

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Annex 1.

GAMS Code

Mozambique Multi-Market Model

```
$TITLE MOZAMBIQUE MULTI-MKT MODEL        MOZMMv1e.GMS      6/03/08
$OFFSYMLIST OFFSYMXREF
* Added code for national model  MOZMMv1c.GMS
* Regional model MOZMMv1d.gms
* New SAM for regional model MOZMMv1e.gms
* Need to add code for rural remote
* Need to use a broader price index for inflating real non-agric incomes in YHDEF eqn
* Check closure for services and indust (add endogenous price of services?)
* Set up mechanism to model only second half of crop marketing year

* To run model:
* Specify commodities/regions connected with ROW: i.e. members of IMR(I)
* For regional model:
** CHANGE MEMBERSHIP OF SETS IREG AND IREG2 FOR REGIONAL INTEGRATION
* Specify COMMODITIES WITH REGIONALLY INTEGRATED MARKETS: Set IREG(I,R)
* Define IREG2(I,R1,R2) consistent with IREG(I,R)
* Note that only 1 region of an integrated pair IREG2(I,R1,R2) can be
*    a member of IMR, i.e. integrated with the ROW
* For national model: Sets IREG and IREG2 contain all regions and commodities
* For isolated regional economies: Sets IREG and IREG2 are empty sets

$ONEMPTY

 SET I      COMMODITIES    /MAIZE          1 MAIZE
                            CASS           2 CASSAVA
                            RICE           3 RICE
                            WHEAT          4 WHEAT
                            OAGRIC         5 OTHER AGRIC (INC LIVESTOCK)
                            INDUST         6 INDUSTRY
                            SERVICES       7 SERVICES /


     H               HOUSEHOLDS       / H-REM  REMOTE
                                        H-RUR  RURAL
                                        H-URB  URBAN  /

     UH(H)           URBAN HOUSEHOLDS / H-URB /
     RH(H)           RURAL HOUSEHOLDS / H-RUR, H-REM /

      R           REGIONS / NORTH, SOUTH /

   IT(I)    COMMODITIES TRADED
              / MAIZE, RICE, WHEAT, INDUST /

** Need to fix M.fx(i,r) for any commodity not in IMR
** For any commodity, IMR must not contain separate sub-regions that are integrated
   IMR(I,R)    COMMODITIES IMPORTED
               / MAIZE.SOUTH, RICE.SOUTH, RICE.NORTH, WHEAT.SOUTH, WHEAT.NORTH,
                 INDUST.NORTH, INDUST.SOUTH /
*               / MAIZE.SOUTH, INDUST.SOUTH /

   IR(I,R)    ALL COMMODITIES AND REGIONS
              / MAIZE.NORTH, MAIZE.SOUTH,
                CASS.NORTH, CASS.SOUTH,
                RICE.NORTH, RICE.SOUTH,
                WHEAT.NORTH, WHEAT.SOUTH,
                OAGRIC.NORTH, OAGRIC.SOUTH
                INDUST.NORTH, INDUST.SOUTH
                SERVICES.NORTH, SERVICES.SOUTH /
** MUST CHANGE MEMBERSHIP OF SETS IREG AND IREG2 FOR REGIONAL INTEGRATION
** For any commodity, IMR must not contain separate sub-regions that are integrated
   IREG(I,R)    COMMODITIES WITH REGIONALLY INTEGRATED MARKETS
                /    /
*               / MAIZE.NORTH, MAIZE.SOUTH /
*               / MAIZE.NORTH, MAIZE.SOUTH, INDUST.NORTH, INDUST.SOUTH /
   INDR(I,R)      COMMODITIES WITH INDEPENDENT MARKETS
   IE(I,R)    COMMODITIES EXPORTED

     ALIAS (I,J) ;
     ALIAS (R,R2) ;
     ALIAS (R,R1) ;
```

```
   INDR(I,R)$IR(I,R) = YES;
** MAKE SURE IREG IS DEFINED for integrated market!!!
*   IREG(I,R)$IR(I,R) = NO;
   INDR(I,R) = IR(I,R) - IREG(I,R) ;

** MUST CHANGE MEMBERSHIP OF SETS IREG AND IREG2 FOR REGIONAL INTEGRATION
** By convention, for markets linked with ROW, R1 is the market closest to ROW
** Trade margin is defined P(I,R1) + margin = P(I,R2) where margin can be + or -
** For any commodity, IMR must not contain separate sub-regions that are integrated
SET   IREG2(I,R1,R2)    COMMODITIES WITH REGIONALLY INTEGRATED MARKETS
             /     /
*               / MAIZE.NORTH.SOUTH /
*               / MAIZE.NORTH.SOUTH, INDUST.NORTH.SOUTH /
 ;
*PARAMETERS

PARAMETER
* Structural and calibration parmaters
   TM(I,R)     IMPORT TARIFF                                (UNITY)
   EY1(H,I)   INCOME ELAST OF DEMAND FOR HOUSEHOLD H       (UNITY)
   EY(H,I,R)   INCOME ELAST OF DEMAND FOR HOUSEHOLD H       (UNITY)
   ED1(I,J)  PRICE ELASTICITY OF DEMAND FOR HOUSEHOLD H   (UNITY)
   ED(I,J,H,R) PRICE ELASTICITY OF DEMAND FOR HOUSEHOLD H   (UNITY)
   ES1(I,J)  PRICE ELASTICITY OF SUPPLY                   (UNITY)
   ES0(I,J,R) PRICE ELASTICITY OF SUPPLY IN REGION R - base value     (UNITY)
   ES(I,J,R) PRICE ELASTICITY OF SUPPLY IN REGION R - sim value       (UNITY)
   AGSHARE(I,H,R) SHARE OF AGR INCOME PER HOUSEHOLD         (UNITY)
   PRODH(H,I,R) PRODUCTION BY HOUSEHOLD BY REGION         ('000 TONS)
   totcons(r)  total value of consumption                 (bn Meticais)
   pcwt(i,r)  weights for consumer price index              (unity)
   LOSS(I,R)  LOSSES FACTOR                                 (UNITY)
   PRODSHK(I,R) PRODUCTION SHOCK                            (UNITY)
   yhnagshk(h,r) SHOCK TO YHNAG                             (UNITY)
*DUMMIES TO HOLD INITIAL DATA
   MARG0(I,R)  DOMESTIC MARKETING MARGIN                    (UNITY)
   REGMARG0(I,R,R2)  REGIONAL MARKETING MARING              (UNITY)
   PU0(I,R)    CONSUMER (URBAN) PRICE                 (Meticais per kg)
   PR0(I,R)    PRODUCER (RURAL) PRICE                 (Meticais per kg)
   PMROW0(I,R)  IMPORT BORDER PRICE                   (Meticais per kg)
   PEROW0(I,R)  EXPORT BORDER PRICE                    (Meticais per kg)
   PWMROW0(I,R)  WORLD IMPORT PRICE                       ($ per ton)
   PWEROW0(I,R)  WORLD EXPORT PRICE                       ($ per ton)
   PINDEX0(R)  PRICE INDEX OF REGION R                 (UNITY)
   IMARG0(I,R)  MARKETING MARGIN ON IMPORTS OR EXPORTS      (UNITY)
   X0(I,R)     PRODUCTION                                ('000 TONS)
   C0(I,R)     TOTAL CONSUMPTION                         ('000 TONS)
   HC0(H,I,R)  CONSUMPTION BY HOUSEHOLD H            ('000 TONS)
   MROW0(I,R)     IMPORTS                            ('000 TONS)
   MREG0(I,R,R2) REGIONAL TRADE (IMPORTS)            ('000 TONS)
   EROW0(I,R)     EXPORTS                            ('000 TONS)
   IVTGOV0(I,R) INVESTMENT AND GOV SPENDING              (Bn Meticais)
   YH0(H,R)    HOUSEHOLD INCOME                          (Bn Meticais)
   YHAG0(H,R)  HOUSEHOLD AGRICULTURE INCOME              (Bn Meticais)
   YHNAG0(H,R) HOUSEHOLD NON-AGRICULTURAL INCOME         (Bn Meticais)
   ER0       REAL EXCHANGE RATE BASE                 (Meticais per $)
   CHPRSTK0(I,R)  CHANGE IN PRIVATE STOCKS               ('000 TONS)
   BSTK(I,R)     PRICE RESPONSIVENESS OF STOCK PARAMETER    (UNITY)
   GOVIMP0(I,R)   GOVERNMENT IMPORTS                     ('000 TONS)
   GOVPROC0(I,R)  GOVERNMENT DOMESTIC PROCUREMENT        ('000 TONS)
   OFFTAKE0(I,R)  DISTRIBUTION FROM GOVT STOCK           ('000 TONS)
   VA(I,H,R)  VALUE ADDED BY ACTIVITY BY HOUSEHOLD          (UNITY)
   CALKG(I) calories per gram of commodity i        (KCALS PER GRAM)
   CAL(H,I,R)  calories from commodity i                    (KCALS)
   CAL0(H,I,R) initial calories for commodity i             (KCALS)
   CALAVG0(I,R) average national calories per person per day (KCALS)
   TOTCAL0(H,R) total initial calories per household group  (KCALS)
   TOTCAL(H,R)  total calories per household group          (KCALS)
   POP(H,R)    POPULATION OF HOUSEHOLD TYPE H                 ('000)
   TOTPOP(R)      TOTAL POPULATION OF REGION R                ('000)
;
SCALAR
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ER0       EXCHANGE RATE                               / 25 /
Y0        NATIONAL INCOME          (million dollars)  / 2746 /
YAG0      AGRICULTURAL INCOME      (million dollars)  / 523 /
YNAG0     NON-AGRICULTURAL INCOME  (million dollars)  / 2222 /

TABLE ZZ(*,I) NATIONAL INCOME BY ACTIVITY  (million dollars)
        MAIZE      CASS      RICE    WHEAT     OAGRIC      INDUST     SERVICES
Y0        173       309        41        0        849        1374         2952
;

TABLE YH0(H,R) BASE LEVEL HOUSEHOLD INCOME (million dollars)
        NORTH        SOUTH
H-REM     311          359
H-RUR     933         1077
H-URB    1056         1962
;

TABLE POPULATION (H,R) POPULATION OF HOUSEHOLD GROUP H IN REGION R ('thousands)
             NORTH        SOUTH
H-REM         1967         1059
H-RUR         5900         3177
H-URB         2473         4593
;

TABLE ZZNORTH (*,I) INITIAL PRODUCTION AND PRICES
        MAIZE      CASS      RICE    WHEAT     OAGRIC      INDUST     SERVICES
PU0       168       126       300      137       1250        1000         1000
PR0       141       105       252      171       1000        1250         1000
PMROW0    140       200       100      100        100         100          100
PEROW0    100        40        20       20         20          20           20
XPROD     685      1365       147        0          0           0            0
IMPORTS     0         0       201      141          0           0            0
EXPORTS    13         0         0        2          0           0            0
IVTGOV      0         0         0        0          0           0            0
FEED      152         0        71        0          0           0            0
LOSS      0.1      0.26       0.1      0.1        0.1           0            0
TM          0         0         0        0          0           0            0
BSTK        1         1         1        1          1           1            1
;

TABLE ZZSOUTH (*,I) INITIAL PRODUCTION AND PRICES
        MAIZE      CASS      RICE    WHEAT     OAGRIC      INDUST     SERVICES
PU0       228       170       407      186       1250        1000         1000
PR0       155       116       277      232       1000        1250         1000
PMROW0    140       200       100      100        100         100          100
PEROW0    100        40        20       20         20          20           20
XPROD     752       238        31        2          0           0            0
IMPORTS    63         0       159      367          0           0            0
EXPORTS     0         0         0        0          0           0            0
IVTGOV      0         0         0        0          0           0            0
FEED      167         0        15      218          0           0            0
LOSS      0.1      0.26       0.1      0.1        0.1           0            0
TM          0         0         0        0          0           0            0
BSTK        1         1         1        1          1           1            1
;

TABLE PRODNORTH (H,I) AGRICULTURAL PRODUCTION ('000 TONS)
        MAIZE        CASS        RICE        WHEAT        OAGRIC
H-REM     171         341          37            0           104
H-RUR     513        1024         110            0           311
H-URB       0           0           0            0             0
;

TABLE PRODSOUTH (H,I) AGRICULTURAL PRODUCTION ('000 TONS)
        MAIZE        CASS        RICE        WHEAT        OAGRIC
H-REM     188          59           8            1           108
H-RUR     564         178          23            2           325
H-URB       0           0           0            0             0
;

TABLE HCN(H,I) QUANTITIES CONSUMED IN THE NORTH ('000 TONS)
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```
          MAIZE       CASS      RICE    WHEAT    OAGRIC    INDUST   SERVICES
H-REM        82        164        22        5        42        53        118
H-RUR       245        491        65       16       125       158        353
H-URB       124        358       175      118       119       301        674
;

TABLE HCS(H,I) QUANTITIES CONSUMED IN THE SOUTH ('000 TONS)
          MAIZE       CASS      RICE    WHEAT    OAGRIC    INDUST   SERVICES
H-REM       104         29        14        6        69        62        139
H-RUR       311         86        43       18       207       186        416
H-URB       157         62       114      127       287       559       1252
;

TABLE ZZPRICE_S(*,I) MARKET PRICES IN SOUTH  (dollars per ton)
            MAIZE     CASS         RICE     WHEAT    OAGRIC   INDUST  SERVICES
REM-PR0       155      116          277       232      1000     1250      1000
RUR-PR0       155      116          277       232      1000     1250      1000
URB-PU0       228      170          407       186      1250     1000      1000;

TABLE ZZPRICE_N(*,I) MARKET PRICES IN NORTH (dollars per ton)
            MAIZE     CASS         RICE     WHEAT    OAGRIC   INDUST  SERVICES
REM-PR0       141      105          252       171      1000     1250      1000
RUR-PR0       141      105          252       171      1000     1250      1000
URB-PU0       168      126          300       137      1250     1000      1000
;

TABLE ZZEXP_S(*,I) (dollars)
        MAIZE        CASS         RICE    WHEAT    OAGRIC     INDUST   SERVICES
H-REM    16.1         3.3          4.0      1.4      68.9       77.5      138.8
H-RUR    48.4        10.0         11.9      4.1     206.7      232.5      416.4
H-URB    35.8        10.6         46.5     23.7     358.8      559.3     1252.0
;

TABLE ZZEXP_N(*,I) (dollars)
        MAIZE        CASS         RICE    WHEAT    OAGRIC     INDUST   SERVICES
H-REM    11.5        17.3          5.5      0.9      41.7       65.8      117.8
H-RUR    34.6        51.8         16.5      2.8     125.0      197.3      353.3
H-URB    20.8        44.9         52.4     16.1     148.9      301.1      674.2

TABLE ES1(I,J) ELASTICITY OF SUPPLY    (UNITY)
            MAIZE       CASS       RICE   WHEAT    OAGRIC   INDUST    SERVICES
MAIZE       0.200      0.000      0.000   0.000     0.000    0.000       0.000
CASS        0.000      2.000      0.000   0.000     0.000    0.000       0.000
RICE        0.000      0.000      0.300   0.000     0.000    0.000       0.000
WHEAT       0.000      0.000      0.000   0.300     0.000    0.000       0.000
OAGRIC      0.000      0.000      0.000   0.000     0.300    0.000       0.000
  ;
ES0(I,J,R) = ES1(I,J) ;
ES(I,J,R) = ES1(I,J) ;

* INCOME ELASTICITIES OF DEMAND BY HOUSEHOLD    (UNITY)
TABLE EY1(H,I)
            MAIZE       CASS       RICE   WHEAT    OAGRIC    INDUST   SERVICES
H-REM        0.50       0.10       0.70    0.80      1.00      1.20       1.00
H-RUR        0.50       0.10       0.70    0.80      1.00      1.20       1.00
H-URB        0.50       0.10       0.70    0.80      1.00      1.20       1.00
  ;
EY(H,I,R) = EY1(H,I) ;
* EY(H,I,R) = 1.0 ;

* Urban Poor (1st and 2nd quartiles)
* ED(I,J) I is quantity and J is price

TABLE ED1(I,J)   ELASTICITY OF DEMAND      (UNITY) RURAL NORTH
            MAIZE       CASS       RICE   WHEAT    OAGRIC   INDUST    SERVICES
MAIZE      -0.500      0.200      0.000   0.000     0.000   -0.300      -0.200
CASS        0.300     -0.200      0.000   0.000     0.000   -0.300      -0.200
RICE        0.100      0.000     -0.800   0.000     0.000   -0.100      -0.200
WHEAT       0.100          0      0.000  -0.800     0.000   -0.100      -0.200
OAGRIC      0.100          0      0.000   0.000    -0.800   -0.100      -0.200
INDUST      0.000          0      0.000   0.000     0.000   -1.000      -0.200
```

```
SERVICES    0.000          0      0.000   0.000     0.000    0.000      -1.000
;

TABLE ED2(I,J)   ELASTICITY OF DEMAND      (UNITY) URBAN NORTH
            MAIZE       CASS       RICE   WHEAT    OAGRIC   INDUST    SERVICES
MAIZE      -0.400      0.200      0.000   0.000     0.000   -0.300      -0.200
CASS        0.050     -0.200      0.000   0.000     0.000    0.200       0.250
RICE        0.100      0.000     -0.800   0.000     0.000    0.000      -0.100
WHEAT       0.100          0      0.000  -0.800     0.000    0.000      -0.100
OAGRIC      0.100          0      0.000   0.000    -0.800   -0.100      -0.200
INDUST      0.000          0      0.000   0.000     0.000   -1.000      -0.200
SERVICES    0.000          0      0.000   0.000     0.000    0.000      -1.000
;

ED(I,J,H,R) = ED1(I,J) ;
ED(I,J,"H-RUR","NORTH") = ED1(I,J) ;
ED(I,J,"H-REM","NORTH") = ED1(I,J) ;
ED(I,J,"H-URB","NORTH") = ED2(I,J) ;
VA("maize",RH,R) = 0.9;
VA("cass",RH,R) = 1.0;
VA("rice",RH,R) = 0.8;
VA("oagric",RH,R) = 1.0;
VA(I,UH,R) = 0.0;
PRODH(H,I,"NORTH") = PRODNORTH(H,I) ;
PRODH(H,I,"SOUTH") = PRODSOUTH(H,I) ;


* TABLE VA(I,H) VALUE ADDED COEFFICIENT BY ACTIVITY    (UNITY)
*           HN-REM     HN-RUR       HN-URB     HN-REM      HS-RUR HS-URB
* MAIZE      0.72       0.72         0.72       0.72        0.72
*  ;

PARAMETER CALKG(I) Calories per gram

/   MAIZE               3.4
    CASS                3.4
             /
;

PARAMETER POP(H,R)  POPULATION OF HOUSEHOLD H IN REGION R ;
POP(H,R) = 100 ;
TOTPOP(R) = SUM(H,POP(H,R)) ;

PU0(I,"north") = ZZNORTH("PU0",I)*ER0/1000 ;
PU0(I,"south") = ZZSOUTH("PU0",I)*ER0/1000 ;
PR0(I,"north") = ZZNORTH("PR0",I)*ER0/1000 ;
PR0(I,"south") = ZZSOUTH("PR0",I)*ER0/1000 ;
TM(I,"north") = ZZNORTH("TM",I)*ER0/1000 ;
TM(I,"south") = ZZSOUTH("TM",I)*ER0/1000 ;
IMARG0(I,R) = .1 ;
PMROW0(I,R) = PU0(I,R)/(1+IMARG0(I,R)) ;
PEROW0(I,R) = PU0(I,R) ;
PWMROW0(I,R) = PMROW0(I,R)/(ER0*(1+TM(I,R))) ;
PWEROW0(I,R) = PEROW0(I,R)/ER0 ;
DISPLAY PMROW0, PEROW0, PU0, PR0, IMARG0 ;

X0(I,"north") = sum(h,PRODH(H,I,"north") );
X0(I,"south") = sum(h,PRODH(H,I,"south") );
LOSS(I,"north") = ZZNORTH("LOSS",I) ;
LOSS(I,"south") = ZZSOUTH("LOSS",I) ;
PRODSHK(I,R) = 1.0 ;

* hc0 inputted as quantities
hc0(uh,i,"north") = hcn(uh,i)  ;
hc0(uh,i,"south") = hcs(uh,i) ;
hc0(rh,i,"north") = hcn(rh,i) ;
hc0(rh,i,"south") = hcs(rh,i) ;
C0(I,R) = SUM(H,HC0(H,I,R)) ;

MROW0(I,"north") = ZZNORTH("IMPORTS",I) ;
MROW0(I,"south") = ZZSOUTH("IMPORTS",I) ;
```

```
EROW0(I,"north") = ZZNORTH("EXPORTS",I) ;
EROW0(I,"south") = ZZSOUTH("EXPORTS",I) ;

MREG0(I,R,R2) = 0.0 ;
REGMARG0(I,R1,R2) =  PU0(I,R1) -   PU0(I,R2) ;
* REGMARG0(I,R1,R2) =  PU0(I,"SOUTH") -   PU0(I,"NORTH") ;
display REGMARG0 ;

CHPRSTK0(I,R) = 0 ;
GOVIMP0(I,R) = 0 ;
GOVPROC0(I,R)= 0 ;
OFFTAKE0(I,R) = 0 ;
* CHPRSTK0(I,r)= ZZ("CHPRSTK",I) ;
* GOVIMP0(I,r) = ZZ("GOVIMP",I) ;
* GOVPROC0(I,r) = ZZ("GOVPROC",I) ;
* OFFTAKE0(I,r)= -ZZ("OFFTAKE",I) ;

* IVTGOV0(I,R) = 0 ;
IVTGOV0(I,"north") = ZZNORTH("IVTGOV",I) ;
IVTGOV0(I,"south") = ZZSOUTH("IVTGOV",I) ;
* BALANCE THE COMMODITY ACCOUNTS USING EXGOENOUS GOVIVT AS RESIDUAL
IVTGOV0(I,R) = X0(I,R)*(1-LOSS(I,R)) - C0(I,R) + MROW0(I,R)
   - (GOVPROC0(I,R) + GOVIMP0(I,R) - OFFTAKE0(I,R)) - CHPRSTK0(I,R) ;

* MARG(I) = ZZ("MARGIN",I) ;
MARG0(I,R) = (PU0(I,R)/PR0(I,R) - 1)$PR0(I,R) ;
* BSTK(I,R) = ZZ("BSTK",I) ;
BSTK(I,R) = 0 ;

AGSHARE(I,UH,R) = 0 ;
AGSHARE(I,H,R) = (PRODH(H,I,R)/X0(I,R))$X0(I,R) ;
DISPLAY AGSHARE ;

YHAG0(H,R) = SUM(I,AGSHARE(I,H,R)*X0(I,R)*PR0(I,R)*VA(I,H,R)) ;
* CALCULATE HOUSEHOLD INCOMES AS EQUAL TO EXPENDITURES
YH0(H,R) = SUM(I,PR0(I,R)*HC0(H,I,R)) ;
YH0("H-URB",R) = SUM(I,PU0(I,R)*HC0("H-URB",I,R)) ;
YHNAG0(H,R) = YH0(H,R) - YHAG0(H,R) ;
YAG0 = SUM(H, SUM(R, YHAG0(H,R))) ;
YNAG0 = SUM(H, SUM(R, YHNAG0(H,R))) ;

Y0 = YAG0 + YNAG0 ;
DISPLAY MARG0, Y0, YAG0, YNAG0 ;
DISPLAY YH0, YHAG0, YHNAG0   ;
DISPLAY PMROW0, PU0, PR0, IMARG0, TM ;

parameter budshr(i,h,r), homogchk(i,h,r), engelchk(h,r), hhconval(h,r), ed0(i,j,h,r),
edchk1(i,h,r),
 edchk2(i,h,r), engel1(h,r), EY0(H,I,r) ;

* $ontext
* check Engel's Law

hhconval(uh,r) = sum(i,pu0(i,r)*hc0(uh,i,r)) ;
hhconval(rh,r) = sum(i,pr0(i,r)*hc0(rh,i,r)) ;
budshr(i,uh,r) = pu0(i,r)*hc0(uh,i,r) / hhconval(uh,r) ;
budshr(i,rh,r) = pr0(i,r)*hc0(rh,i,r) / hhconval(rh,r) ;
* ey(h,i,r) = 1 ;
ey(h,"SERVICES",r) = 0 ;
engel1(uh,r) = sum(i,pu0(i,r)*hc0(uh,i,r)*ey(uh,i,r))/hhconval(uh,r) ;
engel1(rh,r) = sum(i,pr0(i,r)*hc0(rh,i,r)*ey(rh,i,r))/hhconval(rh,r) ;
ey(uh,"SERVICES",r) = (1 - engel1(uh,r))
    /(pu0("services",r)*hc0(uh,"SERVICES",r)/hhconval(uh,r));
ey(rh,"SERVICES",r) = (1 - engel1(rh,r))
    /(pr0("services",r)*hc0(rh,"SERVICES",r)/hhconval(rh,r));
* ey(h,"othfood") = (1 - engel1(h))
*    /((hc0(h,"othfood"))/hhconval(h));
engelchk(uh,r) = sum(i,pu0(i,r)*hc0(uh,i,r)*ey(uh,i,r)/hhconval(uh,r)) ;
engelchk(rh,r) = sum(i,pr0(i,r)*hc0(rh,i,r)*ey(rh,i,r)/hhconval(rh,r)) ;
display engel1, engelchk, ey, budshr  ;
* Note that symmetry is not imposed
```

```
* check homogeneity
homogchk(i,h,r) = sum(j,ed(i,j,h,r)) + ey(h,i,r) ;
display homogchk ;
ED0(I,J,H,r) = ED(I,J,H,r)  ;
ED(I,"SERVICES",H,r) = 0 - SUM(J,ED0(I,J,H,r)) + ED0(I,"SERVICES",H,r) - EY(H,I,r) ;
homogchk(i,h,r) = sum(j,ed(i,j,h,r)) + ey(h,i,r) ;
display HOMOGCHK ;
display ed ;

* $offtext

$ontext
* convert food quantities into kilocalories
CAL0(H,I) = (CALKG(I)*HC0(H,I)*1000000/365)/POP(H)  ;
* units: (kcal/g)*(10^12 g/year)*(1/365 days/years)/(10^6 persons)
* equals kcal/person/day
TOTCAL0(H) = SUM(I,CAL0(H,I))  ;
CALAVG0(I) = (CALKG(I)*C0(I)*1000000/365)/(SUM (H,POP(H)) ) ;
DISPLAY HC0, CAL0, CALAVG0, TOTCAL0  ;
$offtext

totcons(r) = sum(i, pu0(i,r)*sum(uh,hc0(uh,i,r))
                + pr0(i,r)*sum(rh,hc0(rh,i,r)) ) ;
pcwt(i,r) = ( pu0(i,r)*sum(uh,hc0(uh,i,r))
               +   pr0(i,r)*sum(rh,hc0(rh,i,r)) )  / totcons(r) ;
display totcons, pcwt ;


TABLE SECTRES(*,I,R)   SECTORAL VARIABLES RESULTS
            MAIZE.NORTH    MAIZE.SOUTH
PW
PM
PC
PP
MARG
IMARG
TM
GOVIMP
IMPORTS
CHPRSTK
ENDSTK
XPROD
CONS

IVTGOV
GOVPROC
OFFTAKE
;


PARAMETER HCRES(H,I,R)  household consumption results
          CALRES(H,I,R)  calorie consumption results
          TOTCALRES(H,R) total hh calorie cons. results
          PRODHRES(H,I,R)   household production results ;

TABLE           YHRES(*,H,R)   HOUSEHOLD VARIABLES RESULTS
         h-urb.north  h-rur.north  h-rem.north h-urb.south h-rur.south h-rem.south
 YH
 YHAG
 YHNAG
 ;


*DEFINITION OF MODEL - VARIABLES
 VARIABLES

*PRICE BLOCK
   PU(I,R)    CONSUMER (URBAN) PRICE                  (Meticais per kg)
   PR(I,R)    PRODUCER (RURAL) PRICE                  (Meticais per kg)
   PMROW(I,R)    IMPORT EXPORT PRICE                   (Meticais per kg)
```

```
   PEROW(I,R)    EXPORT) PRICE                   (Meticais per kg)
   PWMROW(I,R)    WORLD PRICE                               ($ per ton)
   PWEROW(I,R)    WORLD PRICE                               ($ per ton)
   pindex(R)  consumer price index                      (unity)
   IMARG(I,R)  MARKETING MARGIN ON IMPORTS OR EXPORTS       (UNITY)
   MARG(I,R)  DOMESTIC MARKETING MARGIN                    (UNITY)
*COMMODITY FLOWS
   X(I,R)     PRODUCTION                                (MILLION TONS)
   C(I,R)     TOTAL CONSUMPTION                         (MILLION TONS)
   HC(H,I,R)  HOUSEHOLD CONSUMPTION                     (MILLION TONS)
   IVTGOV(I,R) INVESTMENT AND GOVERNMENT SPENDING       (Bn Meticais)
   M(I,R)     IMPORTS (NEGATIVE EXPORTS)                (MILLION TONS)
   MREG(I,R,R2) REGIONAL TRADE (IMPORTS)            (MILLION TONS)
   CHPRSTK(I,R)  CHANGE IN PRIVATE STOCKS               (MILLION TONS)
   GOVIMP(I,R)  GOVERNMENT IMPORTS                      (MILLION TONS)
   GOVPROC(I,R) GOVERNMENT DOMESTIC PROCUREMENT         (MILLION TONS)

   OFFTAKE(I,R)  DISTRIBUTION FROM GOVT STOCK           (MILLION TONS)
*INCOMES, ETC.
*   Y(R)        NATIONAL INCOME                           (Bn Meticais)
   YH(H,R)    HOUSEHOLD INCOME                          (Bn Meticais)
   YHAG(H,R)  HOUSEHOLD AGRICULTURAL INCOME             (Bn Meticais)
   YHNAG(H,R) HOUSEHOLD NON-AGRICULTURAL INCOME         (Bn Meticais)
   ER       EXCHANGE RATE                       ('000 Meticais per $)
*OBJECTIVE FUNCTION
   OMEGA    OBJECTIVE FUNCTION                        (Bn Meticais) ;

* PC.LO(I) = .01; PP.LO(I) = .01 ; PM.LO(IM) =.01;

* MODEL DEFINITION - EQUATIONS
 EQUATIONS
*PRICE BLOCK
   PMROWDEF(I,R)      DEFIN OF IMPORT PRICE     (Meticais per kg)
   PEROWDEF(I,R)      DEFIN OF EXPORT PRICE     (Meticais per kg)
   PRDEF(I,R)      DEFIN OF PRODUCER PRICE            (Meticais per kg)
   PUDEF(I,R)      DEFIN OF CONSUMER PRICE            (Meticais per kg)
   PUREGDEF(I,R,R2)  PRICE LINK OF GOODS REGIONALLY INTEGRATED (Meticais per kg)
   pindxdef(R)      defin of consumer price index            (unity)
*COMMODITY FLOWS
   XDEF(I,R)          PRODUCTION EQUATION               (MILLION TONS)
   CONDEF(I,R)        CONSUMPTION EQUATION              (MILLION TONS)
   UHCONDEF(H,I,R)     HOUSEHOLD CONSUMPTION EQUATION    (MILLION TONS)
   RHCONDEF(H,I,R)    RURAL HOUSEHOLD CONSUMPTION EQN   (MILLION TONS)
   TRADE(I,R)         TRADE EQUATION                    (MILLION TONS)
   EQUIL(I,R)         EQUILIBRIUM EQUATION              (MILLION TONS)
   EQUIL2(I,R,R2)      EQUILIBRIUM EQUATION REGIONAL GOODS (MILLION TONS)
*INCOMES,ETC.
   YHDEF(H,R)         HOUSEHOLD INCOME EQUATION           (Bn Meticais)
   YHAGDEF(H,R)       AG INCOME EQUATION                  (Bn Meticais)
*OBJECTIVE FUNCTION
   OBJ              OBJECTIVE FUNCTION                        ;
*MODEL DEFINITION - PRICE BLOCK

* PMROWDEF(IT,R)..   PMROW(IT,R) =E= PWMROW(IT,R)*ER*(1 + TM(IT,R)) ;
 PMROWDEF(IMR)..   PMROW(IMR) =E= PWMROW(IMR)*ER*(1 + TM(IMR)) ;
 PEROWDEF(IT,R)..  PEROW(IT,R) =E= PWEROW(IT,R)*ER*(1 + TM(IT,R)) ;
 PRDEF(I,R)..    PR(I,R) =E= PU(I,R) / (1 + MARG(I,R)) ;
 PUDEF(IMR)..   PU(IMR) =E= PMROW(IMR) * (1 + IMARG(IMR));
 PUREGDEF(I,R1,R2)$IREG2(I,R1,R2)..  PU(I,R1) =E= PU(I,R2)+ REGMARG0(I,R1,R2) ;
*    + REGMARG0("maize","north","south")*PU("services","north");

* PUDEF(IT,R)..   PU(IT,R) =E= PMROW(IT,R) * (1 + IMARG(IT,R));
** PUDEF DETERMINES CONS PRICE OF TRADED GOODS
** IF IMPORTS ARE FIXED, IMARGS ARE ENDOGENOUS AND INCLUDE RENTS

 pindxdef(r)..  pindex(r) =e= sum(i,pcwt(i,r)*pu(i,r)/pu0(i,r) ) ;
**PNT IS THE NUMERAIRE OF THE MODEL
** AND IS FIXED THROUGH IMPLICIT FISCAL AND MONETARY POLICIES

 XDEF(I,R)..    X(I,R) =E= X0(I,R) * PRODSHK(I,R)
    * PROD(J, (PR(J,R)/PR0(J,R)) **ES(I,J,R) )  ;
```

```
 CONDEF(I,R)..   C(I,R) =E= SUM(H, HC(H,I,R)) ;
 UHCONDEF(UH,I,R)..  HC(UH,I,R) =E= HC0(UH,I,R)
          * PROD(J,(PU(J,R)/PU0(J,R))**ED(I,J,UH,R)  )
          * (YH(UH,R)/YH0(UH,R))**EY(UH,I,R) ;

 RHCONDEF(RH,I,R)..  HC(RH,I,R) =E= HC0(RH,I,R)

          * prod(J,(PR(J,R)/PR0(J,R))**ED(I,J,RH,R)  )
              * (YH(RH,R)/YH0(RH,R))**EY(RH,I,R) ;

* TRADE(IT,R)..  M(IT,R) =E= M0(IT,R) * (1+EM(IT,R)*(PW(IT,R)/PW0(IT,R)-1)) ;
**IF EM IS EQUAL TO INFINITY THEN WORLD PRICE OF IMPORTS IS FIXED


 YHDEF(H,R)..     YH(H,R) =E= YHAG(H,R)
                        + YHNAG(H,R) * yhnagshk(h,r) ;
*                        + YHNAG(H,R)*PINDEX(R)/PINDEX0(R) ;
*                        + YHNAG(H,R)*PU("SERVICES",R)/PU0("SERVICES",R) ;

 YHAGDEF(H,R)..

       YHAG(H,R) =E= SUM(I, AGSHARE(I,H,R)*PR(I,R)*X(I,R)*VA(I,H,R) ) ;

*MARKET CLEARING
* EQUIL(I,R)..   X(I,R)*(1-LOSS(I,R)) =E= C(I,R)+IVTGOV(I,R) - M(I,R)
*       + GOVPROC(I,R) + GOVIMP(I,R) - OFFTAKE(I,R) + CHPRSTK(I,R) ;

EQUIL(INDR)..   X(INDR)*(1-LOSS(INDR)) =E= C(INDR)+IVTGOV(INDR) - M(INDR)
       + GOVPROC(INDR) + GOVIMP(INDR) - OFFTAKE(INDR) + CHPRSTK(INDR) ;

EQUIL2(I,R1,R2)$IREG2(I,R1,R2)..   X(I,R1)*(1-LOSS(I,R1)) + X(I,R2)*(1-LOSS(I,R2))
  =E= C(I,R1)+IVTGOV(I,R1) - M(I,R1)
           + GOVPROC(I,R1) + GOVIMP(I,R1) - OFFTAKE(I,R1) + CHPRSTK(I,R1)
    + C(I,R2)+IVTGOV(I,R2) - M(I,R2)
           + GOVPROC(I,R2) + GOVIMP(I,R2) - OFFTAKE(I,R2) + CHPRSTK(I,R2);

* EQUIL(I,R)..   X(I,R)*(1-LOSS(I,R)) =E= C(I,R)+IVTGOV(I,R) - M(I,R) -
sum(R2,MREG(I,R,R2))
*       + GOVPROC(I,R) + GOVIMP(I,R) - OFFTAKE(I,R) + CHPRSTK(I,R) ;

* EQUIL(IREG2)..   sum(,X(INTI,INTR)*(1-LOSS(INTI,INTR)) ) =E=
*    SUM(INTR,   C(INTI,INTR) + IVTGOV(INTI,INTR) - M(INTI,INTR)
*      + GOVPROC(INTI,INTR) + GOVIMP(INTI,INTR) - OFFTAKE(INTI,INTR)
*      + CHPRSTK(INTI,INTR) ) ;

 OBJ..          OMEGA =E= YH("H-URB","NORTH") ;
* OBJ..          OMEGA =E= 10 ;

*MODEL SETUP - INITIALIZATION
ER.L = ER0 ;
PINDEX0(R) = 1.0 ;
pindex.l(r) = pindex0(r) ;
pwmrow.l(i,r) = pwmrow0(i,r) ;
pwerow.l(i,r) = pwerow0(i,r) ;
pmrow.l(i,r) = pmrow0(i,r) ;
perow.l(i,r) = perow0(i,r) ;
pu.l(i,r) = pu0(i,r);
pr.l(i,r) = pr0(i,r);
MARG.L(I,R) = MARG0(I,R) ;
IMARG.L(I,R) = IMARG0(I,R) ;
X.L(I,R) = X0(I,R) ;
C.L(I,R) = C0(I,R) ;
M.L(I,R) = MROW0(I,R) ;
MREG.L(I,R,R2) = MREG0(I,R,R2) ;
HC.L(H,I,R) = HC0(H,I,R) ;
GOVPROC.L(I,R) = GOVPROC0(I,R) ;
GOVIMP.L(I,R) = GOVIMP0(I,R) ;
OFFTAKE.L(I,R) = OFFTAKE0(I,R) ;
CHPRSTK.L(I,R) = CHPRSTK0(I,R) ;
IVTGOV.L(I,R) = IVTGOV0(I,R) ;
```

```
YHNAG.L(H,R) = YHNAG0(H,R);
YHAG.L(H,R) = YHAG0(H,R);
YH.L(H,R) = YH0(H,R) ;
omega.L = YH.L("H-URB","NORTH") ;
* REGMARG0(I,R,R2) = 0 ;
*omega.L = 10;

parameter  wt(h,i,r)   consumer price index weight  (unity)
           totexp(h,r) total household expenditure  (unity) ;

totexp(uh,r) = sum(i,pu0(i,r)*hc0(uh,i,r)) ;
wt(uh,i,r) = pu0(i,r)*hc0(uh,i,r)/totexp(uh,r) ;
totexp(rh,r) = sum(i,pr0(i,r)*hc0(rh,i,r)) ;
wt(rh,i,r) = pr0(i,r)*hc0(rh,i,r)/totexp(rh,r) ;
display totexp,wt ;

PARAMETER CHECKY(H) ;
PARAMETER  PUGR(I,R,*) URBAN PRICE CHANGE   (PERCENT)
           PRGR(I,R,*) RURAL PRICE CHANGE   (PERCENT)
           PWGR(I,R,*) WORLD PRICE CHANGE      (PERCENT)
           XGR(I,R,*)  PRODUCTION CHANGE       (PERCENT)
           CGR(I,R,*)  CONSUMPTION CHANGE      (PERCENT)
           CHGR(H,I,R,*) HOUSEHOLD CONSUMPTION CHANGE (PERCENT)
           ABSCC(I,R) abs change in cons. ('000 mt)
           ABSCHC(H,I,R) abs change HH cons ('000 mt)

           CALGR(H,I,R)  growth in calorie consumption  (percent)
           TOTCALGR(H,R) growth in household cal. cons. (percent)
           MGR(I,R,*)  TRADE CHANGE AS PCT OF BASE CONS (PERCENT)
           YGR(H,R)    INCOME CHANGE           (PERCENT)
parameter  cpi(h,R)    consumer price index         (unity)
           YABSCH(H,R) absolute change in household income -- Y2 (BN Meticais)
           YRABSCH(H,R) absolute change in real hh income -- Y2 (BN Meticais)
           YRGR(H,R)   real income change -- Y2       (unity)


           YHRABSCH(H,R) absolute change in real income -- YH (Bn Meticais)
           YHRGR(H,R)  real income -- YH change (Percent)
           SHOCK(*,I,R) PRODUCTION SHOCK                     (UNITY)
           DSHOCK(*,I,R)  EXOGENOUS DEMAND SHOCK               ('000 TONS)
           yhnagshock(*,h,r) Exogenous shock to yhnag       (UNITY)
           es_shock(*,i,j,r) Changes to elasticities of supply (unity) ;
set
  sim   simulations
    / base, S1-mz-north, S2-mz-n-rnag, S3-Dmz-north, S4-Malawi-100 /;
* S2-mz-natl,


** CLOSURE

** if tradable and fixed imports, then imarg must be variable
** if tradable and endogenous imports, then imarg (=mktg margin) is fixed
** if non-tradable and fixed imports, imarg does not enter model

* Exogenous Variables
ER.FX = ER0 ;
PWMROW.FX(I,R) = PWMROW0(I,R);
PWEROW.FX(I,R) = PWEROW0(I,R);
CHPRSTK.FX(I,R) = CHPRSTK0(I,R) ;
GOVIMP.FX(I,R) = GOVIMP0(I,R) ;
GOVPROC.FX(I,R) = GOVPROC0(I,R);
OFFTAKE.FX(I,R) = OFFTAKE0(I,R) ;
IVTGOV.FX(I,R) = IVTGOV0(I,R) ;
MARG.FX(I,R) = MARG0(I,R) ;
IMARG.FX(I,R) = IMARG0(I,R) ;
YHNAG.FX(H,R) = YHNAG0(H,R) ;
* ENDSTOCK0(I,R) = ENDSTK0(I,R) ;

* Closure for Tradeable Goods: Fix PW (above, via PW(I)) and
* fix PC (via eqtn PC(IT)..); But let M vary:
M.FX(I,R) = MROW0(I,R) ;
```

```
M.LO(IT,R)=-INF; M.UP(IT,R)=+INF;
* MREG.FX(I,R,R2) = MREG0(I,R,R2) ;
* MREG.LO("maize","south","north") = -INF ;
* MREG.UP("maize","south","north") = +INF ;
* REGMARG0("maize","north","south") = 0.2 * PU0("maize","north") ;

* Must fix imports of one sub-region if commodity is in integrated basin
M.FX("maize","north") = MROW0("maize","north") ;
* M.FX("indust","north") = MROW0("indust","north") ;

$ontext
* Closure for Nonfoods: Fix X, PC; let M vary
* The following restrictions are redundant if all elasticities of supply are 0
X.FX("INDUST",R) = X0("INDUST",R) ;
X.FX("SERVICES",R) = X0("SERVICES",R) ;
* PU.FX("INDUST",R) = PU0("INDUST",R) ;
* PU.FX("SERVICES",R) = PU0("SERVICES",R) ;
M.LO("INDUST",R)=-INF; M.UP("INDUST",R)=+INF;
M.LO("SERVICES",R)=-INF; M.UP("SERVICES",R)=+INF;
$offtext

** SIMULATIONS
* PRODSHK("base",I,R) = 1.0 in base

* EY(H,I,R)
* EY(H,I,R) = 0 ;
* ED0(I,J,H,R) = ED(I,J,H,R);
* ED(I,J,H,R) = 0 ;
* ED("maize",J,H,"north") = ED0("maize",J,H,"north") ;
* ED("maize",J,H,"north") = -0.5 ;
* Make production exogenous for all products except cassava
es_shock(sim,i,j,r) = 0.0 ;
es_shock(sim,"cass",j,r) = 1.0 ;
* Use original elasticities of supply for some sims
es_shock("S4-Malawi-100",i,j,r) = 1.0 ;
* es(i,j,r) = 0.0 ;
* es("maize","maize","north") = 0.2 ;
* es("cass","cass","north") = 2.0 ;
SHOCK(sim,I,R) = 1.0 ;
SHOCK("base",I,R) = 1.0 ;
SHOCK("S1-mz-north","maize","north") = 0.9 ;
SHOCK("S2-mz-n-rnag","maize","north") = 0.9 ;
SHOCK("S2-mz-n-rnag","oagric","north") = 0.9 ;
yhnagshock(sim,h,r) = 1.0 ;
yhnagshock("S2-mz-n-rnag",rh,"north") = 0.9 ;
* SHOCK("S2-mz-natl","maize",R) = 0.9 ;
DSHOCK(sim,I,R) = 0 ;
DSHOCK("base",I,R) = 0 ;
DSHOCK("S3-Dmz-north","maize","north") = 40 ;
DSHOCK("S4-Malawi-100","maize","north") = 100 ;


**PUT CODE**
FILE SOL /'N:\FEU\SPATIAL\Dorosh\Africa\Trade and Food Security\MozMM1out.PRN'/;
PUT SOL ;
SOL.PC = 5 ;
* COMMA DELIMITED FORMAT
* IMPORT FILE INTO LOTUS USING "NUMBERS" OPTION

* MODEL 1 FIXES REAL NON-AG INCOMES (DEFLATED BY PU("services",r)
* and fixes pc("non-ag") using simple ("no macro") closure
* and fixes ag production
** NOTE THAT SOME TRADABLE GOODS SHOW M0=0 IN BASE DATA, SO
**  "TRADE" EQN DOES NOT FIX PW FOR THESE GOODS


MODEL MOZMM1  MODEL /
  PRDEF, PUDEF, PMROWDEF, PEROWDEF, pindxdef,
  XDEF,
  CONDEF, UHCONDEF, RHCONDEF, EQUIL,
  EQUIL2,  PUREGDEF,
```

```
  YHDEF, YHAGDEF,
* TRADE,
*  PUREG1,
  OBJ / ;

OPTIONS ITERLIM=200, LIMROW=8, LIMCOL=8 ;
* OPTIONS ITERLIM=1, LIMROW=20, LIMCOL=20 ;
* OPTION NLP = MINOS ;
OPTION NLP = conopt ;

loop(sim,
es(i,j,r) = es0(i,j,r) * es_shock(sim,i,j,r) ;
* es(i,j,r) = 0.0 ;
* es("maize","maize","north") = 0.2 ;
* es("cass","cass","north") = 2.0 ;
prodshk(I,R) = SHOCK(sim,I,R) ;
GOVPROC.fx(I,R) = GOVPROC0(I,R) ;
GOVPROC.fx(I,R) = GOVPROC0(I,R) + dshock(sim,I,R) ;
yhnagshk(h,r) = yhnagshock(sim,h,r) ;
display prodshk, shock, govproc.l ;

SOLVE MOZMM1 MINIMIZING OMEGA USING NLP ;
* OPTIONS SOLPRINT=OFF ;

* STORE RESULTS *
SECTRES("PU",I,R) = PU.L(I,R) ;
SECTRES("PR",I,R) = PR.L(I,R) ;
SECTRES("PMROW",I,R) = PMROW.L(I,R) ;
SECTRES("XPROD",I,R) = X.L(I,R) ;

SECTRES("CONS",I,R) = C.L(I,R) ;
SECTRES("IVTGOV",I,R) = IVTGOV.L(I,R) ;
SECTRES("IMPORTS",I,R) = M.L(I,R) ;
SECTRES("TM",I,R) = TM(I,R) ;
SECTRES("CHPRSTK",I,R) = CHPRSTK.L(I,R) ;
* SECTRES("ENDSTK",I,R) = ENDSTOCK.L(I,R) ;
SECTRES("GOVIMP",I,R) = GOVIMP.L(I,R) ;
SECTRES("GOVPROC",I,R) = GOVPROC.L(I,R) ;
SECTRES("OFFTAKE",I,R) = OFFTAKE.L(I,R) ;
SECTRES("MARG",I,R) = MARG.L(I,R) ;
SECTRES("IMARG",I,R) = IMARG.L(I,R) ;
HCRES(H,I,R) = HC.L(H,I,R) ;
YHRES("YH",H,R) = YH.L(H,R) ;
YHRES("YHAG",H,R) = YHAG.L(H,R) ;
YHRES("YHNAG",H,R) = YHNAG.L(H,R) ;

PUGR(I,R,"URBAN PRICE") =100*(pu.l(i,r)/pu0(i,r) - 1)$pu0(i,r) ;
PRGR(I,R,"RURAL PRICE") =100*(pr.l(i,r)/pr0(i,r) - 1)$pr0(i,r) ;
XGR(I,R,"PROD") = 100*(x.l(i,r)/x0(i,r) - 1)$x0(i,r) ;
CGR(I,R,"CONS") = 100*(c.l(i,r)/c0(i,r) - 1)$c0(i,r) ;
CHGR(H,I,R,"HHCONS") = 100*(hc.l(h,i,r)/hc0(h,i,r) - 1)$hc0(h,i,r) ;
MGR(I,R,"IMPORTS") = (100*(m.l(i,r)-mrow0(i,r))/c0(i,r))$c0(i,r) ;
YGR(H,R) = 100*(yh.l(h,r)/yh0(h,r)-1)$yh0(h,r) ;
YRGR(H,R) = 100*( (yh.l(h,r)/pindex.l(r))/(yh0(h,r)/pindex0(r)) -1)$yh0(h,r);

* PRINT RESULTS
DISPLAY X0, X.L ;
DISPLAY IMARG.L,pmrow.l ;
DISPLAY ER.L, pindex.l ;
display yhag.l, yhag0, yhnag.l, yhnag0, yh.l, yh0   ;
DISPLAY HC0,  HC.L, m.l, mrow0, pu.l, pu0   ;
DISPLAY PUGR, PRGR, XGR, CGR, CHGR, MGR, YGR, YRGR ;

*end of main loop
* );


*$ONTEXT
**PUT CODE**
PUT // ;
PUT  ' ', SIM.TL, PUT / ;
```

```
PUT /, PUT '','Prod N', PUT // ;
LOOP(I, PUT I.TL, XGR(I,"north","PROD"):11:2, PUT/ ) ;

PUT /, PUT '','Prod S', PUT // ;
LOOP(I, PUT I.TL, XGR(I,"south","PROD"):11:2, PUT/ ) ;

PUT /, PUT '','Urban Price N', PUT // ;
LOOP(I, PUT I.TL, PUGR(I,"north","URBAN PRICE"):11:2, PUT/ ) ;

PUT /, PUT '','Urban Price S', PUT // ;
LOOP(I, PUT I.TL, PUGR(I,"south","URBAN PRICE"):11:2, PUT/ ) ;

PUT /, PUT ' ','Household Consumption N', PUT // ;
LOOP(I, PUT I.TL, PUT / ;
LOOP(H, PUT H.TL, CHGR(H,I,"north", "HHCONS"):11:3, PUT/)  ) ;

PUT /, PUT ' ','Household Consumption S', PUT // ;
LOOP(I, PUT I.TL, PUT / ;
LOOP(H, PUT H.TL, CHGR(H,I,"south", "HHCONS"):11:3, PUT/)  ) ;

* PUT ' ','Change in Consumer Price', PUT // ;
* LOOP(I, PUT I.TL, PCGRTP(SIM,I,"CONS PRICE"):11:3, PUT/ ) ;

PUT /, PUT '','Trade N', PUT // ;
LOOP(I, PUT I.TL, MGR(I,"north","IMPORTS"):11:2, PUT/ ) ;

PUT /, PUT '','Trade S', PUT // ;
LOOP(I, PUT I.TL, MGR(I,"south","IMPORTS"):11:2, PUT/ ) ;

**END OF PUT CODE**
*end of main loop
 );

* $OFFTEXT
* END OF FILE
```

Annex 2.

Baseline Data

Table A.2.1. Baseline Population and Income Data

	Population ('000)	Income (US$ millions)	Per Capita Income
Northern Mozambique	10,340	2,300	222
remote	1,967	311	158
rural	5,900	933	158
urban	2,473	1,056	427
Southern Mozambique	8,829	3,398	385
remote	1,059	359	339
rural	3,177	1,077	339
urban	4,593	1,962	427
Malawi	12,894	2,625	204
remote	1,068	145	135
rural	9,613	1,304	136
urban	2,212	1,177	532
Northern Zambia	5,338	2,385	447
remote	750	217	290
rural	2,251	653	290
urban	2,337	1,514	648
Southern Zambia	5,932	3,056	515
remote	1,039	309	298
rural	3,117	928	298
urban	1,776	1,819	1,024

Table A.2.2. Baseline Production Data

	Commodities						
	maize	cassava	rice	wheat	other ag	industry	services
Production ('000 tons)							
Northern Mozambique	685	5,461	147	0	415	481	1,033
remote	171	1,365	37	0	104	24	90
rural	513	4,096	110	0	311	72	271
urban	0	0	0	0	0	385	672
Southern Mozambique	752	952	31	2	433	893	1,919
remote	188	238	8	1	108	45	168
rural	564	714	23	2	325	134	504
urban	0	0	0	0	0	714	1,247
Malawi	1,733	1,905	50	2	934	454	1,167
remote	147	161	4	0	82	15	45
rural	1,321	1,452	38	1	735	136	405
urban	265	291	8	0	118	302	718
Northern Zambia	390	945	6	48	518	672	1,193
remote	97	236	2	12	129	28	60
rural	292	709	5	36	388	84	179
urban	0	0	0	0	0	560	954
Southern Zambia	824	12	5	71	834	807	1,433
remote	206	3	1	18	208	34	72
rural	618	9	4	54	625	101	215
urban	0	0	0	0	0	673	1,146

Table A.2.3. Baseline Consumption Data

	Commodities						
	maize	cassava	rice	wheat	other ag	industry	services
Consumption ('000 tons)							
Northern Mozambique	451	4,051	262	140	286	512	1,145
remote	82	655	22	5	42	53	118
rural	245	1,966	65	16	125	158	353
urban	124	1,430	175	118	119	301	674
Southern Mozambique	572	707	171	151	563	807	1,807
remote	104	114	14	6	69	62	139
rural	311	343	43	18	207	186	416
urban	157	249	114	127	287	559	1,252
Malawi	1,472	1,180	40	47	934	454	1,167
remote	122	97	3	3	68	31	65
rural	1,096	870	30	30	613	280	584
urban	254	214	7	14	254	143	518
Northern Zambia	367	832	10	45	455	574	1,018
remote	73	198	1	4	66	59	105
rural	219	594	4	13	199	177	314
urban	75	39	5	27	190	338	600
Southern Zambia	729	11	8	68	896	905	1,607
remote	145	3	1	7	110	70	123
rural	435	8	3	20	329	209	370
urban	148	0	4	41	457	627	1,113

Table A.2.4. Baseline Price Data

	Commodities						
	maize	cassava	rice	wheat	other ag	industry	services
Prices (US$ per ton)							
Northern Mozambique							
rural	141	53	252	171	1,000	1,250	1,000
urban	168	63	300	137	1,250	1,000	1,000
Southern Mozambique							
rural	155	58	277	232	1,000	1,250	1,000
urban	228	85	407	186	1,250	1,000	1,000
Malawi							
rural	106	21	240	438	1	1	1
urban	133	27	300	350	1	1	1
Northern Zambia							
rural	134	25	255	263	1	1	1
urban	168	32	319	210	1	1	1
Southern Zambia							
rural	118	51	225	525	1	1	1
urban	148	63	281	420	1	1	1