# *FOOD SECURITY RESEARCH PROJECT*

**The 2011 Surplus in Smallholder Maize Production in Zambia: Drivers, Beneficiaries, and Implications for Agricultural and Poverty Reduction Policies**

**by**

**Nicole M. Mason, William J. Burke, Arthur Shipekesa, and T. S. Jayne**

***WORKING PAPER No. 58***
***FOOD SECURITY RESEARCH PROJECT***
***LUSAKA, ZAMBIA***
***November 2011***
***(Downloadable at: http://www.aec.msu.edu/agecon/fs2/zambia/index.htm )***

# The 2011 Surplus in Smallholder Maize Production in Zambia: Drivers, Beneficiaries, and Implications for Agricultural and Poverty Reduction Policies

**by**

**Nicole M. Mason, William J. Burke, Arthur Shipekesa, and T. S. Jayne**

**FSRP Working Paper No. 58**

**November 2011**

Mason and Jayne are, respectively, assistant professor and professor, International Development, and Burke is research specialist, all in the Department of Agricultural, Food, and Resource Economics, Michigan State University, and currently on long-term assignment with the Food Security Research Project (FSRP) in Lusaka, Zambia. Arthur Shipekesa is research associate, FSRP.

## ACKNOWLEDGMENTS

The Food Security Research Project is a collaborative programme of research, outreach, and local capacity building, between the Agricultural Consultative Forum, the Ministry of Agriculture and Cooperatives, and Michigan State University's Department of Agricultural, Food, and Resource Economics.

We would like to thank the enumerators and supervisors who have collected the six years of survey data used in this report. We would like to acknowledge Margaret Beaver for her substantial contribution to the training of enumerators, data entry personnel and data cleaners. We are also grateful to Patricia Johannes for her editorial and formatting assistance.

We wish to acknowledge the financial and substantive support of the Swedish International Development Agency and the United States Agency for International Development (USAID) in Lusaka. Research support from the Global Bureau, Office of Agriculture and Food Security, and the Africa Bureau, Office of Sustainable Development at USAID/Washington also made it possible for MSU researchers to contribute to this work.

Any views expressed or remaining errors are solely the responsibility of the authors.

Comments and questions should be directed to the Food Security Research Project Director, 26A Middleway, Kabulonga, Lusaka: tel +260 211 261194; fax +260 211 261199; email: *kabaghec@msu.edu*

## FOOD SECURITY RESEARCH PROJECT TEAM MEMBERS

The Zambia Food Security Research Project field research team is comprised of Chance Kabaghe, Antony Chapoto, T. S. Jayne, William Burke, Nicole Mason, Munguzwe Hichaambwa, Solomon Tembo, Stephen Kabwe, Auckland Kuteya, Nicholas Sitko, Mary Lubungu, and Arthur Shipekesa. MSU-based researchers in the Food Security Research Project are Eric Crawford, Steve Haggblade, James Shaffer, Margaret Beaver, David Tschirley, and Chewe Nkonde.

# EXECUTIVE SUMMARY

In 2011, Zambia recorded its second consecutive record-breaking maize harvest, and aggregate maize production levels in 2011 were more than double the average level from 2006 to 2008. The expansion in maize production over the period corresponds with the scaling up of the Government of the Republic of Zambia's (GRZ) two flagship agricultural sector programmes. These are: (i) maize purchases at pan-territorial, above-market prices through the Food Reserve Agency (FRA); and (ii) subsidized fertilizer distribution through the Fertilizer Support Programme and its successor, the Farmer Input Support Programme (FSP/FISP). More than 90% of GRZ funding for Poverty Reduction Programmes is devoted to the FRA and FSP/FISP, yet there has been no major reduction in rural poverty rates in Zambia since 2004.

In this paper, we analyze the extent to which FRA activities, GRZ fertilizer subsidies, and other factors are responsible for the increase in smallholder maize production between the 2006-2008 baseline and 2011, and attempt to resolve the apparent paradox of a doubling of maize output with no discernible impact on rural poverty. Eight key findings emerge from the analysis.

1. Although maize production per agricultural household increased by 92% between the baseline and 2011, the mean household net value of total (maize and non-maize) crop production increased by just 20%. Some of the maize expansion is coming at the expense of other crops and expenditures on fertilizer and other inputs reduce the net value of production.
2. Decomposition of the growth in maize production between the baseline and 2011 indicates that 37% of the increase can be attributed to yield improvements, 28% to a decrease in the amount of land that is lost or abandoned after being planted with maize, and 35% to an increase in the area planted to maize.
3. Nearly all of the increase in the area planted to maize can be explained by the incentives introduced by FRA maize buying activity, both in terms of the increases in quantity purchased and additional price incentives introduced.
4. The change in fertilizer use is responsible for an estimated 36% of the increase in yield, while changes in the availability of fertilizer explains just 5% of the change in the ratio of harvested to planted maize land. Together, these figures show that increases in fertilizer use explain only 15% of the growth in total production from the base period to 2011.
5. The surprisingly underwhelming contribution of the increase in fertilizer use can be explained by the agronomic conditions under which it is applied. Particularly for basal fertilizer, yield response to fertilizer application is severely limited by the high level of soil acidity that prevails throughout 98% of Zambia’s maize fields.
6. The majority contributor to increases in both yield and the area harvested ratio has been two consecutive years of unusually favorable weather throughout Zambia. Specifically, 58% of the yield increase and 75% of the area harvested ratio increase stem from weather differences between 2011 and the base period. Overall, favorable weather is responsible for 42% of the growth in total production from the base period to 2011. These findings demonstrate that Zambia is highly vulnerable to shifting weather patterns.
7. Households cultivating two or more hectares of land captured a disproportionately large share of the maize production expansion, while those cultivating less than two hectares (and likely to be the poorest) garnered very little of the direct benefits of the increase in maize output. The 42% of households cultivating less than one hectare of land, who are among the poorest of the poor, captured just 7% of the expansion of

maize output. Thus, it is not surprising that the increase in total smallholder maize production has failed to reduce rural poverty significantly.

8. In general, alternative strategies for managing variability in food crop production and availability in Zambia include: (i) creating an enabling environment for private sector involvement and investment in food marketing and trade, particularly by instituting a more rules-based system for direct GRZ involvement in the agricultural sector; ii) diversifying away from a maize-centric agricultural portfolio, and developing and encouraging the adoption of economically viable technologies to reduce the risk of weather-induced food production shortfalls; and (iii) reviewing and ameliorating transport and storage capacity constraints.

## TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

## ACRONYMS

| | |
|---|---|
| AMA | Agricultural Marketing Act |
| AMIC | Agriculture Market Information Centre |
| APE | Average partial effect |
| CAADP CIP | Comprehensive African Agriculture Development Programme Country Investment Plan for Zambia |
| CFS | Crop Forecast Survey |
| CPI | Consumer Price Index |
| CSO | Central Statistical Office |
| FISP | Farmer Input Support Programme |
| FRA | Food Reserve Agency |
| FSP | Fertilizer Support Programme |
| FSRP | Food Security Research Project |
| GRZ | Government of the Republic of Zambia |
| ha | Hectare |
| kg | Kilogramme |
| MACO | Ministry of Agriculture and Cooperatives |
| MT | Metric Tonne |
| PRP | Poverty Reduction Programme |
| RSZ | Railway Systems of Zambia |
| SS | Supplemental Survey |
| USAID | US Agency for International Development |
| ZAMACE | Zambia Agricultural Commodity Exchange |
| ZARI | Zambia Agricultural Research Institute |

# 1. INTRODUCTION

Zambia's small- and medium-scale farmers produced an impressive maize surplus in 2011. The marked increase in maize production between the mid-2000s and 2011 coincides with the scaling-up of the Government's two flagship agricultural sector programmes: (i) the Farmer Input Support Programme (FISP, formerly known as the Fertilizer Support Programme), which distributes subsidized inputs to farmers, and (ii) the purchase of maize at above-market prices through the Food Reserve Agency (FRA). These programmes together accounted for over 60% of the public budget to the Ministry of Agriculture over the past five years. These programmes also accounted for 90-96% of the total budget allocated to the Ministry of Agriculture's Poverty Reduction Programmes (PRPs) in Zambia during the 2006-2011 budget years. While there have been other poverty-reduction programmes such as the Food Security Pack and Programme Against Malnutrition, the budgets allocated to these programmes have been tiny in relation to the FISP and FRA. In budget terms, then, the FISP and FRA operations have been the main anti-poverty programmes in the country.

Perhaps ironically, rural poverty has declined very little between 2006 and 2010. Although the rural poverty rate declined from 83.0% in 1998 to 77.3% in 2004, it was virtually unchanged at 76.8% in 2006 (CSO 2010). While official poverty rate estimates for 2010 have not yet been released, preliminary estimates suggest that the rural poverty rate remains in the range of 74% to 78%.

The government has spent over 2% of the nation's gross domestic product in supporting maize production and subsidizing inputs for farmers. So, why is it that maize production has increased so impressively without making a serious dent in rural poverty? Moreover, how should the new Patriotic Front government be measuring success in agriculture?

This paper uses nationally representative farm survey data collected by the Government's Central Statistical Office to analyze: (i) how broad-based the national maize production expansion was among Zambia's small- and medium-scale farmers; (ii) the relative importance of the FISP and FRA programmes, weather, and other factors in contributing to Zambia's record maize harvest in 2011; and (iii) overall trends in smallholder maize and total crop production levels over the last decade. Based on these findings, the paper explores strategies for dealing with future maize bumper crops and, more broadly, instability in food production levels and availability.

The remainder of the paper is organized as follows. Section 2 presents trends in smallholder maize and crop production levels over the last decade. Section 3 decomposes smallholder maize production increases between 2006-2008 and 2011 into changes in: (a) maize area planted, (b) the percentage of maize area planted that is harvested, and (c) maize yields on the harvested area. Section 4 identifies the main drivers of changes in these three components and empirically assesses the contribution of GRZ policies. Section 5 determines the likely distribution of benefits within the small- and medium-scale farm sector of increased smallholder maize production. The concluding Section 6 explores strategies for dealing with future maize bumper crops and, more broadly, instability in food production levels and availability.

## 2. TRENDS IN MAIZE AND TOTAL CROP OUTPUT, 2000/01-2010/11

The analysis in this section draws on the Ministry of Agriculture and Cooperatives/Central Statistical Office (MACO/CSO) Crop Forecast Surveys (CFSs) for agricultural years 2000/01 through 2010/11.[1] The CFS is a nationally representative survey conducted shortly before the harvest each year to collect information on input use and area planted to various field crops, as well as the quantities expected to be harvested and sold in the coming months. In this section, we use CFS data on small- and medium-scale farm households, who cultivate less than 20 hectares. An average of 7,292 small- and medium-scale farm households (hereafter smallholder households) was interviewed in the 2000/01 to 2002/03 CFSs. This average increased to 7,992 from 2003/04 through 2005/06, and to 13,434 for the 2006/07 through 2010/11 CFSs.

Table 1 summarizes the estimated number of smallholder agricultural households in Zambia over the study period as well as total and mean per household maize area planted, quantity harvested, and yield. Smallholder maize production levels in 2010/11 were roughly double what they were during the 2005/06-2007/08 baseline period. When expressed on a per farm household basis, mean maize production rose from 964 kgs to 1,851 kgs per farm, a 92% increase. The estimated number of smallholder agricultural households grew by less than 5% during this time and although there was some expansion in maize area planted (22-28% growth), the increase in maize yields between the baseline period and the 2011 harvest accounted for the majority of the production expansion (55.5%).

**Table 1. Smallholder Agricultural Households and Maize Area Planted, Quantity Harvested, and Yields, 2000/01-2010/11**

| Agricultural Year | Total # of agricultural HHs | Maize area planted (ha) | | Maize quantity harvested | | National maize yield (kg/ha planted) |
|---|---|---|---|---|---|---|
| | | Total | Mean HH | Total (MT) | Mean HH (kg) | |
| 2000/01 | 1,127,109 | 748,314 | 0.66 | 957,437 | 849 | 1,279 |
| 2001/02 | 1,169,525 | 785,183 | 0.67 | 673,673 | 576 | 858 |
| 2002/03 | 1,212,079 | 745,670 | 0.62 | 970,317 | 801 | 1,301 |
| 2003/04 | 1,275,428 | 780,768 | 0.61 | 1,364,841 | 1,070 | 1,748 |
| 2004/05 | 1,326,631 | 801,976 | 0.60 | 652,414 | 492 | 814 |
| 2005/06 | 1,373,537 | 864,970 | 0.63 | 1,339,479 | 975 | 1,549 |
| 2006/07 | 1,439,086 | 1,039,350 | 0.72 | 1,419,545 | 986 | 1,367 |
| 2007/08 | 1,497,045 | 1,176,221 | 0.79 | 1,392,180 | 930 | 1,184 |
| 2008/09 | 1,459,694 | 1,078,192 | 0.74 | 1,657,674 | 1,136 | 1,537 |
| 2009/10 | 1,483,439 | 1,182,217 | 0.80 | 2,463,523 | 1,661 | 2,084 |
| 2010/11 | 1,505,885 | 1,311,295 | 0.87 | 2,786,896 | 1,851 | 2,125 |
| Baseline avg. (05/06-07/08) | 1,436,556 | 1,026,847 | 0.71 | 1,383,735 | 964 | 1,366 |
| % change, baseline to 10/11 | 4.8% | 27.7% | 22.2% | 101.4% | 92.0% | 55.5% |

Sources: MACO/CSO Crop Forecast Surveys, 2000/01-2010/11.

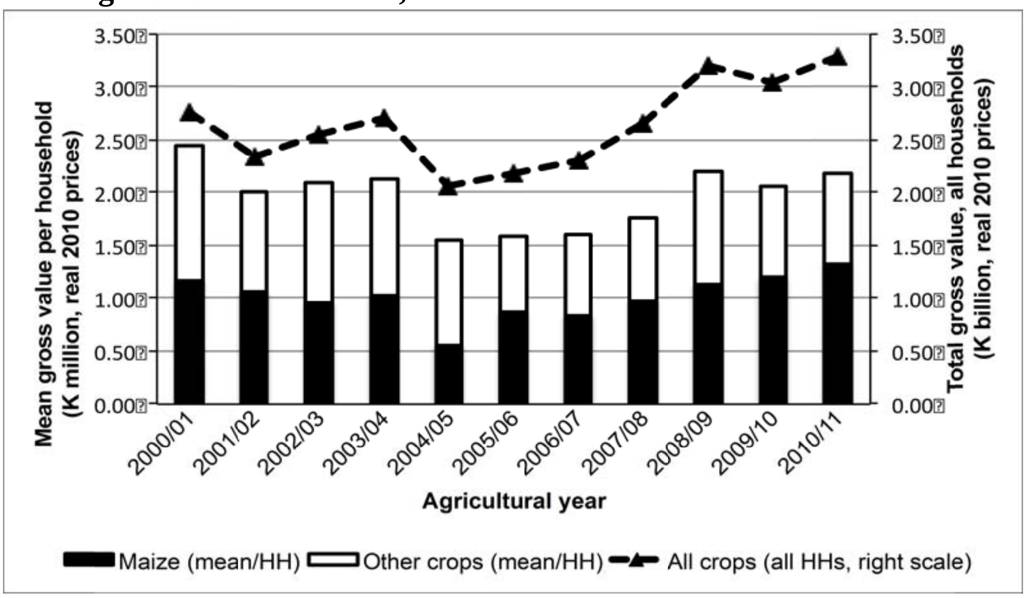
[1] The crop season in Zambia runs from October of one year to September of the next. So, the 2000/01 crop year refers to the crop planted after October of 2000 and harvested before September of 2001.

In the past several years, Zambia has clearly made demonstrable improvements in maize yields and total production. Without putting this into the context of overall crop production, however, these apparent accomplishments may be misleading. Specifically, focusing on total output figures ignores two potential costs that may counterbalance the benefits of increased maize production: the foregone production of other crops caused by farmers shifting area and other resources from other crops to maize, and the increased costs of production caused by the additional use of inputs to produce maize.

To examine the cost in terms of forgone production of other crops, Figure 1 illustrates the real (2010) gross value of total crop production per household over time, separating the value of maize and other crop production. See Appendix A for details on how these values were calculated. Compared to our baseline period (2005/06-2007/08) the gross real value of maize production per household in 2011 is 49% greater. The per household value of crops produced other than maize (sorghum, millet, groundnuts, mixed beans, sweet potatoes, cassava, and cotton) increased by 11% over the same period. Therefore, the expansion of maize production does not appear to have caused a decline in the total value of other crops produced. The total gross value of all crops was 32% greater in 2011 than during the baseline period. Yet there has been an increase in the share of maize in the total value of crop production. In 2011, maize accounted for 61% of the value of all production compared to 54% from the baseline period and 48% in 2001.

Also, note that while the difference over our baseline is substantial, crop production in 2011 was similar to some of Zambia's earlier harvests in terms of the gross value of production after adjusting for price inflation. For example, the consumer price index (CPI) -adjusted total value of crop production in 2011 is virtually identical to the value of production from 2000/01 to 2002/03 (the latter is actually 0.2% greater). In short, despite consecutive years of above average maize production, the gross real value of Zambia's crop output has not exceeded its levels of the early 2000s, reflecting the fact that less land and labor is currently allocated to relatively high-valued crops.

**Figure 1. Gross Real Value of Zambian Smallholder Crop Production – Total and Total/agricultural Household, 2000/01-2010/11**

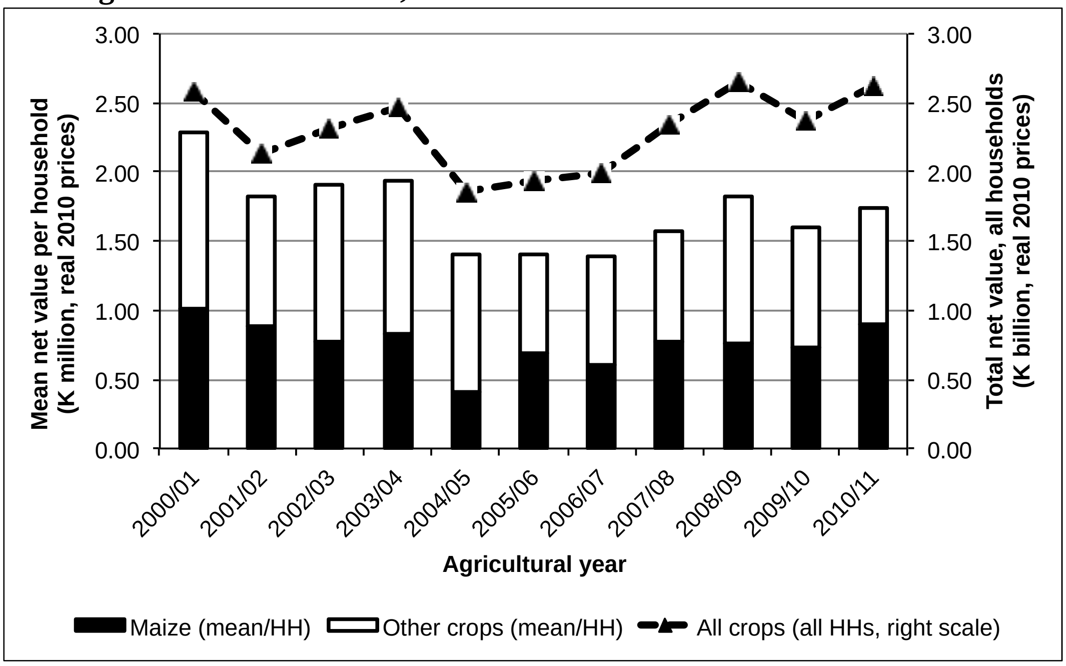



Sources: MACO/CSO Crop Forecast Surveys, 2000/01-2010/11; CPI data from the Central Statistical Office.
Notes: Other crops are sorghum, millet, groundnuts, mixed beans, sweet potatoes, cassava, and cotton. Crops valued at real 2010 prices (nominal prices in each year adjusted by the 2010 CPI).

To examine trends in crop output after accounting for possible changes over time in the costs of inputs, Figure 2 presents the net value of crop production per household. Net value is computed as gross value minus the cost of fertilizer use. Fertilizer is valued at the Lusaka retail price of compound D fertilizer according to the MACO Agriculture Market Information Centre (AMIC). See Appendix A for further details. Note that the vast majority of fertilizer in Zambia is used on maize fields, so the other crops value of production in Figure 2 is quite similar to that in Figure 1. In net real terms, the increase in the 2011 value of maize production over the 2005/06-2007/08 baseline period is only 29%. The net real value of other crops produced is 11% greater than during the baseline period, while the net real value of total crop output increased by 19%. This growth is relatively modest compared to the more than 100% increase in maize production between these periods, which is indicative of the fact that the production increase has come at considerable cost in terms of greater costs of fertilizer use. In fact, fertilizer costs in 2010/11 constituted 20.1% of the total value of maize output, compared to 12.2% during the 2005/06-2007/08 baseline period, and only 6.5% in the 2000/01crop season.

Finally, if we compare the 2011 net value of crop production to earlier years we see that the average household is actually producing *less* net value than in the beginning of the decade. In fact, net value of production per household was 15% greater, on average, during the 2000/01 to 2002/03 period than it was in 2011.

**Figure 2. Net Real Value of Zambian Smallholder Crop Production – Total and Total/agricultural Household, 2000/01-2010/11**




Sources: MACO/CSO Crop Forecast Surveys, 2000/01-2010/11; CPI data from the Central Statistical Office.
Notes: Other crops are sorghum, millet, groundnuts, mixed beans, sweet potatoes, cassava, and cotton. Crops and fertilizer valued at real 2010 prices (nominal prices in each year adjusted by the 2010 CPI).

## 3. DECOMPOSITION OF MAIZE PRODUCTION GROWTH, 2006-2008 TO 2011

To study the sources of growth in smallholder maize production, we use MACO/CSO CFS data for harvest years 2006 to 2011. These nationally representative samples provide data from roughly 13,000 Zambian maize fields each year, giving us a total sample of 78,126 observations over the six-year period. In this analysis, we compare the 2011 harvest to the mean of that from the baseline period, the 2006-2008 harvests. These three years are historically average in terms of maize yield and harvest, while 2009, 2010, and 2011 have been three consecutive bumper crops. We focus our comparison on the 2011 harvest because it is the most recent and largest in Zambia's recorded history.

It can be shown that changes in production can come from three sources directly: (a) changes in yield per hectare harvested, (b) changes in the ratio of harvested to planted land, and (c) changes in area planted (Burke, Jayne, and Chapoto 2010). The determinants of production such as weather, fertilizer use, price incentives, and so on, have their effect through one of these sources. In this section, we decompose the growth in maize production from the base period to 2011 into contributions from the three sources using the approach described in detail in Burke, Jayne, and Chapoto (2010). The three subsequent sections examine the determinants of production growth in each of these three components.

Results of the decomposition of production growth from the baseline period to the bumper harvest of 2011 are reported in Table 2. For Zambia as a whole, 37% of the increase in total maize production over this period can be attributed to yield growth. National yield per hectare harvested increased from 2,024 kg/ha to 2,631 kg/ha between these periods. Expansion of area planted to maize accounted for 35% of the total maize production growth. Maize area planted increased from an average of 1.0 million hectares in 2005/06-2007/08 to 1.3 million hectares in 2010/11. The remaining 28% of growth comes from an increase in the ratio of area harvested to area planted, which rose from 0.67 during the base period to 0.81 in 2011.

The importance of yield growth ranges from as high as 72% in Western Province to as low as 24-26% in Southern, Copperbelt, and Luapula Provinces. In provinces where yield growth made a smaller contribution, the growth in the ratio of area harvested to area planted contributes as much as 73%, as in Central Province. The area planted with maize has actually decreased in Central and Western Provinces, while contributing to as much as 64% of the growth in overall production in Luapula Province.

All together, the results in Table 2 demonstrate that each of the three sources of growth have played an important role in the recent growth of maize production in Zambia, underlining the importance of understanding the determinants of each of these sources.

**Table 2. Contributions to Production Growth by Province (2011 vs. 2006-08 Mean)**

| Province | Relative Contribution to Production growth between 2006-08 and 2011 harvests from changes in: | | |
|---|---|---|---|
| | Yield | Ratio of Harvested to Planted land | Area Expansion |
| | ------------------------------------- | Percent | ------------------------------------- |
| Central | 35 | 73 | -10 |
| Copperbelt | 25 | 17 | 57 |
| Eastern | 36 | 22 | 41 |
| Luapula | 26 | 10 | 64 |
| Lusaka | 38 | 23 | 38 |
| Northern | 49 | 06 | 44 |
| Northwestern | 59 | 18 | 23 |
| Southern | 24 | 40 | 36 |
| Western | 72 | 35 | -06 |
| All Zambia | 37 | 28 | 35 |

Sources: MACO/CSO Crop Forecast Surveys, 2005/06-2007/08 and 2010/11.

## 4. DRIVERS OF MAIZE PRODUCTION GROWTH BETWEEN 2006-2008 AND 2011

As shown in the previous section, increases in maize yields, in the proportion of maize area planted that is harvested, and in the total area planted to maize contributed to the growth of smallholder maize production between the 2005/06-2007/08 baseline and 2010/11. In this section, we identify the likely drivers of growth in each of these three components.

### 4.1. Factors Contributing to the Growth in Maize Yields per Hectare Harvested

To understand the determinants of the growth in maize yields from the base period to the 2011 harvest, we use ordinary least squares to estimate an econometric model of yield as a function of weather, cropping method, planting time, tillage method and fertilizer use. Due to missing tillage data for some observations, the model is estimated using an analytical sample of 74,955 observations. Variables for aggregate growing season rainfall and rainfall stress (defined as the number of 20-day periods with less than 40 mm of rain) are included in the model to control for weather effects. The rainfall data are from the Zambia Meteorological Department. Other net weather effects are captured using geographic time-variant dummy variables. The full regression results are reported in Appendix B. The estimation results are then used to simulate the share of the change in yield that can be attributed to management practices, input use, and weather following the approach described in Burke, Jayne, and Chapoto (2010).

Simulation results are summarized in Table 3. In the first simulation (row *i*), we simulate the expected average maize yield in the base period by plugging into the regression model the national mean values from 2006 to 2008 for each of the explanatory variables. The result is a predicted yield of 1,993 kg/ha. If we replace all of the values during the baseline period with the national means from 2011 (row *v*), the simulation results in a predicted yield of 2,684 kg/ha, or a 35% increase. It is worth noting that these predicted yield values are quite close to the actual mean yield estimates from their respective years (off by 6% for the 2006-08 period and off by 2% in 2011). Now, in rows *ii* through i*v* we return all values to their 2009 levels, then change only certain variables to ascertain the relative contributions from various factors such as weather, fertilizer, and seed use to total yield changes. Changes in other management practices, such as tillage timing and method, crop mixing and weeding, did not have a substantial effect on yield growth over this period.

First consider row *ii*, which demonstrates that the increase in the share of fields planted using hybrid maize seed or improved open pollinated variety seeds accounts for a 6% share of the change in yield (or a 2% increase in yield itself).

If all variables are held at base values and only the fertilizer variables are changed to their 2011 value (row *iii*), the predicted yield is 2,244 kg/ha, or a 13% increase in predicted yield. This means that the increase in fertilizer use can be attributed with a 36% share of the increase in national maize yield from 2006-08 to 2011. It is important to note that the increase in fertilizer use in this analysis includes both commercially purchased fertilizer as well as fertilizer acquired through the FISP and Food Security Pack programmes.

**Table 3. Contributions to the Growth in Yield from the 2006-08 Period to 2011**

| Simulations changing specific factors from their 2006-8 means to 2011 values.[a] | Results: Yield Prediction (kg/ha) | % change vs. 2006-8 | Share of contribution to total change[b] |
|---|---|---|---|
| *i*) Predicted yield using all 2006-8 mean values for weather, fertilizer, hybrid seed use, and others. | 1,993 | -- | -- |
| *ii)* Predicted yield changing hybrid seed use from 2006-8 to 2011 value[c]. All other variables held at 2006-8 levels. | 2,031 | 2% | 6% |
| *iii*) Predicted yield changing fertilizer from 2006-8 to 2011 value. All other variables held at 2006-8 levels. | 2,244 | 13% | 36% |
| *iv*) Predicted yield changing weather from 2006-8 to 2011 values. All other variables held at 2006-8 levels. | 2,397 | 20% | 58% |
| *v*) Predicted yield using 2011 values for weather, fertilizer hybrid seed use, and others. | 2,684 | 35% | 100% |

Sources: MACO/CSO Crop Forecast Surveys, 2005/06-2010/11.
Notes: a) Values refers to the national Crop Forecast Survey means from 2006-08 unless otherwise indicated (e.g., in row *iii* the values of all variables in the simulation are 2006-08 national means, except the fertilizer application rates, which are set to the 2011 national mean. In addition to weather, fertilizer and seed use, factors controlled for are timing and method of tillage, other crops in the field (nitrogen fixing legumes and other crops controlled separately), and field size as a proxy for management. b) Contribution to total change is calculated as the percent change vs. 2006-08 from each simulation, divided by the percent change vs. 2006-08 for the 2011 simulation in row *v*. c) Measured as the share of fields under cultivation using purchased hybrid seed (including improved open pollinated varieties).

Finally consider row *iv*, where the weather variables are changed from their mean value during the baseline period to their 2011 values, holding all else at the baseline averages. This predicts a yield of 2,397 kg/ha, or an increase of 20% over the base period. In other words, if nothing else had changed from the 2006-08 period to 2011 except for the weather, yields would have increased by 20%. Put into the context of a 35% change in the prediction overall, this translates into a 58% share of the total change being attributable to favorable weather in 2011.

Jointly these three factors – good weather, increased fertilizer use, an increased use of improved maize seed – explain nearly all of the explained increase in yield from the base period to 2011. Other variables that were considered were the proportion of fields cultivated with conservation farming practices (bunds, ridging, potholing, etc.) and the proportion of fields using nitrogen-fixing legumes with maize. For the full list of variables, see Appendix B. These variables had virtually no impact on the increase in maize yields in 2011. This is not because the practices did not have a significant impact on maize yield (many of them did, as shown in Appendix B). The reason why conservation tillage practices and the use of nitrogen-fixing legume intercrops did not appreciably affect 2011 maize yields is because of the limited increase in these practices between 2011 and the 2005/06-2007/08 baseline period. Less than 5% of the maize fields in Zambia benefited from conservation farming practices in 2011. The fact that some of these practices showed a statistically significant positive contribution to maize yield – for the limited number of households than employed them – have important implications that are considered in the concluding section.

Also from the regression results, we can estimate the contribution of both basal and top dress fertilizer to maize yield growth in Zambia. These results are reported in Table 4. First note that these results indicate a positive and significant effect of fertilizer application on maize yields for both basal and top dressing fertilizers. That said, the response rates are fairly low. Each kilogram of basal fertilizer applied per hectare of maize added 2.385kgs to maize yield, all other factors held constant. In fact, the upper bound of basal fertilizer's 95% confidence interval is still only 3.055 kgs maize per kg of basal applied. Given this response rate, a kilogram of maize would need to be sold at a price that is at least 34-42% of the price of fertilizer in order for the use of basal fertilizer to be profitable. The contribution of top dressing (primarily urea) to maize yield was higher; each kg of top dress fertilizer raised maize yield by 4.21 kgs. In the case of top dressing, a kg of maize could be valued at 24% of the value of urea or higher for the usage of urea to be profitable for farmers. At June 2011 prices (selling time for surplus producers) that ratio is 24%[2]. In other words, our evidence suggests that at commercial prices fertilizer adoption is, on average, only a break-even investment for top dressing if we ignore all transaction costs, and a losing investment in the case of basal fertilizer.

Agronomic literature offers a few possible explanations for the relatively low response rate for basal fertilizer in Zambia. First, the primary ingredient in basal fertilizer is phosphorus, which can take several years to become available to the maize plant. In fact, it is estimated that crops consume only 20% of phosphorus applied in the year of application (Griffith 2010). That said, if there is any persistence in fertilizer use at the field level, the effect of carry-over fertilization would be captured as the contemporaneous fertilizer variable acts as a proxy for past applications.

A second possible explanation is the chemical makeup of Zambian soils. Burke (2011) uses Zambian data from two Supplemental Surveys to the 2000 Post Harvest Survey, which is relatively rich in information on soil types and soil acidity. In that study, yield response to basal fertilizer is estimated conditional on prevailing regional soil acidity. Results on the average partial effect of basal fertilizer by pH levels from Burke (2011) are presented in Table 5 along with the distribution of the sample across each pH range.

The effect of basal fertilizer is allowed to vary across three pH ranges in that study: (i) below 4.4, (ii) 4.4 up to 5.4, and (iii) 5.5 to 7.1. This is because there are important threshold levels of pH that affect the productivity of the plants themselves and the availability of soil phosphorus. Specifically, the Zambia Agricultural Research Institute (ZARI) estimates maize plants are critically unproductive on soils with pH below 4.4, and it is a known agronomic principle that phosphorus becomes locked in soils where pH is below 5.5 because it converts to iron and aluminum phosphates that are unavailable for plant consumption.

**Table 4. Average Partial Effect (APE) of Zambian Fertilizers (2006 - 2011)**

| Fertilizer | APE (kg/kg) | 95% confidence interval | |
|---|---|---|---|
| Basal | 2.385***<br>(0.00) | 1.714 | 3.055 |
| Top dressing | 4.213***<br>(0.00) | 3.580 | 4.847 |

Notes: Robust p-values in parentheses; *** p<0.01, ** p<0.05, * p<0.10.

[2] Source for this price data is the Airtel Commodity Price Information service.

**Table 5. Estimated Additional Maize Yield per kg of Basal Fertilizer Applied, by Soil pH**

| Soil pH | 3.1 - 4.3 | 4.4 - 5.4 | 5.5 - 7.1 |
|---|---|---|---|
| Kgs of maize per kg of basal applied | 2.175**<br>(0.01) | 3.813***<br>(0.00) | 7.876***<br>(0.00) |
| % of maize fields in soil pH category | 51% | 47% | 2% |

Source: Burke (2011). Data on pH soil levels are from the Central Statistical Authority, Lusaka.
Note: Marginal yield response computed conditional on application rate and soil acidity. Robust p-values in parentheses; *** p<0.01, ** p<0.05, * p<0.10.

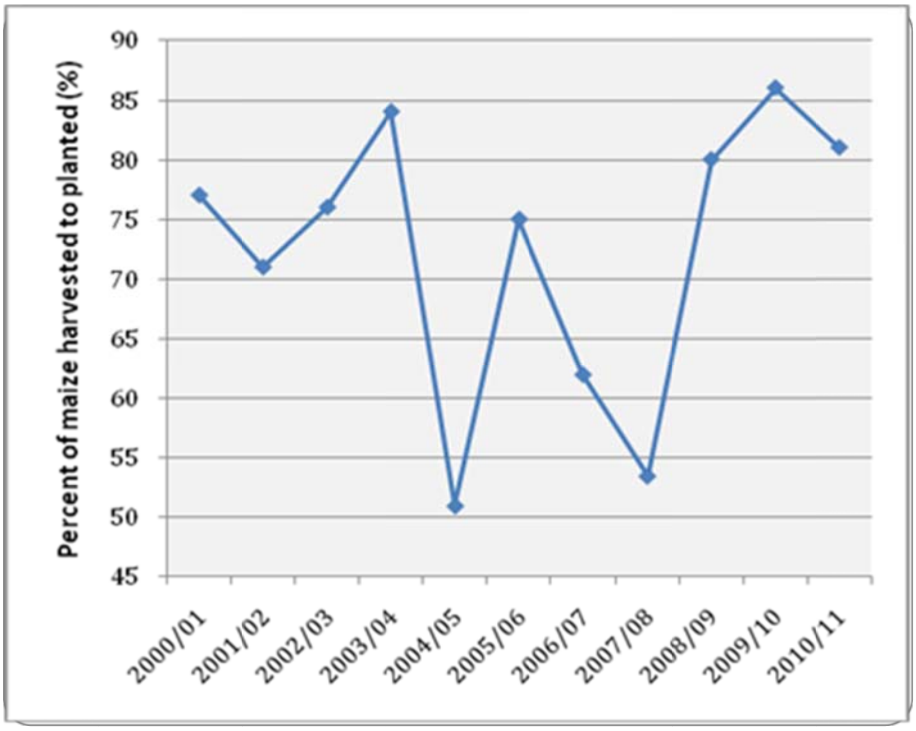
The pH range of 5.5 - 7 is optimal for phosphoric fertilization since, in this range, phosphorus converts to plant-available mono- and di-calcium phosphates (Griffith 2010). In pH levels above 7, phosphorus is vulnerable to becoming locked into tri-calcium phosphates that are also unavailable to plants (Griffith 2010), but there are very few areas in Zambia where such alkaline soils are present, and none with a pH above 7.1 in Burke (2011).

Below the critical pH threshold of 4.4 for growing maize in Zambia, Burke (2011) estimates the average partial effect of basal application is just over 2 kg of maize per kg of fertilizer applied. Although this response is significant at the 5% level, such a response rate would not be profitable under any feasible price ratio between maize and basal fertilizer. In the pH range of 4.4 to 5.4 the response rate increases to 3.81 kg/kg on average, and is significant at the 1% level. While better conditions for the plant seem to improve the effectiveness of basal application, the chemical limitations of phosphorus at this pH range are still dramatically reducing the profitability of fertilization. In the pH range above 5.5 the estimated response rate is a much more appealing 7.88 kg/kg, which would be profitable at a realistic price ratio (0.13) and is closer to what farmers in other countries enjoy under optimal conditions. Unfortunately, the majority of Zambians are not farming on pH neutral soils in this range. In the sample used in Burke (2011) only 2% of the observations fell in this pH range. On the other hand, 49% were in the pH range of 4.4 - 5.4, and 49% were in the very acidic pH range below 4.4. Thus, the vast majority of Zambian farmers are working on soil where the acidity levels have rendered basal fertilizer application largely ineffective and unprofitable.

### 4.2. Factors Contributing to Growth in the Ratio of Area Harvested to Area Planted

An underappreciated fact about maize farming in Zambia, and perhaps Africa more broadly, is that each year there is a substantial amount of land that is planted but never harvested. Moreover, the ratio of area harvested to area planted can vary considerably both temporally and geographically. In Zambia's three most recent harvests (2009-2011), this ratio has been above average, and much higher than our baseline period. In 2008, for example, less than 55% of the area planted was harvested, compared to 81% in 2011 (Figure 3). As described in section 3, this increase can be attributed with 28% of the increase in overall production between our baseline and the record harvest of 2011.

**Figure 3. Zambian Maize Area Harvested as a Percent of Area Planted over Time**




Sources: MACO/CSO Crop Forecast Surveys, 2000/01-2010/11.

During the 2011 harvest, Luapula Province had the highest ratio at 96%, seconded by Eastern and Northern, where 91% of the maize area planted was harvested. Southern and Western Provinces had the lowest ratios, with only 70% and 56% of the area planted being harvested, respectively.

However, the majority of famers (83.1%) harvested 100% of the area they planted to maize during the 2010/11 agricultural season. 5.8% harvested between half and all of the maize area they planted, 6.7% harvested half of the area planted to maize, and 4.4% harvested less than half of their maize area planted. Thus, the national ratio of area harvested to area planted is driven by a small percentage of farmers failing to convert a large portion of the area that they planted, rather than a symptom of most farmers abandoning a certain portion of their fields.

Since 2004/05, the CFS has collected detailed information on farmers' reasons for losing or abandoning portions of their fields. Between 2004/05 and 2010/11, the primary reason has consistently been weather-related (Table 6). In 2011, for example, 63% of the land that was planted with maize but un-harvested was lost to either drought or flood. Similarly, during our baseline period of 2005/06 to 2007/08, on average, 67% of the hectares planted but un-harvested were lost because of drought or flooding.[3]

Beyond flood and drought, the third most common response from farmers when asked why some portion of their fields was not harvested is a lack of fertilizer. The method by which failure to acquire fertilizer leads some farmers to leave their fields un-harvested requires additional research attention. There may be a perception that a failure to fertilize leads to such a low yield that production is not worth the harvest labor time.

[3] See Shipekesa and Jayne (2011) for more details on farmers' reasons for not harvesting all of their maize area planted during the 2010/11 agricultural season.

**Table 6. Reasons for Losing or Abandoning Area Planted to Maize, 2004/05-2010/11**

| | Percentage of un-harvested maize planted hectares lost or abandoned due to: | | | |
|---|---|---|---|---|
| Season | Drought | Flood | Lack of fertilizer | Other |
| 2004/05 | 91 | 1 | 4 | 4 |
| 2005/06 | 4 | 41 | 37 | 18 |
| 2006/07 | 30 | 41 | 18 | 11 |
| 2007/08 | 6 | 79 | 10 | 5 |
| 2008/09 | 10 | 30 | 39 | 21 |
| 2009/10 | 25 | 18 | 37 | 20 |
| 2010/11 | 51 | 12 | 26 | 12 |

Sources: MACO/CSO Crop Forecast Surveys, 2004/05-2010/11.
Note: Rows sum to 100%.

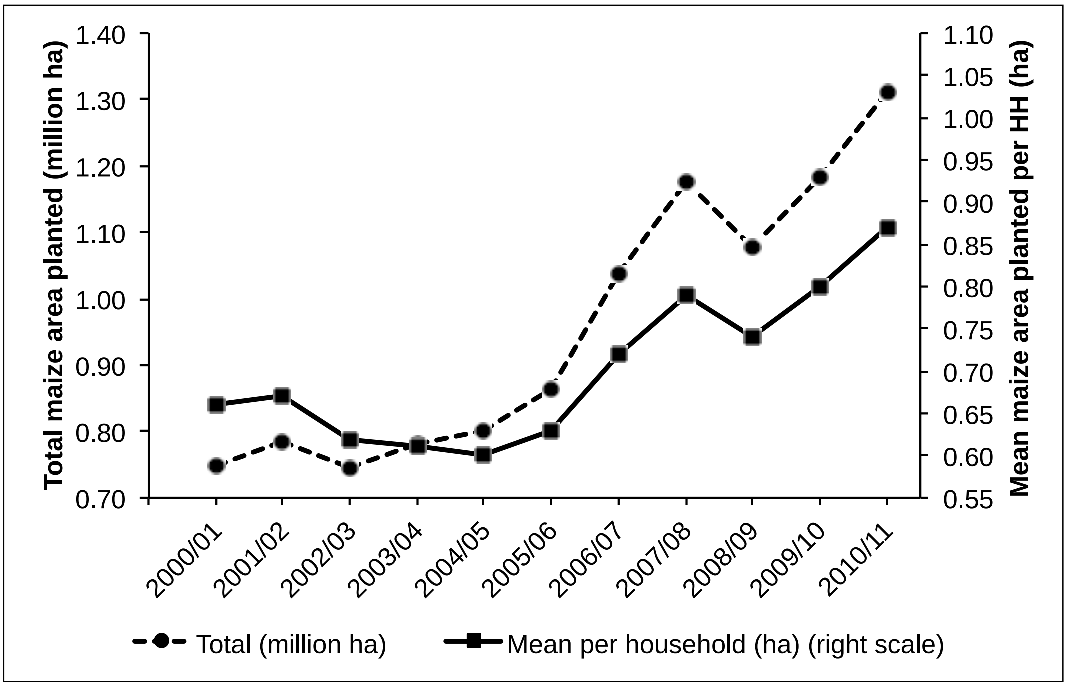
### 4.3. Factors Contributing to the Growth in Area Planted to Maize

Smallholder maize area planted has been on the rise since the 2006/07 agricultural season (Figure 4). Mean maize area planted per smallholder household (the dotted line in Figure 4) expanded less rapidly than total smallholder maize area planted (the solid line in Figure 4) due to the increase in the total number of smallholder households over the period. Excluding a brief dip in 2008/09, the year-to-year increase in total maize area planted by smallholders averaged 13% between 2006/07 and 2010/11. Total maize area planted was 28% higher in 2010/11 than on average between 2005/06 and 2007/08. As reported earlier, this expansion can be attributed with 35% of the difference between the bumper harvest of 2010/11 and those from our base period. In this section we examine the factors driving the change in this source of production growth.

Two potential contributing factors are (i) the increases in distribution of subsidized fertilizer and hybrid maize seed through the Farmer Input Support Programme (FISP, a reformed version of the FSP, and (ii) increases in maize purchases by the FRA at a pan-territorial price that has been greater than prevailing market prices in recent years. These programmes (FSP/FISP and FRA) both aim to increase smallholder maize production and count among their objectives raising incomes and improving household and/or national food security (MACO 2008; MACO 2009; FRA n.d.).

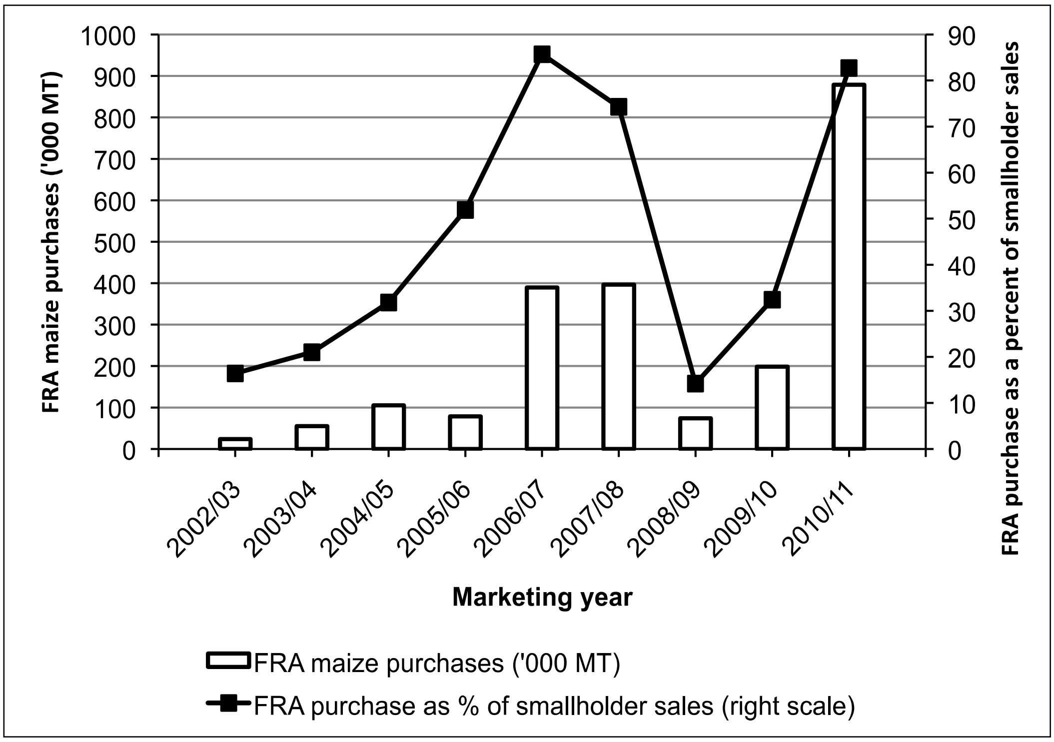
Figure 5 shows FRA maize purchases in tonnes and as a percentage of the total maize marketed by smallholders. Although the level of FRA's maize purchases dropped sharply in the 2008/09 marketing year, it had steadily increased before that and has been on the rise the last two years. The scale of FSP/FISP has also grown over the last several years, both in terms of the tonnes distributed and the number of intended smallholder beneficiaries (Figure 6). The latter is due, in part, to the reduction in the fertilizer pack size from 400 kg under FSP (2002/03-2008/09) to 200 kg under FISP (2009/10-present). These substantial interventions could potentially have a sizable impact on the area planted to land through their impact on the effective input and output prices faced by farmers.

**Figure 4. Smallholder Maize Area Planted (Total and Mean per Household), 2000/01-2010/11**



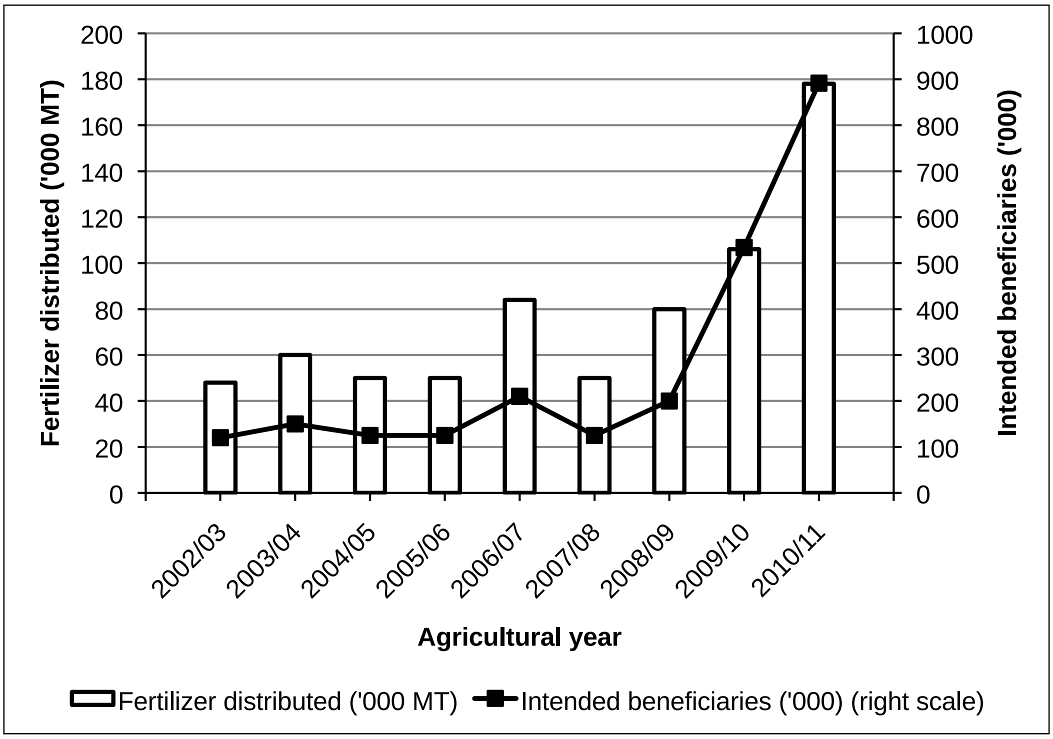

Sources: MACO/CSO Crop Forecast Surveys, 2000/01-2010/11.

**Figure 5. Total Maize Purchases by the Food Reserve Agency and FRA Purchases as a Percentage of Total Smallholder Maize Sales, 2002/03-2010/11**




Sources: FRA; MACO/CSO Crop Forecast Survey data, 2002/03-2010/11.

**Figure 6. FSP/FISP Fertilizer Distributed and Intended Beneficiaries, 2002/03-2010/11**




Source: MACO.
Note: Figures are for the Fertilizer Support Programme (FSP) for 2002/03-2008/09 and for the Farmer Input Support Programme (FISP) for 2009/10-2010/11.

A recent study by Mason (2011) examines how increases in the quantity of GRZ-subsidized fertilizer received, and in past FRA maize purchase prices and quantities affect various dimensions of smallholder behavior, including area planted to maize. Mason (2011) estimates a model for household-level maize area planted as a function of expected harvest-time prices for maize and other crops, the farmgate market price of fertilizer, the quantity of GRZ-subsidized fertilizer received by the household, and other variables that might affect how much maize area it decides to plant.

The household does not know the maize and other crop prices that will prevail at harvest time when it makes its planting decisions, thus those decisions must be based on its price *expectations*. In Mason (2011), expected farmgate maize prices at the next harvest are modeled as a function of farmgate maize prices offered by private traders and the FRA at the previous harvest, and the quantity of maize purchased by the FRA in the household's district in previous years. Other factors include the household's access to markets and market information, its ability to use that market information and negotiate a higher price, and variables affecting the quantity of maize it produces and sells. Although the FRA pays a pan-territorial price for maize at its satellite depots, households face different farmgate FRA prices depending on their distance from the nearest FRA depot and the cost of transporting their maize to the depot.

Increases in the previous year's farmgate market or FRA maize prices are expected to have a positive marginal effect on the maize price households expect to receive at the next harvest. An increase in the quantity of maize purchased by the FRA in the household's district in previous years is also expected to have a positive effect on its expected maize price. Other factors fixed, larger FRA maize purchases in a given area mean less maize is flowing through private sector channels. This is expected to put upward pressure on maize market prices. Econometric models estimated in Mason (2011) draw on CSO/MACO/FSRP Supplemental Survey (SS) data, which cover the 1999/2000, 2002/03 and 2006/07 agricultural seasons. The SS is a nationally representative longitudinal study of rural smallholder households in 70 districts in Zambia. A total of 6,922 households were interviewed in the first wave of the SS. Of those, 5,358 households were re-interviewed in the second wave, and 4,286 households were interviewed in all three waves. The GRZ fertilizer subsidy programmes in place during the three years covered in the SS were the FRA Fertilizer Credit Programme (1999/2000), the Fertilizer Support Programme (2002/03 and 2006/07), and the Food Security Pack Programme (2002/03 an 2006/07).

Mason (2011) uses the SS data to estimate expected maize price and maize area planted equations. The former produces estimates of the change in the expected maize price given a marginal change in the past farmgate FRA price or FRA purchases in a household's district. The latter produces estimates of the change in maize area planted given a change in the expected maize price or in the quantity of GRZ-subsidized fertilizer received by the household. Together, results from the two sets of equations provide estimates of the extent to which past FRA policies affect maize area planted by a smallholder household.

The key results in Mason (2011) are summarized in Table 7. As expected, increases in the farmgate FRA maize price at the previous harvest and in the quantity of maize purchased by the FRA in the household's district during the previous harvest year have positive effects on the household's expected maize price (rows I.A and I.B). An increase in the household's expected maize price has a positive effect on the area it plants to maize (row II). Together these results indicate that increases in the past farmgate FRA price and FRA maize purchases have positive effects on smallholder maize area planted (rows III.A and III.B).

An increase in the quantity of GRZ-subsidized fertilizer received by the household also has a positive effect on the area it plants to maize. For each additional 100 kg of subsidized fertilizer received, the household is expected to plant an additional 0.09 to 0.12 hectares of maize (Table 7, row IV.A.)[4]

Extrapolating from these results, we can estimate the extent to which recent expansions in FRA and FSP/FISP activities have contributed to the 28% increase in smallholder maize area planted between the baseline period and 2010/11. Table 8 summarizes the FRA pan-territorial price and district-level FRA maize purchases during the two periods as well as mean household kilograms of GRZ-subsidized fertilizer received (columns A through E). Predicted *ceteris paribus* changes in mean household smallholder maize area planted are calculated (column H) based on the percentage changes in these variables from the baseline to 2010/11 (column F) and the elasticities from Table 7 (repeated in Table 8, column G).

[4] This is the estimated average partial effect across all smallholder households, not just those that did in fact receive GRZ-subsidized fertilizer.

**Table 7. Marginal Effects of FRA Policies and GRZ Fertilizer Subsidies on Smallholder Expected Maize Prices and Maize Area Planted**

| Estimated effect on a farm household (HH) | Estimate | p-value |
|---|---|---|
| I. % change in the expected maize price given a 1% increase in: | | |
| A. the quantity of maize purchased by the FRA in the HH's district during the previous harvest | 0.10 | 0.06 |
| B. the FRA maize price (minus transport costs to the farm) during the previous harvest | 0.12 | 0.16 |
| II. % change in maize area planted by the HH given a 1% increase in the expected maize price | 0.64-0.97 | 0.05-0.07 |
| III. % change in maize area planted by the HH given a 1% increase in: | | |
| A. the quantity of maize purchased by the FRA in the HH's district during the previous harvest | 0.07-0.09 | 0.14-0.18 |
| B. the FRA maize price (minus transport costs to the farm) during the previous harvest | 0.09-0.12 | 0.07-0.12 |
| IV. Marginal effects of GRZ fertilizer subsidies on HH maize area planted: | | |
| A. Change in maize ha planted given a 100-kg increase in the quantity of GRZ-subsidized fertilizer acquired by the HH | 0.09-0.12 | 0.00 |
| B. % change in maize area planted given a 1% increase in the quantity of GRZ-subsidized fertilizer acquired by the HH | 0.04 | 0.00 |

Notes: Estimates I-III are for the 2006/07 agricultural year. Ranges instead of single values are listed for some estimates because multiple estimators were employed, yielding slightly different results.
Source: Mason (2011)

The 227% increase in FRA maize purchases in the average smallholder's district is estimated to have resulted in a 16-20% increase in household maize area planted from the baseline period to 2010/11.[5] In real terms the FRA pan-territorial price increased by 8% between the two periods.[6] If nothing else had changed, results predict that smallholders would have increased their maize area by approximately 1% in response to this increase in real FRA prices (Table 8). Combined with the effects through increases in FRA quantities purchased, FRA activities are estimated to have induced a 17-21% increase in total maize area planted. This implies that FRA activities are responsible for about three-quarters of the 28% total increase in maize area actually observed between the baseline period and 2010/11.

The quantity of GRZ-subsidized fertilizer received by the average smallholder household in 2010/11 (82 kg) was 183% higher than during the baseline period. Again using the results from Mason (2011), we estimate that a 7% increase in the mean household area planted can be attributed to the expansion of the FSP/FISP in recent years. All together, our findings indicate that through FRA and fertilizer subsidies, government activities have induced a 24-28% increase in the amount of land planted to maize by smallholder farmers in Zambia. That is, nearly all of the growth in national production that has come from area expansion can be attributed to government activity. Any remainder likely stems from annual population growth.

[5] The range in our estimate (rather than a single value) stems from the fact that in Mason (2011) multiple estimators were employed, yielding slightly different results. Different results from different estimators were used to compute the minimum and maximum elasticity results.

[6] The Mason (2011) elasticities with respect to the FRA price in Tables 8 and 9 are for the farmgate (transportation-cost adjusted) FRA price; however, it is not possible to compute a farmgate FRA price for each household using the CFS data. Instead, we can only examine effects of changes in the pan-territorial FRA price from baseline to 2010/11.

**Table 8. Predicted Changes in Maize Area Planted between 2010/11 and the Baseline Period (2005/06-2007/08), Given Changes in FRA Prices and Purchase Quantities, and in the Quantity of GRZ-subsidized Fertilizer Received by Farm Households**

| Mean household: | 2005/06 | 2006/07 | 2007/08 | Average, 2005/06-2007/08 ("baseline") | 2010/11 | % change, baseline to 2010/11 | Estimated elasticity from Table 7 | Predicted % change in maize area (F×G) *holding other factors fixed* |
|---|---|---|---|---|---|---|---|---|
| | (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) |
| FRA district-level purchases (MT) | 1,429 | 7,430 | 8,013 | 5,624 | 18,408 | 227% | 0.07-0.09 | 16-20% |
| FRA pan-territorial price (ZMK/50-kg bag) | | | | | | | | |
| Nominal | 36,000 | 38,000 | 38,000 | 37,333 | 65,000 | | | |
| Real (2010/11 prices)[a] | 66,736 | 60,222 | 53,323 | 60,094 | 65,000 | 8% | 0.09-0.12 | 0.7-1.0% |
| Kg of GRZ-subsidized fertilizer received | 21.3 | 37.8 | 28.0 | 29.0 | 82.1 | 183% | 0.04 | 7% |

Notes: Levels are for marketing years for the FRA variables and for agricultural years for GRZ-subsidized fertilizer. [a]FRA pan-territorial price deflated by the non-food CPI.

Source: MACO/CSO Crop Forecast data (2005/06, 2006/07, 2007/08, and 2010/11); 2005/06 CSO/MACO Post-Harvest Survey data; 2008 CSO/MACO/FSRP Supplemental Survey data; CSO (non-food CPI); FRA (FRA maize purchases).

## 5. MAIZE PRODUCTION GAINS: WHO ARE THE LIKELY BENEFICIARIES?

This section shows how maize production has increased between the baseline period and 2011 according to farm size in Zambia. As discussed in previous sections, total smallholder maize production roughly doubled between the 2005/06 to 2007/08 baseline and 2010/11. However, the extent to which the production growth was broadly based among the smallholder population has not yet been examined.

Column A of Table 9 shows the number of farmers in five farm size categories. Overall there are an estimated 1,471,221 small- and medium-scale farmers in Zambia (hereafter smallholder farmers), defined as farmers cultivating less than 20 hectares. Approximately 42% of them are cultivating less than one hectare of land; 33.3% of the smallholder farms are cultivating 1-2 hectares; 2.9% of the farms are cultivating 5-10 hectares, and 0.5% of the farms are cultivating over 10 hectares (column B). Farmers cultivating less than 2 hectares accounted for 75% of the total number of farmers in Zambia's smallholder farm sector.

Column C shows the estimated total maize production within each of the farm size categories over a baseline period (the three years covering the 2005/06 to 2007/08 crop seasons). Column D shows the estimated maize production for these five farm size categories in the 2010/11 crop season. Overall, maize production increased from an average of 1,383,735 tonnes in the three years constituting the baseline period, to 2,786,896 tonnes in the 2010/11 season.

Column E of Table 9 shows the change in maize production over this period for each farm size category. Farmers cultivating 0-0.99 hectares contributed an additional 96,989 tonnes to national maize production in 2010/11 compared to their average maize production during the 3-year period 2005/06-2007/08. By dividing the additional maize production in column E by the number of farms in each category as shown in Column A, we derive the additional maize production per farm for each of the farm size categories, as shown in Column F. When expressed on a per farm basis, it is apparent that farmers cultivating between 0-0.99 hectares produced 157.2 additional kilograms of maize per farm in 2011 compared to the baseline period. Similarly, the 33.3% of farmers cultivating 1-1.99 hectares contributed 326,145

**Table 9. Smallholder Maize Production Growth from the Baseline Period (2005/06-2007/08) to 2010/11, by Farm Size Category**

| Total area cultivated (maize + all other crops) | Average number of farms, 2005/06 to 2007/08, & 2010/11 | % of farms | Total smallholder maize production: Annual mean during 2005/06 to 2007/08 baseline period (MT) | 2010/11 (MT) | Absolute change (MT) (D-C) | Change per farm (kg per farm) (E*1,000/A) |
|---|---|---|---|---|---|---|
| | (A) | (B) | (C) | (D) | (E) | (F) |
| 0-0.99 ha | 616,867 | 41.9% | 212,335 | 309,324 | 96,989 | 157.2 |
| 1-1.99 ha | 489,937 | 33.3% | 381,293 | 707,438 | 326,145 | 665.7 |
| 2-4.99 ha | 315,459 | 21.4% | 490,102 | 1,130,527 | 640,425 | 2,030.1 |
| 5-9.99 ha | 42,332 | 2.9% | 196,848 | 494,719 | 297,871 | 7,036.6 |
| 10-20 ha | 6,626 | 0.5% | 103,156 | 144,888 | 41,732 | 6,298.4 |
| Total | 1,471,221 | 100% | 1,383,735 | 2,786,896 | 1,403,161 | 953.7 |

Sources: MACO/CSO Crop Forecast Surveys, 2005/06-2007/08, 2010/11.

additional tonnes of maize in 2010/11 compared to 2005/06-2007/08. This amounts to 666 kgs of additional maize per farm in this category. Farmers cultivating 2-4.99 hectares contributed an additional 640,425 tonnes of maize to national maize production in 2010/11, or 2.03 tonnes per household. By contrast, the 2.9% of the farmers cultivating 5-9.99 hectares contributed an additional 297,871 tonnes to national maize production in 2010/11, which amounted to 7.04 tonnes additional maize production per farm. Lastly, the 0.5% of farmers cultivating 10-20 hectares increased their maize production in 2010/11 by 6.3 tonnes per household in 2010/11 compared to the earlier baseline period.

The data in Table 9 show that very little of the increase in national maize production in 2010/11 came from the bottom category of farmers (0-0.99 hectares cultivated) even though they accounted for 42% of the smallholder farms in Zambia. The main increase in national maize production (column E) came from farmers in the three middle area cultivated categories: those in the 1-1.99, 2-4.99 and 5-9.99 cultivated area categories. However, when expressed in per farm terms, the major increases in maize production were enjoyed by farmers cultivating over 5 hectares; these farm households constitute only 3.4% of all the smallholder farms in Zambia. Table 9 clearly shows that the increase in maize production per farm is strongly related to farm size.

Table 10 uses the same Crop Forecast Survey data to examine the amount of subsidised FISP fertiliser received during the 2010/11crop season by farmers within the same five categories. The number and percentage of farms in each category in 2010/11 are shown in columns A and B, respectively. The percentage of farms receiving FISP fertilizer in each land cultivated category in 2010/11 is presented in column C. Slightly over 14% of the farmers cultivating 0-0.99 hectares received FISP fertilizer in the 2010/11 crop season. For these 14% of recipient farmers, the average quantity of fertilizer received was 168 kgs. Therefore, across all 596,334 households in the 0-0.99 hectare category, the average household received 24.1 kgs of FISP fertilizer as shown in column D. By contrast, over 50% of farmers in the 10-20 hectare cultivated category received FISP fertilizer in 2010/11, and these recipient farmers received 657 kgs per farm. Therefore, the average amount of FISP fertilizer received by farmers in the 10-20 hectare category was 346 kgs, about 14 times more per farm than those in the 0-0.99 hectare category.

**Table 10. FISP Fertilizer Received (2010/11 Crop Season) and Expected Maize Sales, 2011, by Farm Size Category**

| Total area cultivated (maize + all other crops) | Number of farms (A) | % of farms (B) | % of farmers receiving FISP fertilizer (C) | kg of FISP fertilizer received per farm household (D) | % of farmers expecting to sell maize (E) | Expected maize sales (kg/farm household) (F) |
|---|---|---|---|---|---|---|
| 0-0.99 ha | 596,334 | 39.6% | 14.3% | 24.1 | 22.2 | 135 |
| 1-1.99 ha | 499,026 | 33.1% | 30.6% | 69.3 | 47.7 | 609 |
| 2-4.99 ha | 354,116 | 23.5% | 45.1% | 139.7 | 64.0 | 1,729 |
| 5-9.99 ha | 49,410 | 3.3% | 58.5% | 309.7 | 82.1 | 6,613 |
| 10-20 ha | 6,999 | 0.5% | 52.6% | 345.6 | 86.8 | 15,144 |
| Total | 1,505,885 | 100% | 28.6% | 77.1 | 42.7 | 950 |

Source: MACO/CSO Crop Forecast Surveys, 2010/11.

Column E shows the percentage of households selling maize. This ranges from 22.2% among the smallest farm size category to 86.8% among the largest. In terms of quantities of maize sold (or expected to be sold, as it was asked in the 2011 CFS survey), column F shows that, on average, about 135 kgs of maize will be sold for every farm in the 0-0.99 hectare category, compared to 1.7 tonnes per household in the 2-4.99 hectare category, and over 15.1 tonnes per household in the 10-20 hectare category. Clearly, the benefits of the FRA maize support prices are disproportionately enjoyed by the relatively large farmers over 5 hectares, even though they constitute only 3.8% of the smallholder farm population.

# 6. ALTERNATIVE STRATEGIES FOR COPING WITH FLUCTUATING FOOD PRODUCTION LEVELS AND AVAILABILITY

A review of the new government Agricultural Manifesto shows commitment to key agriculture growth drivers such as investing more into research and extension services, infrastructure, irrigation promoting utilization of improved seed and crop diversification, and rationalizing the operations of the FRA. These objectives are in line with the commitment set forth in the Comprehensive African Agriculture Development Programme (CAADP) Compact.

The immediate task is the development of the Country Investment Plan (CIP) as outlined in the Compact and the SNDP. A well-conceived Zambia CIP will reduce poverty by raising on-farm productivity and improving market access (domestically and abroad) in a manner that effectively reaches the poorest segments of the rural population. Achieving agricultural growth *with* poverty reduction will require the targeting of inputs, technologies, and delivery systems to the rural poor. A well-conceived CAADP Investment Plan will also recognize the importance of policy in determining the impacts of good agricultural investments. Appropriate policies and public investments can leverage much greater investments by the private sector in support of smallholder-led development. By the same token, policies that are unpredictable and/or crowd out private investment can cause an otherwise good CAADP Investment Plan to create little enduring benefit.

This section outlines seven challenges and proposed responses for consideration by government.

**Challenge 1: How can GRZ best invest its limited budget resources?**

The distribution of the agricultural budget in the recent past has not placed enough emphasis on broad-based public investments. Most of the funds allocated to the sector over the years have been spent on fertilizer subsidies through the Farmer Input Support Programme (FISP) and maize price stabilization through the FRA, which together have accounted for between 50-70% of the total budget over the last seven years. Certainly, the FRA and FISP have contributed to the increase in the country's maize output. Results presented in earlier sections of this report show that rural poverty rates remain roughly constant over the past 10 years despite the massive increases in the size of the FRA and FISP programmes. Only a minority of small-scale farmers in the sector produce enough maize to sell to the FRA and benefit from the high FRA price. FRA activities also affect maize prices in the private sector. Evidence suggests that FRA activities raised average maize market prices by 17% to 20% between 2003 and 2008. Urban consumers and most rural households are negatively affected by higher maize and other staple food prices.

Fertilizer use could be profitable under the right conditions but it is in no way the only input that farmers require to achieve broad based productivity. Results from national surveys shows that fertilizer distributed under the FISP programme usually reached farmers late (though improved in recent years), sometimes crowds out private participation and reaches mostly those who can already afford to buy commercial fertilizers.

Moreover, the fertilizer that does reach rural households is largely ineffective by international standards. Specifically, much of the soil on which fertilizer is applied in Zambia is highly acidic. This causes a chemical reaction to many fertilizers that locks the nutrients intended for the plant into the soil in an altered chemical state. In other cases, soil textures are not robust enough to hold nutrients long enough for plants to ingest them, and the potential benefits of the fertilizer applied quite literally wash away. The challenge for the government is to make a deliberate policy change or pronouncement that re-aligns this programme to benefit the least poor farmers and hence achieve greater reductions in rural poverty in the process of promoting agricultural production.

**Proposals for consideration**

a) Enacting the Agricultural Marketing Act (AMA) to guide all private and public agricultural marketing activities in Zambia. The draft Agricultural Marketing Bill provided guidance on the involvement of government in the fertilizer, seed, crops and livestock markets. In particular, it proposed that FRA activities in the grain market should be restricted to Strategic Grain Reserves as well as the role of FISP in ensuring that fertilizer distribution by private dealers is not curtailed.
b) Promote the use of a flexible e-voucher in the FISP to accommodate other commodities other than maize and rice but include a whole range of agricultural inputs such as veterinary medicines, blended fertilizers, lime, herbicides, tractor services etc. Government could consider an input voucher equivalent to 8 fertilizer bags but let private sector bear the cost of delivering input to farmers. Moreover, this would allow those with the most information, the farmers themselves, to identify the most appropriate technology for their fields.
c) The FISP programme focus should be revised to target only the poorest small scale farmer. This will have the impact of addressing the high inequality levels that currently exist in Zambia.
d) Reorientation of spending, away from private input subsidies and towards increased investment in public goods, would be anticipated to accelerate agricultural growth in Zambia. For example to: a) irrigation development as a means to mitigate drought and improve productivity; b) crop, soil, and livestock science research and development to enhance genetic advances and refinements in the adaptation of improved practices and technologies; c) extension programmes, particularly focusing on effective and appropriate input use and d) physical infrastructure development. Decades of research evidence shows that these types of public investments provide the greatest payoffs to agricultural growth and poverty reduction.
e) Policy discussions and subsequent decisions need to account for the fact that actual budgetary allocations often differ in significant ways from planned disbursements. Monitoring systems designed to increase budgeting transparency and accountability might provide a method to reduce such differences by making them more transparent.
f) Increase the budget to agricultural research and development to improve the productivity of small scale farmers.
g) Promote the use of blended fertilizers and agricultural lime to deal with soil acidity problems.
h) In discussing agricultural marketing policy and how it might impact the sector, it is also important to understand the participants and their abilities to respond. A clear understanding of the composition and structure of the small and medium-scale farming community needs to be fully integrated into any efforts to enhance market participation.

This will better enable the government to anticipate potential effects of alternative policy actions. One-size-fits-all policies have, in the past, been shown to be ineffective.

### Challenge 2: How can low smallholder productivity be effectively raised?

Since 2001, Zambia has spent over 1.4 trillion Kwacha providing subsidized fertilizer to farmers under the FSP (now FSIP). Modest yield improvements were seen in 2010 and 2011 (Figure 3), but, while increased fertilizer use played a role, it has been shown that this was primarily due to consecutive years of unusually favorable weather. Moreover, the relative importance of favorable weather in the two most recent harvests should serve as a reminder that Zambian agricultural production is highly vulnerable to shifting weather patterns. It is generally accepted that agricultural productivity growth is a pre-condition for sustainable poverty reduction and improved living standards in most of Sub-Saharan Africa. However, the evidence suggests that Zambia is failing to achieve significant productivity increases in the agricultural sector. The challenge of improving farm productivity appears to have a straightforward solution: use the power of crop science to generate improved farm technologies, put them into the hands of small farmers, and provide them with the knowledge to get the most out of these technologies. Over the past several decades, however, several highly committed and well-funded efforts to kick-start such green revolutions in Zambia have been thwarted by their inability to anticipate and address downstream issues of marketing and governance.

Studies have shown that there is great variability across the small- and medium-scale farm sector in terms of productivity. About 30% of farmers are able to get a high return on fertilizer use (over 28kg maize per kg N applied) while another 30% cannot get more than 10kgs maize per kg N. Farmers' management and input use practices vary widely. A greater share of the public budget to agriculture devoted to research and extension efforts can help smallholder farmers get maximum benefit out of fertilizer application and other input use, and hence raise their effective demand for fertilizer even in the absence of subsidies. Moreover, raising agricultural productivity and the sustainable use of fertilizer in many maize growing parts of the country will require addressing squarely the problem of soil acidity.

#### Proposals for consideration

a) Reorientation of spending away from private input subsidies and towards increased investment in agricultural research, technology dissemination, and adoption.
b) Promote irrigation where feasible and economically viable.
c) Promote use of other forms of fertilizer including blended fertilizers and lime
d) Promote the construction of localized fertilizer blending facilities.
e) Reform FISP to use a flexible e-voucher that includes other agriculture inputs instead of just fertilizer, maize seed, and rice seed.

### Challenge 3: How can crop diversification by smallholder farmers be promoted?

Maize-centric policies through the FRA and FISP programmes have retarded growth in production of other crops. While the net value of total crop production per agricultural household has increased between 2004/05 and 2010/11, the share of crop production other than maize has clearly declined. Crop diversification will only take place under conditions that encourage private sector investment.

**Proposals for consideration**

a) Quickly enact the Agricultural Marketing Bill. This will provide guidance on the involvement of government in the fertilizer, seed, crops and livestock markets.
b) Address maize pricing issues through encouraging market based pricing for maize bought by FRA.
c) Abandon pan territorial and pan seasonal pricing by FRA.
d) Reform the FISP programme to crowd-in the private sector. In particular, promote the use of a flexible e-voucher that covers various inputs for different crops and livestock not just fertilizer for maize or rice seed.
e) Promote breeding centers to increase livestock numbers.
f) Promote smallholder aquaculture.
g) Promote smallholder supplementary livestock feeding and commercialization of the same.

**Challenge 4: How can Zambia ensure that it does not price itself out of export markets?**

Following the record-breaking maize harvests of nearly 2.8 million MT in 2010 and over 3 million MT in 2011, Zambia has been faced with challenges of marketing the surplus maize. When the crop forecast results of 2011 were being announced, Zambia had maize carry-over stocks of over 700,000 MT. Because of transport capacity constraints and the fact that FRA had purchased its maize stocks at levels above import parity, the country has been unable to take advantage of the export markets in the region, such as Kenya, Zimbabwe and Democratic Republic of Congo. Instead, Zambia faces the distinct possibility of having to sell the vast majority of its current maize stocks at a major financial loss in order to avoid experiencing the deterioration of its stock quality.

In addition to huge financial losses due to deterioration of FRA's maize stock, the government lost will lose at least 1.3 million kwacha on every tonne it is able to export (see Appendix 1 and 2). Over the past few years, the FRA prices have been announced before the crop forecast exercise is completed. Unfortunately, this process has resulted in undesirable consequences to the country's limited financial resources. The challenge facing the government is how to ensure that the process of setting FRA prices is determined on sound and sustainable economic and social principles.

**Proposals for consideration**

a) In buying the strategic reserves, FRA producer prices, should consider the following:
    - Supply and demand conditions in the country, regional and international markets.
    - Cost of production estimates from MACO/CSO farm household surveys such as the Crop Forecast Survey and the Post-Harvest Survey.
    - FRA buying price should only be set after the crop forecast and cost of production have been estimated.

b) FRA should consider buying its grain requirements via innovative strategies that do not distort market e.g. buy strategic grain reserves requirements through the Zambia Agricultural Commodity Exchange (ZAMACE).
c) Establish rules and triggers for the FRA maize stocks releases on to the market as well as pricing that reflects prevailing market conditions.

**Challenge 5: How can transport capacity be expanded to facilitate the export of surplus maize?**

Consecutive bumper maize harvests have exposed the transport capacity problems in the country. Assuming that Zambia's maize exports were competitive in the region, it still would not be feasible to export over 500,000 MT in one season due to transport capacity limitations. It is currently believed that the country has about 30-40 thousand metric tonnes per month excess road transport capacity for grain per month after the regular demands on the transport system from copper, petrochemicals, and other commodities are considered. Based on this estimate it would take more than three years to export the maize estimated to be in FRA's possession by the end of 2011. The Railway Systems of Zambia's (RSZ's) termination of rail-based copper transport has further tightened the market for available road transport. However, these assertions need to be substantiated through more rigorous research. In the meantime, the Ministry of Agriculture and Livestock should consider how the capacity of the regional transport system is affecting Zambia's potential to be a major surplus producer of maize.

**Proposals for consideration**

a) Commission an in-depth study on Zambia's transport capacity, the factors influencing its ability to export surplus maize production (and other agricultural commodities), and the costs thereof.
b) Engage the Minister of Transport on the government's efforts to revitalize the capacity and efficiency of the rail transport system in Zambia.
c) Establish a sustainable system of upgrading and maintaining all existing primary and secondary road systems in the country.
d) Review existing regulations that might inhibit expansion of private investment in road transport capacity.

**Challenge 6: How can adequate storage in Zambia be ensured?**

The country may not be in a position to store all the grain from the 2010/2011 agricultural season due to limited storage capacity. The government has embarked on a project of building slabs, but this is a temporary fix because with the rains, FRA grain stocks on these slabs are likely to accelerate its spoilage. While the private sector has started investing in storage infrastructure, this investment is limited due to the uncertainty of the grain markets in the country.

**Proposals for consideration**

a) Government to quickly rehabilitate existing silos in order to expand the national storage capacity.

b) Government should provide long term incentives for private sector to build new storage structures.
c) Disband pan-territorial and pan-seasonal pricing to encourage storage.
d) FRA should stick to buying only Strategic Grain Reserves in order to avoid distorting the market.
e) Promote the development of certified warehouse receipting systems around the country.

**Challenge 7: How can private investment in maize marketing be encouraged?**

Discretionary and unpredictable government intervention is one of the greatest policy problems plaguing the maize marketing system and food security in Zambia because actual and potential government interventions generate private sector uncertainties and inaction leading to additional need for government intervention. For example, 1) suddenly altering maize imports tariff rates, banning exports, or not issuing export permits; 2) FRA willingness to sell maize below its export price at a financial loss in order to unload its own stocks, export marketing opportunities for private traders have been very limited. In these ways, government policies have discouraged the private sector's involvement in exportation that otherwise could have relieved the national surplus without causing major financial losses on the Treasury.

**Proposals for consideration**

a) Effective implementation of the Zambian CAADP Programme to address the aforementioned challenges.
b) Improve the predictability of government policy formulation with regard to marketing through the enactment of the Agricultural Marketing Bill and adhering to the legislation
c) Encourage predictable, rules-based market and trade policies (including elimination of import and export bans).
d) Support alternatives to large-scale maize purchases by FRA, such as ZAMACE.
e) Serious efforts to encourage market development and to ameliorate market failure will require an increased commitment to investment in public goods (e.g., road, rail and port infrastructure, research and development, agricultural extension systems, market information systems) and institutional change in order to promote the functioning of market-oriented trading systems.
f) In the mixed policy environment, the government co-exists with the private sector as an unfairly large competitor, and this hinders the development of the agricultural sector. While total government withdrawal from the market may not be a realistic or even helpful option, the government should avoid crowding out private sector participation, and should instead seek to facilitate market growth. If, however, the government insists on participating directly in agricultural markets, it should be clear about its intentions to ensure predictability.
g) Promote effective coordination between the private and public sector through greater consultation and transparency with regard to changes in FRA purchase and sale prices, import and export decisions, and triggers for release of stocks. This approach does not imply that government need be passive. Instead, it implies that Government responses, including humanitarian responses and donor interventions, will be transparent and predictable, thereby creating space for the private sector to play its role.

## 7. SUMMARY AND CONCLUSION

Zambia has enjoyed two consecutive years of record-setting maize harvests in 2010 and 2011, generated largely by smallholder farmers, following several years of heavily subsidized inputs and outputs and unusually favorable weather. In fact, these years coincided with a considerable increase in the government's flagship subsidies: FISP for fertilizer and FRA for marketed maize. By all accounts, these harvests should go a long way to ensuring Zambia's food security in the short run, and Zambian farmers should be congratulated for their accomplishment.

That said, despite nearly a decade of subsidized production and marketing, and consecutive record harvests, rural poverty in the country remains stubbornly high, with no significant decrease in poverty rates since it was above 80% in 1998. The most recent data available show that nearly three out of four rural Zambians still live in poverty. The goal of this study was to examine, from several angles, the relationships between crop production (especially maize), poverty, and government policy, including a discussion of how future bumper harvests could provide greater benefit to Zambians. We carry out our research by comparing the harvest of 2011 to a baseline period average harvest from 2006 to 2008, which were historically average years.

The first conclusion we are able to draw from our analysis is that increased maize production does not necessarily translate into increased agricultural production, especially in terms of the value of production. Specifically, results suggest that the poverty reducing effects of the large maize harvests are being off-set by relatively low growth of other major crops, as well as the increasing cost of producing maize. For example, in net real terms, the increase in the value of mean household maize production from the baseline period to 2011 is 29%, but the value of total production increased just 20%. This growth is relatively modest compared to the more than 100% increase in maize production between these periods, which indicates that the production increase has come at considerable cost in terms of increased use of inputs, mainly fertilizer. In fact, the ratio of input costs to gross production value was over 20% in 2011, compared to 12% during the baseline period and 6% in 2001.

We next decompose the growth in production from the base period to 2011 to demonstrate that 37% of the increase can be attributed to yield improvements, 28% can be attributed to a decrease in the amount of land that is lost or abandoned after being planted with maize, and 35% can be attributed to an increase in the area planted to maize. Nearly all of the increase in the area planted to maize can be explained by the incentives introduced by FRA maize buying activity, both in terms of the increases in quantity purchased and additional price incentives introduced.

Perhaps surprisingly, our results indicate that the primary force behind both the increases in yield and the ratio of area harvested to area planted is *not* the changes in input use that coincided with the dramatic increases in subsidized fertilizer. We estimate that the change in fertilizer use alone is responsible for 36% of the increase in yield, and only 15% of the growth in total production from the base period to 2011. A major factor limiting fertilizer's contribution to national maize production can be explained by the agronomic conditions under which it is applied. Particularly for basal fertilizer, yield response to fertilizer application is severely limited by the high level of soil acidity that prevails throughout 98% of the nation's maize fields.

In fact, the majority contributor to increases in both yield and the area harvested ratio has been two consecutive years of unusually favorable weather throughout Zambia. Specifically, results indicate that 58% of the yield increase and 75% of the area harvested ratio increase stems from weather differences between 2011 and the base period. Combined with the attributions of these growth sources, this implies that favorable weather is responsible for 42% of the growth in total production from the base period to 2011. The remaining 6% of total production growth can be attributed to other factors such as farm management, primarily through the effect on the area harvested ratio.

These results have important policy implications. First, while increased fertilizer use has had an impact on the growth of maize production, we reiterate that the most influential determinant has been weather. In recent years, this has been an agricultural boon since weather has been favorable, but this finding also demonstrates that *Zambia is highly vulnerable to shifting weather patterns*. There may be a false sense of security that Zambia has become a reliable maize self-sufficient country, but this might not be the case in an unfavorable rainfall year. There are several options for at least partially addressing this vulnerability problem (e.g., irrigation, use of conservation agricultural techniques, drought tolerant seed varieties, etc.), but investment decisions on various solutions should be backed up by data, which, at least specifically for Zambia, do not exist. More research needs to be done by governments and/or donors to evaluate the options for dampening Zambia's vulnerability to weather. Only then can these options be appropriately prioritized. Undeniably, there is little or no aspect of the government's current, fertilizer-intensive agricultural development policy that will mitigate this vulnerability.

Secondly, the promotion of fertilizer itself appears to be falling well short of productive possibilities, particularly for basal fertilizer, due to the prevailing soil acidity in Zambia. Fortunately, there are measures that could be taken to mitigate these effects. Certain fertilizer application methods could shift up the limited response rates so that greater production response can be seen at the pH levels found in Zambia. For example, it has been shown that applying small bands of fertilizer very near, around or under the seed makes phosphoric fertilization more effective in acidic soil (Boman et al. 1992). This is known as banding application, as opposed to evenly spreading fertilizer over the entire field, or broadcasting, as is commonly practiced in Zambia. In addition, private firms in developed countries produce phosphorus enhancing fertilizer supplements, which they claim harmlessly alter the soil chemistry near the fertilizer to protect it from becoming unavailable to plants.[7] These fertilizer supplements have been tested extensively on U.S. soil, where they have a 15-20% effect on increasing yields, but the benefits may be greater on the more acidic Zambian soils.

Other inputs could also be used to increase pH on Zambian fields up to the levels at which fertilizers are naturally more productive. This is the primary reason farmers throughout the world apply agricultural lime to their fields. Certain types of lime have the added benefit of adding calcium and magnesium (useful elements) to the soil, while neutralizing manganese and aluminum (harmful elements) (Snyder 2010). In other words, lime *is* fertilizer.

Alternatively, management practices could be designed to both increase pH and basal fertilizer's resistance to acidity in order to find a productive middle ground. The optimal solution, however, is not obvious. Finding this solution will once again require substantial

[7] For example, see http://www.chooseavail.com/Science.aspx

research, and will require more funding allocated to institutions such as the Zambian Agricultural Research Institute or the International Institute of Tropical Agriculture, which recently selected Zambia to be the home of its regional offices.

We then explored the extent to which households with different farm sizes benefited from the maize production increase between the 2006-2008 baseline and the 2011 harvest. Evidence suggests that households cultivating two or more hectares of land accounted for the major share of the maize production expansion, while those cultivating less than two hectares (and likely to be the poorest) enjoyed very little of the direct benefits of the increase in maize output. Smallholders cultivating less than two hectares of land represent approximately 75% of small- and medium-scale farm households but garnered only 30% of the total expansion in maize output. The poorest of the rural poor are likely to be in the category cultivating less than one hectare of land, and although 42% of smallholders are in this group, they contributed less than 7% of the expansion of maize output between the baseline period and 2011. Therefore, the direct benefits of the maize production expansion appear to have accrued to relatively better-off smallholders.

The paper highlights the apparent paradox of no substantive change in rural poverty rates in Zambia despite a doubling of smallholder maize production. However, the paradox may be resolved upon noting that the poorest smallholders, specifically those cultivating less than one hectare of land, captured virtually none of the direct government benefits of FISP and FRA. Farm households cultivating over five hectares of land disproportionately benefited from the treasury outlays for these poverty reduction programmes. Furthermore, empirical evidence suggests that FRA activities actually raise market prices for maize (Mason 2011). Rural households cultivating less than one hectare (and urban consumers) are predominately net buyers of maize, and thus are indirectly harmed by FRA activities due to the Agency's effects on maize market prices.

Finally, we presented a number of concrete proposals for managing variability in food crop production and availability in Zambia. These include the following proposals for government consideration:

1. enact the AMA to guide all private and public agricultural marketing activities in Zambia;
2. promote the use of a flexible e-voucher in the FISP to accommodate other commodities other than maize and rice and to include a whole range of agricultural inputs such as veterinary medicines, blended fertilizers, lime, herbicides, tractor services, etc.;
3. refocus the target of FISP programmes to farm households under two hectares, which is where rural poverty is concentrated;
4. shift the overall composition of public expenditures on agriculture away from input subsidies and towards increased investment in public goods;
5. abandon pan-territorial and pan-seasonal pricing by FRA;
6. create transparent and rules-based procedures for guiding FRA operations in the maize market;
7. set FRA buying price only after the crop forecast and cost of production have been estimated;
8. commission an in-depth study on Zambia's transport capacity, the factors influencing its ability to export surplus maize (and other agricultural commodities), and the costs thereof;

9. review existing regulations that might inhibit expansion of private investment in road transport capacity;
10. rehabilitate existing storage silos to expand the national storage capacity;
11. provide long term incentives for private sector to build new storage structures;
12. implement the Zambian CAADP Programme to address the aforementioned challenges; and
13. promote effective coordination between the private and public sector through greater consultation and transparency with regard to changes in FRA purchase and sale prices, import and export decisions, and triggers for release of stocks. This approach does not imply that Government need be passive. Instead, it implies that Government responses, including humanitarian responses and donor interventions, will be transparent and predictable, thereby creating space for the private sector to play its role.

With the election of H.E. Michael Sata as the new Republican President in September 2011, GRZ has an historic opportunity to make bold reforms and put Zambia on a path toward sustainable agriculture sector-led growth and poverty reduction. With two consecutive maize bumper crops, the country has clearly demonstrated its potential to be a breadbasket for the region. The challenge now is to transform Zambia from a surplus maize producer with stocks rotting due to inadequate storage and transport, and other barriers to export, to a country upon which others in the region can confidently rely for grain and that improves the food security and livelihoods of its poorest citizens.

# APPENDIX A

## Assumptions for computing gross value of crop production and value of crop production net of fertilizer costs for CFS 2000/01-2010/11

- Fertilizer prices:
    - Fertilizer prices for each calendar year 2000-2010 are from AMIC and are retail Compound D fertilizer prices in Lusaka deflated by the CPI. The average May-November 2000 fertilizer price was used to value fertilizer used during the 2000/01 agricultural year, and likewise for subsequent years.
- Crop prices:
    - No prices can be derived from the CFS data itself (sales are forecasted, not realized).
    - The major crops produced in Zambia are: maize, sorghum, millet, groundnuts, mixed beans, sweet potatoes, cassava, and cotton
        - Food crops
            - Prices for the food crops were derived from CSO monthly average retail prices for each crop
            - Monthly retail prices were deflated by the CPI and then marketing year average prices were calculated for each crop and year, 2001/02-2010/11
            - Real retail prices were scaled by a crop-specific producer price-to-retail price ratio, to account for the producer-retail marketing margin. Producer price-to-retail price ratios were computed as follows:
                - For all food crops except cassava, nominal marketing year average retail prices for 2000/01, 2003/04 and 2007/08 for each crop were compared to national median producer crop prices for the same marketing years derived from the CSO/MACO/FSRP Supplemental Surveys. The producer price-to-retail price ratio was then calculated for each crop and year. The median producer price-to-retail price ratio across the three years was then used as *the* producer price-to-retail price ratio in subsequent calculations.
                - For cassava, the retail price is for cassava meal but producer prices in the SS data are for raw cassava. The producer price-to-retail price ratio was calculated for raw cassava by comparing the raw cassava price in the 2008 Supplemental Survey (which covers the 2007/08 marketing year) to the 2007/08 raw cassava median retail price in the FSRP Urban Consumption Survey data. This ratio was 0.55 and it was assumed that this marketing margin also holds for the producer cassava meal price-to-retail cassava meal price.
            - Estimated real producer prices for each food crop and marketing year were then calculated as the marketing year average real retail price times the crop-specific producer-to-retail price ratio.

        - Real 2010 prices for the 2011/2012 marketing year (2010/11 agricultural year) were set equal to 2010/11 marketing year real prices, since no price information is yet available on 2011/2012 marketing year prices.
    - Cotton
        - Cotton is valued at the real actual price paid by Dunavant each crop year for grade A cotton.

- Expected production of each crop (kg):
    - Expected quantities to be harvested (kg) of each crop are the quantities reported in the CFS for all crops except for cassava.
    - For cassava, the following procedure was used to estimate quantity to be harvested:
        - Actual or expected cassava quantity harvested was only included in the CFSs for 2007/08-2010/11. No data on cassava quantity harvested were collected in the CFSs for 2000/01-2006/07.
        - Estimated cassava quantity to be harvested was calculated by multiplying the number of hectares under mature cassava by 7 MT/ha. Note that on the 2004/05 CFS Cassava Final Tables, MACO used an estimated yield of 11.7 MT/ha of cassava. This yield was applied to both mature and not-yet-mature cassava area. On the 2005/06 CFS Cassava Final Tables, an estimated yield of 7 MT/ha of mature cassava was used. 7 MT/ha of mature cassava is also the estimated yield used by FAO.
        - Expected production of raw cassava was converted to cassava flour terms using a conversion of 0.25 kg of cassava flour per kg of raw cassava. The 2005/06 CFS Final Tables produced by MACO show that this was the conversion factor used.

## APPENDIX B

**Results from OLS Regression Analysis of Maize Yield Determinants**

| Determinants | Results |
|---|---|
| *Weather effects* | |
| Zone 2a (1 = yes) | 476.8733*** |
| | (0.00) |
| Zone 2b (1 = yes) | -69.5419 |
| | (0.40) |
| Zone 3 (1 = yes) | 348.4581*** |
| | (0.00) |
| Year = 2007 (1 = yes) | -13.3871 |
| | (0.88) |
| Year = 2008 (1 = yes) | -70.5631 |
| | (0.47) |
| Year = 2009 (1 = yes) | -21.9011 |
| | (0.82) |
| Year = 2010 (1 = yes) | 221.8339*** |
| | (0.01) |
| Year = 2011 (1 = yes) | 188.5453** |
| | (0.04) |
| Zone 2a*2007 | -85.1908 |
| | (0.40) |
| Zone 2a*2008 | 102.1810 |
| | (0.38) |
| Zone 2a*2009 | -134.2594 |
| | (0.21) |
| Zone 2a*2010 | 115.4558 |
| | (0.22) |
| Zone 2a*2011 | -39.0675 |
| | (0.71) |
| Zone 2b*2007 | -202.0815* |
| | (0.08) |
| Zone 2b*2008 | -524.3929*** |
| | (0.00) |
| Zone 2b*2009 | -71.8634 |
| | (0.53) |
| Zone 2b*2010 | -59.8731 |
| | (0.60) |
| Zone 2b*2011 | 440.8090*** |
| | (0.00) |
| Zone 3*2007 | 75.7176 |
| | (0.45) |
| Zone 3*2008 | 298.7515*** |
| | (0.01) |
| Zone 3*2009 | 343.7061*** |
| | (0.00) |
| Zone 3*2010 | 227.9168** |
| | (0.02) |
| Zone 3*2011 | 450.0386*** |
| | (0.00) |
| Total growing season rainfall(mm) | -0.0996 |

| | |
|---|---|
| | (0.51) |
| Rainfall squared | -0.0001 |
| | (0.21) |
| Number of 20 day periods with less than 40 mm of rainfall | 72.4982*** |
| | (0.00) |
| *Farm management effects* | |
| Was maize planted with a nitrogen fixing legume (1 = yes) | 187.1074*** |
| | (0.00) |
| Was maize planted with a non-nitrogen fixing crop (1 = yes) | 107.2388** |
| | (0.03) |
| Was maize planted with an improved seed variety (1 = yes) | 315.1552*** |
| | (0.00) |
| Was tillage done before the rains (1 = yes) | 27.2079 |
| | (0.16) |
| Was tillage done in planting basins (1 = yes) | 70.4206 |
| | (0.36) |
| Was tillage done via zero tillage (1 = yes) | -143.4464*** |
| | (0.00) |
| Was tillage done via plow (1 = yes) | 204.5962*** |
| | (0.00) |
| Was tillage done via ripping (1 = yes) | 151.0945 |
| | (0.20) |
| Was tillage done via ridging (1 = yes) | -36.8826* |
| | (0.09) |
| Was tillage done using bunds (1 = yes) | -177.4179*** |
| | (0.00) |
| *Fertilizer applications* | |
| Basal fertilizer application rate (kg/ha) | 2.3281*** |
| | (0.00) |
| Basal fertilizer rate squared | 0.0005 |
| | (0.17) |
| Top dressing application rate (kg/ha) | 4.2889*** |
| | (0.00) |
| Top dressing rate squared | -0.0006* |
| | (0.08) |
| Constant | 1,262.2939*** |
| | (0.00) |
| Observations | 74955 |
| R-squared | 0.119 |

Notes: Robust p-values in parentheses; *** p<0.01, ** p<0.05, * p<0.1

## REFERENCES


Boman, R.K., J.J. Sloan, R.L. Westerman, W.R. Raun, and G.V. Johnson. 1992. Using Phosphorus Fertilizers to Maintain Wheat Forage and Grain Yields on Acid Soils. *Better Crops* 76.4: 16-19.

Burke, W.J. 2011. Determinants of Maize Yield Response to Fertilizer Application in Zambia: Implications for Strategies to Promote Smallholder Productivity. Ph.D. dissertation, Michigan State University.

Burke, W. J., T.S. Jayne and A. Chapoto. 2010. *Factors Contributing to Zambia's 2010 Maize Bumper Harvest.* Food Security Research Project Working Paper No. 48. Lusaka, Zambia: FSRP.

CSO. 2010. Poverty Trends Report, 1996-2006. Lusaka: CSO.

CSO/MACO. Various years. Post-Harvest Survey data. Lusaka: CSO.

CSO/MACO/FSRP. Various years. Supplemental Survey Data. Lusaka: CSO.

Food Reserve Agency (FRA). FRA website. Accessed June 29, 2011. http://www.fra.org.zm

Griffith, B. 2010. Efficient Fertilizer Use - Phosphorus. The Efficient Fertilizer Use Manual. accessed June 7, 2010: http://www.rainbowplantfood.com/agronomics/efu/phosphorus.pdf

MACO/CSO Crop Forecast Surveys, 2000/01-2010/11.

Mason, Nicole M. 2011. Marketing Boards, Prices, and Smallholder Behavior: Modeling, Measurement, and Policy Implications in Zambia. Ph.D. dissertation, Michigan State University.

Ministry of Agriculture and Cooperatives (MACO). 2008. Fertilizer Support Programme Internal Evaluation. Lusaka: MACO. Accessed June 29, 2011. http://www.aec.msu.edu/fs2/zambia/tour/FSP_Internal_Evauation_2008.pdf

MACO. 2009. Farmer Input Support Programme Implementation Manual: 2008/2009 Agricultural Season. Lusaka: MACO.

Shipekesa, A., and T.S. Jayne. 2011. Why Are Zambian Farmers not Harvesting All of their Maize? Food Security Research Project Policy Synthesis No. 45. Lusaka, Zambia: FSRP. http://www.aec.msu.edu/fs2/zambia/ps_45.pdf

Snyder, C. 2010. Efficient Fertilizer Use - Soil pH Management. The Efficient Fertilizer Use Manual. Accessed July 5, 2011. http://www.rainbowplantfood.com/agronomics/efu/ph.pdf