The impact of the PARPA II in promoting the agricultural sector in rural Mozambique

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Abstract

This paper evaluates whether the PARPA II goal of increasing agricultural production and productivity through the promotion of agrarian services has been achieved. The results are drawn from six nationally representative surveys from rural Mozambique. Various factors suggest that PARPA II failed to increase agricultural production and productivity and thus reduce poverty. The variation in maize production is mostly explained by variation in rainfall patterns across agricultural seasons, and not by technological progress or adoption of better cropping practices. Poverty reduction strategy plans should promote agro-processing and diversification of both off-farm activities and crops. In order to increase agricultural productivity, access to improved agricultural technologies should be increased and more investments should be made in irrigation and water conservation technologies.

JEL Classification: O55; I38; R28; Q12.

Keywords: PARPA II; rural Mozambique; poverty.

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1. Introduction

With about 70 percent of its population living in rural areas, agriculture is the predominant economic activity in Mozambique, employing about 80 percent of the population. The smallholder agricultural sector represents over 99 percent of the total number of farms, and the incidence of absolute poverty is highest in rural areas (55%). Mozambique's second Poverty Reduction Strategy Paper (PRSP), the Action Plan for the Reduction of Absolute Poverty 2006-2009 (PARPA II) prioritizes agricultural development to increase rural incomes and to reduce absolute poverty. The PARPA II envisaged a structural transformation of the agricultural sector through: i) the promotion of agrarian services, increased production and productivity, guaranteed food security, increased income and competitiveness of farmers; ii) natural resource management; and iii) institutional development.

Poverty headcount for Mozambique has declined sharply from 69 percent in 1996/97 to 54 percent in 2002/03 (MPF/IFPRI/PU, 2004). The overarching objective of the PARPA II was to further reduce poverty incidence to 45 percent in 2009. A hitherto little explored research area but of paramount importance is an impact evaluation of the PARPA II. Using a set of six nationally representative data sets from rural Mozambique, this paper evaluates whether or not the PARPA II goal of increasing agricultural production and productivity and thus reduce poverty through the promotion of agrarian services has been achieved.

Previous studies on rural livelihoods and poverty reduction strategies in four African countries (other than Mozambique) have found that low household incomes in rural areas are associated with low land and livestock holdings, and a high share of crop income (Ellis and Freeman, 2004). In addition, the same authors recommend that PRSPs should create a facilitating environment for the multiplication of nonfarm enterprises. Poverty research on Mozambique corroborates this view and acknowledges the role of nonfarm income generating activities in reducing rural poverty (Boughton et al., 2006; Cunguara and Kajisa, 2009; Cunguara, 2009; Mather et al., 2008; Walker et al., 2004; Walker et al., 2006;).

While evaluating the impact of PARPA II on the performance of the agricultural sector, this paper provides tentative leads for agricultural policy that could be incorporated in the country's third generation poverty reduction strategy plan. The paper is also an empirical contribution to poverty research in developing countries, and combines different analytical tools to assess the impact of PRSP in enhancing smallholders' production and productivity, and food security.

2. Data sources

We use data from the National Agricultural Survey (TIA) of 2002, 2003, 2005, 2006, 2007, and 2008. The surveys were implemented by the Department of Statistics within the Directorate of Economics of the Ministry of Agriculture. The sampling frame draws heavily on the Census of Agriculture and Livestock of 1999-2000. The TIA samples were stratified by province and agro-ecological zone.

TIA02, TIA05, and TIA08 are the three most comprehensive surveys. They combined the annual household demographic and agricultural and livestock production components with detailed information on household income components. Additionally, data on small and medium-sized farms were complemented by group interviews at the community level, field measurements, and a separate questionnaire for all large-sized farms. All of the TIA surveys collected production and marketing data for each crop, ownership of livestock and the basic characteristics of members of each household. Table 1 presents the TIA sample size for each year, along with selected demographic characteristics. All the figures presented throughout the paper are population weighted unless explicitly mentioned.

Table 1. Sample size and characteristics

	TIA02	TIA03	TIA05	TIA06	TIA07	TIA08
Number of observations	4908	4935	6159	6248	6075	5968
Number of sampled districts	80	80	94	94	94	All 128
Widow female headed households (%)	9.06	NA	8.45	8.88	8.59	10.63
Male headed households (%)	75.68	74.40	74.75	76.69	76.53	74.61
Head is engaged in salaried employment (%)	15.04	22.07	26.94	30.18	28.91	28.20
Head is self-employed (%)	32.83	40.95	43.43	46.44	49.08	37.24
Head’s age	42.04	43.12	43.99	42.37	42.70	43.07
Head’s year of educational attainment	2.23	2.23	2.57	2.51	2.79	2.95

Sources: Authors’ calculations based on TIA02, TIA03, TIA05, TIA06, TIA07, and TIA08

Two limitations of the study deserve mention upfront. The first limitation is related to its focus on cereal production. The paper was not able to broaden the analysis into other crops but cereals, with particular emphasis on maize due to a time constraint in completing the analyses. Nevertheless, cereals in general and maize in particular, is the most widely cultivated crop in rural Mozambique, and a focus on its production and productivity over time may shed light on the trends of other crops too. The second limitation is related to the proxy used for food security, which is somewhat deficient. Following only staple crops can be misleading given that households can substitute to other products. An indicator of total calorie availability per capita over time could be a better proxy for food security, but we refrain from such analysis due also to a time constraint[1].

3. Methods

We focus the analysis on cereal production (with particular emphasis on maize) due to its importance for smallholders’ food security in Mozambique. Cereal production is also

[1] These two limitations could be addressed in future research.

representative of the farming system in Mozambique where few external inputs are deployed to maize production, unlike for instance, cotton and tobacco which account for a significant proportion of all improved seeds, fertilizers, and pesticides used in rural Mozambique. Cotton and tobacco are also grown by fewer farmers, relative to maize and other cereals.

We complement the descriptive analysis presented in the next section with some regression analysis (Heckman sample selection model and OLS regressions), described in more detail in the appendix section. All the Stata codes used to generate the analysis are available from the authors upon request.

4. Descriptive analysis

Figure 1 illustrates per capita cereal production over time. The analysis is split by region in order to account for regional differences in terms of climate, access to infrastructure, inputs, among others. Though it is difficult to discern a clear pattern in terms of trends in per capita cereal production, Figure 1 highlights the importance of maize and sorghum in central and northern provinces. In the case of maize, per capita production levels appear to have recovered in 2006 after a sharp decline in the previous year due to a widespread drought, but such increase was not sustained over time.

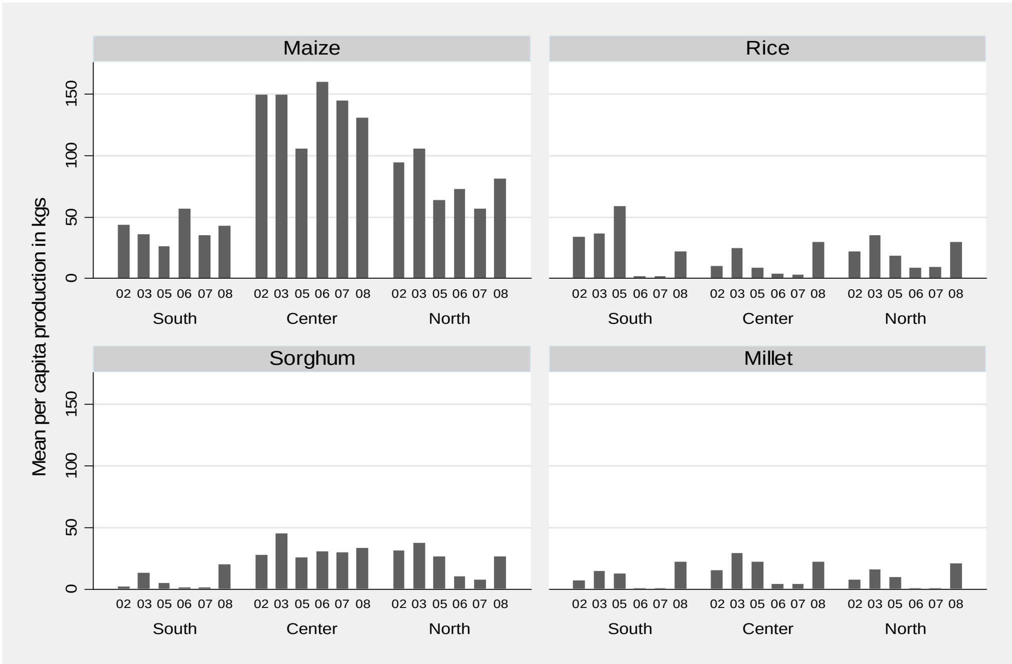

Figure 1. Mean per capita cereal production by year, region and crop

Variations in cereal production can potentially be driven by four factors. The first is technological progress, such as the adoption of improved inputs (e.g. fertilizers, improved seeds). A second source of increase in cereal production could be an improvement in agronomic practices such as line sowing, which affects the density of plants per hectare, hence influencing total cereal production. A third driver is related to changes in cropped area. Total production might be influenced by total area expansion (or reduction). A fourth driver of cereal production is the rainfall distribution in each year since agriculture in Mozambique is almost exclusively rain-fed. We examine each factor in turn[2].

Starting with technological progress, the results show that the percentage of households using improved technologies remains fairly low and unchanged over the last six years (Table 2).

[2] One method to disentangle the main drivers of changes in maize production and productivity could be to use a variance decomposition approach. This is another candidate topic for future research.

Nevertheless, technologies tend to be complementary to each other and looking at changes in a particular technology alone may result in erroneous conclusions. For instance, animal traction was lowest in 2005, a year of widespread drought and lowest per capita production levels. Likewise, the percentage of households who hired seasonal labor was highest in 2006, a year of good rainfall distribution and highest per capita maize production. Taking into account that at present very few households are using improved agricultural technologies (e.g. chemical fertilizers, pesticides, and improved seeds), and the difficulty in establishing a trend in adoption of improved technologies, we speculate that variations observed in cereal production and depicted in Figure 1 are not caused by technological progress in the agricultural sector. Furthermore, most farmers use chemical fertilizers and pesticides in cash crops, and not in cereals.

Table 2. Trends in access to improved technologies and hired labor

	TIA02	TIA03	TIA05	TIA06	TIA07	TIA08
Received extension visits (%)	13.53	13.52	14.77	11.97	10.15	7.74
Membership to farmers association (%)	3.67	4.76	6.39	6.50	8.25	7.43
Hired permanent labor (%)	2.19	1.91	1.84	2.19	2.56	2.98
Hired seasonal labor (%)	15.51	15.32	17.60	23.81	20.76	19.57
Used chemical fertilizers (%)	3.72	2.46	3.76	4.58	3.63	3.16
Used chemical pesticides (%)	6.76	5.12	5.41	5.29	6.51	2.57
Used animal traction (%)	11.22	10.90	9.29	12.38	11.48	14.33

Sources: Authors' own calculations based on TIA02, TIA03, TIA05, TIA06, TIA07, and TIA08 data

The results also show that less than five percent of farmers in Mozambique irrigate their fields, falling short of the target set in the PARPA II. Irrigation plays a determining role in crop production in developing countries (Leiva and Skees, 2008) and can be a catalyst for the adoption of improved technologies.

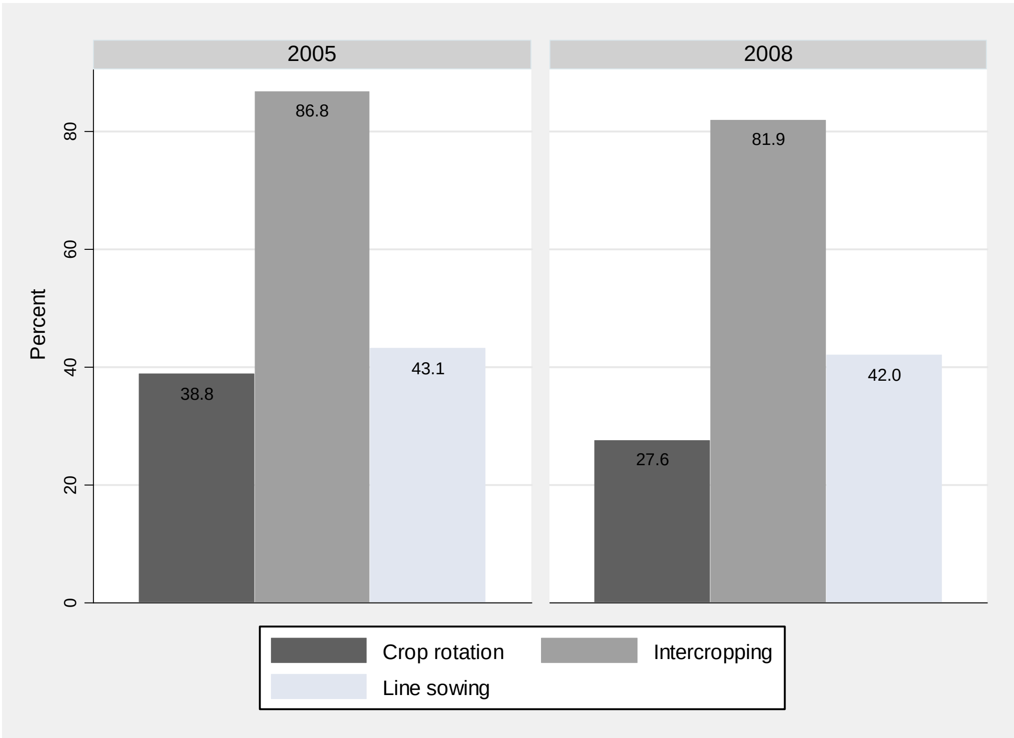

Figure 2. Agronomic practices by year

In terms of agronomic practices, Figure 2 shows a slight decrease in the percentage of households who adopted line sowing. The fact that the use of these three agronomic practices was actually higher in a year of widespread drought than in a presumably better cropping season (in 2008) is worrisome, and implies a decline in the use of the agronomic practices considered here. Indeed, all changes depicted in Figure 2 are statistically significant between 2005 and 2008. The analysis was restricted to two years only, due to data availability. The TIA surveys did not collect this information in other years.

Improved agronomic practices have a significant impact on per capita agricultural production. We examined the relationship between adoption of selected agronomic practices and per capita production. In the case of maize, the average per capita maize production is significantly higher among farmers doing line sowing and intercropping. The same pattern recurs in rice and sorghum, but for illustrative purposes we only present the relationship between line sowing and per capita maize production (Figure 3). In 2008 farmers using line sowing in central provinces achieved per capita maize production levels that were twice as higher, relative to their counterpart farmers in the same region who did not use line sowing. In none of the crops, however, crop rotation was significant. That is not to say that crop rotation does not affect the yields, but this result suggests that crop rotation requires more than one agricultural season for the results to be observed.

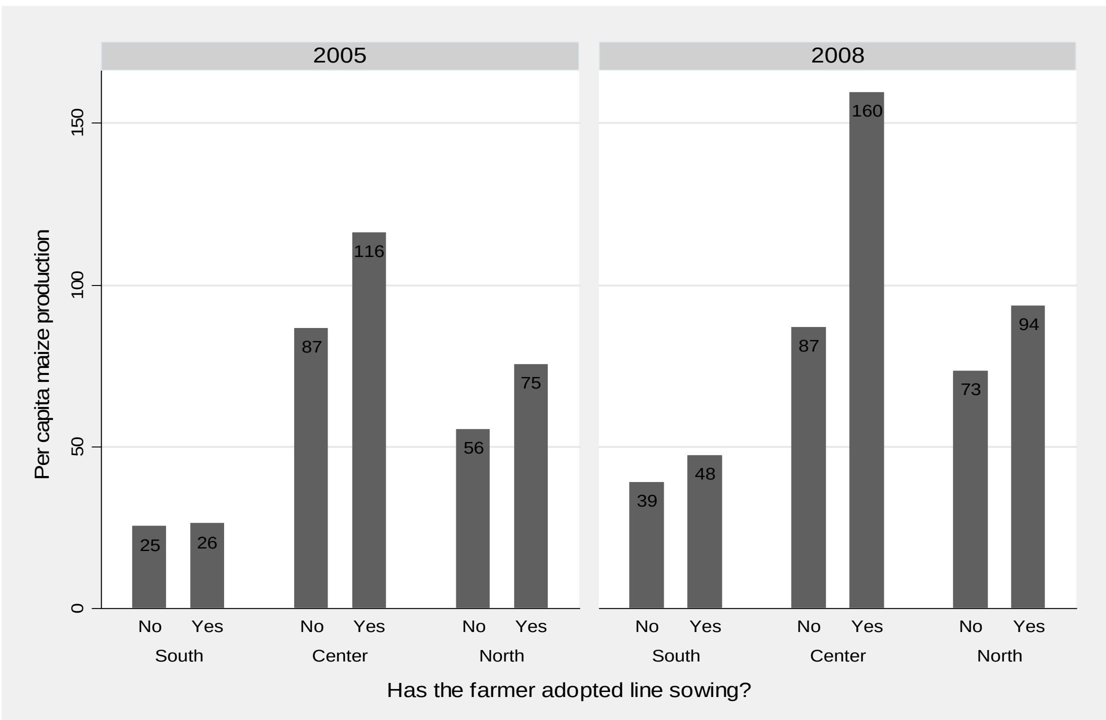

Figure 3. Relationship between line sowing and per capita maize production in 2005 and 2008

In spite of the paramount importance of improved agronomic practices and plant density in increasing cereal production (as elicited in the previous graph), fewer farmers appear to have adopted such practices between 2005 and 2008. Thus, we still believe that variations in total cereal production were not driven by changes in agronomic practices used.

The variation in cereal production observed earlier in Figures 1 is worrisome, considering that the average per capita cultivated area has slightly increased in northern and central provinces (Figure 4), which could imply a decline in cereal productivity over time[3]. Poor households usually increase their production levels through expansion of cropped area, and a decline in cereal production (despite a slight increase in cropped area) implies a lower average yield per hectare. A decline in agricultural productivity will severely affect rural households, especially poor households who own fewer productive assets and have less access to both input and output markets. A direct implication includes an increase in the percentage of households who are food insecure.

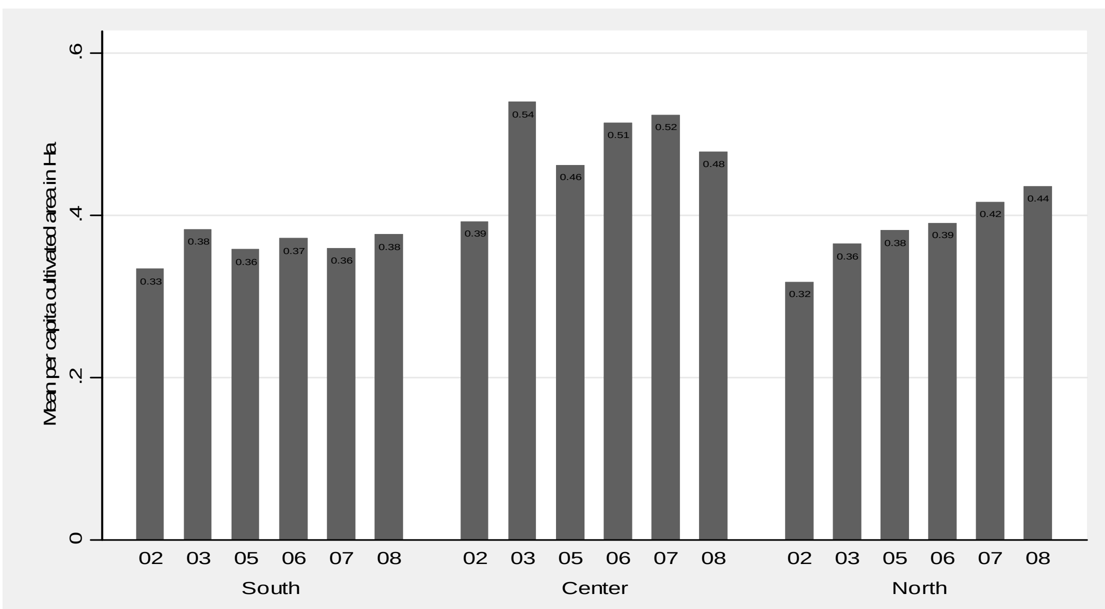

Figure 4. Mean per capita area (hectares) under cultivation with annual crops by region

In a setting where more than 95 percent of farmers do not irrigate their fields, agricultural production will obviously be significantly correlated with rainfall distribution. A somewhat different research question is to evaluate the effect of rainfall distribution in the variation of per

[3] Ideally we should compare variation in cereal production with cereal cultivated area, and not total area under cultivation as is the case in the present analysis.

capita cereal production over time. This could be redressed by using panel methods where one would evaluate the contribution of rainfall distribution to total variation in cereal production. However, TIA02/05 is the only panel data available, comprising the 2001/02 and 2004/05 agricultural seasons, which lie outside the PARPA II period. Thus, we use ordinary least squares (OLS regression) to assess the effect of selected independent variables on per capita cereal production. For the sake of brevity, we focus on per capita maize production as the dependent variable, though the analysis could be easily expanded to include other crops. The vector of independent variables included demographic characteristics, agricultural technology variables, per capita cropped area, rainfall, and district dummies. Rainfall data from each month were used to capture both rainfall distribution and total quantity of rainfall. The results are presented in the appendix section.

The results also suggest that the amount of rainfall in November and December is crucial for achieving better maize yields, which is usually the sowing period in rural Mozambique. Given this climate-driven variability, there may have been a missed opportunity for greater promotion of water conservation technologies and irrigation investments. Subsequent strategic plans should thus promote the adoption of water conservation technologies, drought-tolerant seeds, and also place a higher priority on irrigation investments.

Demographic characteristics were also found significant. For instance, higher per capita maize production levels are found among male headed households. With regard to land variables, per capita cropped area was also important, whereby larger fields were associated with higher per capita maize production levels. Lastly, agricultural technology variables were also significant, implying that farmers who adopted, say fertilizers, attained higher maize yields. Nevertheless, the results are far from conclusive as to what is causing variation in maize production over time, even though the analysis was able to pinpoint some of the factors associated with higher/lower per capita maize production.

The PARPA II outlined policies in various development areas, such as infrastructure and promotion of improved agricultural technologies. The analysis presented in this paper, however, suggests that variations on maize production were not caused neither by the use of improved technologies nor by adoption of better cropping practices or an expansion of cropped area. This is not to say that improved technologies and better cropping practices were not important in determining crop production in each year. Rather, we speculate that most of the changes observed in crop production might be attributed to rainfall distribution in each year, and that PARPA II was not successful in promoting agrarian services, leading to increases in production and productivity. A rigorous analysis is warranted in this subject.

4.1. Per capita cereal production

We use per capita cereal production as a proxy of agricultural productivity. The focus is on labor productivity rather than land productivity (quantity produced per hectare) because the former is measured with less error. Nevertheless, family labor is often considered under utilized/productive because of lack of wage incentive to motivate hard work, and given that few farmers employ hired labor.

Regional disparities in terms of infrastructure undermine the efforts to increase production and productivity in rural Mozambique. For instance, of the two percent of farmers that used tractor mechanization in 2004/05 agricultural season, 50 percent are located in Maputo province, and 75 percent belong to the southern provinces, a region of relatively poorer agricultural potential, but with better road infrastructure and closer links to the nation's capital city.

The importance of improved agricultural technologies in enhancing crop production is evident from Figure 5[4]. Households using chemical fertilizer attain greater per capita maize production than their counterparts. The same pattern is observed with the access to agricultural extension and animal traction. However, the impact of being a member of a farmers' association is less evident. The results thus imply that promoting the adoption of improved technologies would have a significant impact on per capita maize production[5]. Nevertheless, at present fewer farmers have access to improved technologies (e.g. less than 5% used chemical fertilizers in each year).

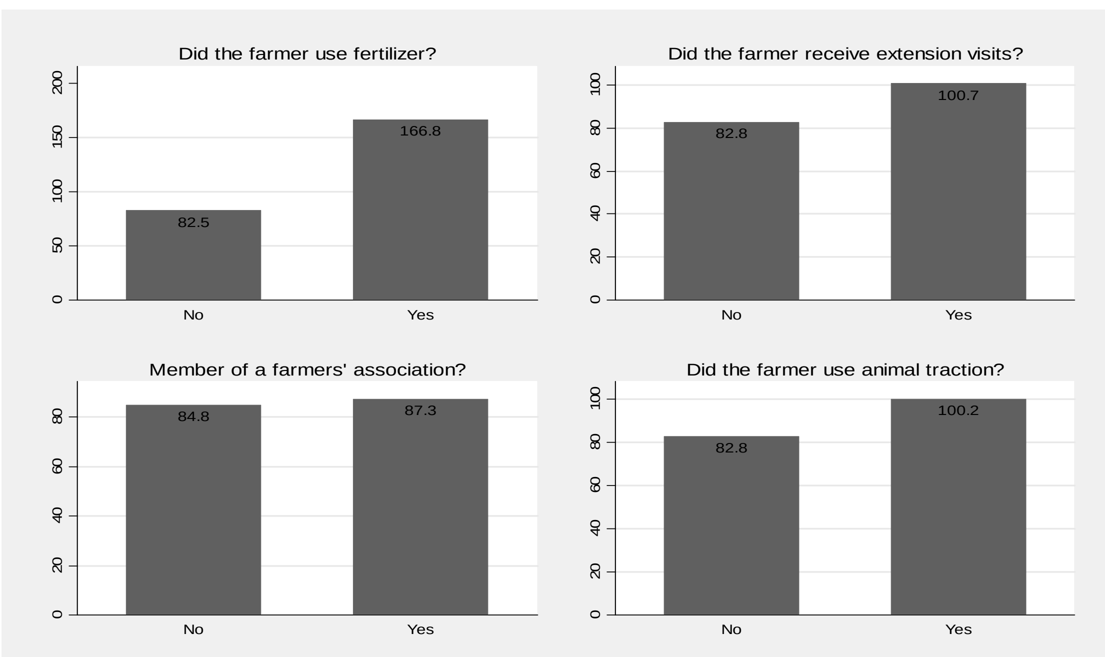

Figure 5. Mean per capita maize production (Kg) by agricultural technology, extension and membership to a farmers' association

[4] Figure 5 uses all six years of data.
[5] Yet there is also reverse causality: increased household income may lead to a higher level of adoption of improved technologies and conversely increased use of improved technologies may lead to an increase in household income.

4.2 Food security

The PARPA II recognizes the very close relationship between poverty reduction, food and nutritional security, rural development and sustainable economic growth. Further, it recognizes that hunger is both the cause and result of poverty. Figure 6 portrays the average number of months each household reported to have a sufficient food supply from own production of the main staple crop. With the exception of 2007, households in Mozambique had an adequate food supply for less than eight months per year. “Regular, predictable access to food is a fundamental right of all people” (Government of Mozambique, 2006, p. 62). The analysis shows that a high proportion of Mozambicans are being denied this fundamental right from their own production, especially in southern provinces. This result also substantiates the widespread empirical evidence suggesting that a significant fraction of farmers in low-income countries are net buyers of crops (Minten and Barrett, 2008; Tiffen, 2003; Boughton et al., 2006). Boughton et al. (2006) argue that at least 61 percent of rural households in Mozambique are net buyers of maize.

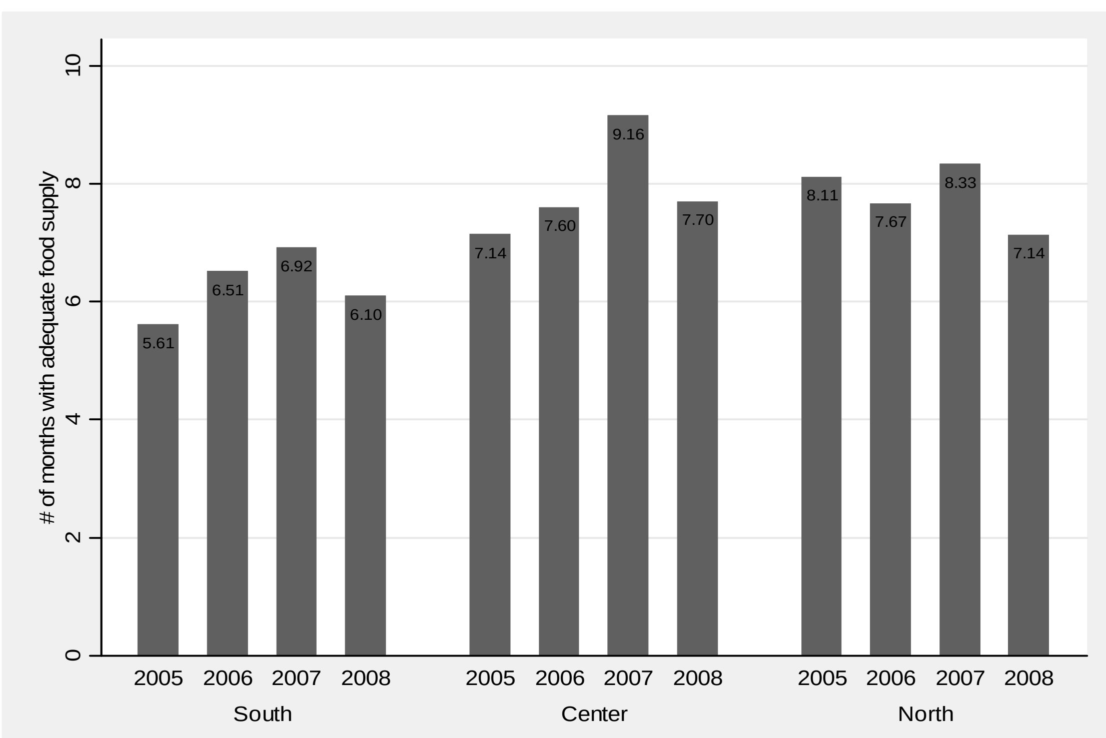

Figure 6. Mean number of months with adequate staple food supply from own production

When faced with food shortage, households choose a variety of coping strategies to combat food insecurity. Table 3 depicts the coping strategies used to deal with food insecurity. The number of households experiencing food shortage has significantly declined from 38 percent in 2005 to about 31 percent in 2008. A possible explanation is that over time households are diversifying their crops. The average number of crops grown by each household slightly increased from 7 in 2002 to about 8 crops in 2005.

In terms of strategies used to cope with food shortage, more extreme behaviors, such as sales of productive assets and removing children from school, hold long-term consequences for the household (Maxwell et al., 2008). Such behaviors, however, have slightly decreased over time. The percentage of households removing their children from school has decreased. Moreover, significantly fewer households are selling their productive assets to cope with food shortage.

Table 3. Percentages of coping strategies used during the lean season for each year

		Agricultural season			
		2005	2006	2007	2008
Household experienced food shortage (%)		38.23	37.35	27.41	31.28
Coping strategies used during the lean season (%)	Eat less-preferred food	87.78	90.34	86.76	86.99
	Reduce number of meals	82.20	85.46	81.83	82.39
	Increase income generating activities	37.69	50.72	50.01	41.14
	Eat all or part of seeds	53.56	49.46	41.31	53.97
	Sell assets abnormally	17.56	26.22	19.24	18.33
	Borrow money	11.04	16.90	15.28	12.24
	Seek government/church/NGO assistance	3.87	5.19	4.07	3.27
	Send children to other households	2.84	3.39	3.92	2.79
	Remove children from school	2.37	2.00	2.07	1.76
	Share food with family/neighbors	40.08	37.91	47.35	38.96
	Other	2.17	1.72	2.69	2.46

Sources: Authors' calculations based on TIA05, TIA06, TIA07, and TIA08

The coping strategy used varies with household typology. For the sake of brevity, we compare the coping strategies based on two household characteristics (Table 4). First, with the exception of reducing the number of meals, the strategies adopted by female headed households are statistically and significantly different from those adopted by their male counterparts. For instance, the former borrow significantly less while the latter are significantly more likely to sell their productive assets. Second, with the exception of engaging in income generating activities and borrowing money, households whose head is engaged in off-farm activities employ all other coping strategies with less frequency. This result underscores the importance of off-farm employment in coping with food insecurity.

Table 4. Percentages of coping strategies used during the lean season by household typology

		Gender of household head			Head is engaged in off-farm		
		Male	Female	P-value	Yes	No	P-value
Coping strategies used during the lean season	Eat less-preferred food	87.69	89.35	0.035	87.68	88.91	0.092
	Reduce number of meals	82.52	83.84	0.149	82.24	83.91	0.047
	Increase income generating activities	45.27	38.33	0.000	55.65	23.92	0.000
	Eat all or part of seeds	50.08	52.89	0.021	49.90	52.39	0.027
	Sell assets abnormally	26.66	20.31	0.000	24.15	26.70	0.025
	Borrow money	14.55	12.05	0.003	14.96	12.08	0.000
	Seek government/church/NGO assistance	4.06	5.09	0.037	4.20	4.59	0.388
	Send children to other households	2.67	3.62	0.035	2.70	3.27	0.166
	Remove children from school	1.96	2.61	0.094	1.93	2.47	0.129
	Share food with family/neighbors	34.35	41.28	0.000	36.33	36.27	0.954
	Other	1.82	2.48	0.059	1.79	2.34	0.090

Notes: Ha: The difference in means is different from zero; ttest procedure in Stata does not allow the use of weights, hence the figures in this Table were not weighted.
Sources: Authors' calculations based on TIA05, TIA06, TIA07, and TIA08

4.3. Agro-processing

The use of improved granaries and other agro-processing equipment can reduce post-harvest losses. Agro-processing mills continue to be the practically exclusive method of agro-processing used in rural Mozambique. The use of thresher and oil presses are rare, and their use has been slightly declining over time (Table 5), possibly due to a lack of maintenance for the pre- existing stock of threshers and oil presses. The reduction in oil presses may also be due to farmers shift out of oilseeds such as sunflowers (which were heavily promoted) into sesame seeds which are sold raw for export.

Table 5. Trends in types of basic agro-processing used (percentage of total households)

	TIA02	TIA05	TIA07	TIA08
Used agro-processing mills (%)	55.09	52.25	57.55	55.92
Used a thresher (%)	0.20	0.21	0.18	0.69
Used an oil press (%)	0.71	0.29	0.35	0.10

Sources: Authors' calculations based on TIA02, TIA05, TIA07, and TIA08 data

4.4. The influence of market signals on production

Figure 7 shows the percentage of households with access to price information. PARPA II sets 38 percent as the target for 2009. The graph shows that PARPA II actions failed to increase the number of households with access to price information. There is a downward trend in the access to price information since 2003.

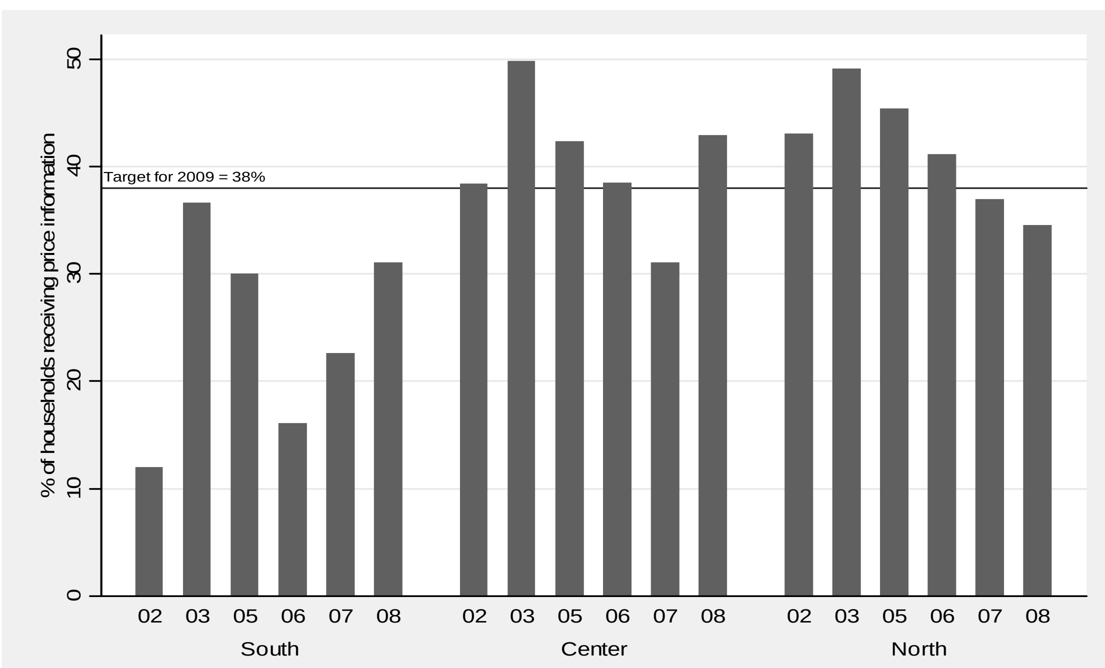

Figure 7. Percentage of households with access to price information by region and year

Access to price information may be correlated with crop production (Walker et al., 2004), as farmers with low levels of production have limited incentives to seek price information. Furthermore, access to price information is positively and significantly correlated with off-farm income (Cunguara and Kajisa, 2009). Figure 8 contrasts per capita maize production with access to price information during the period under analyses. Access to price information is usually positively correlated with higher productivity levels. This is not to say, however, that households receiving price information will necessarily attain higher productivity levels[6].

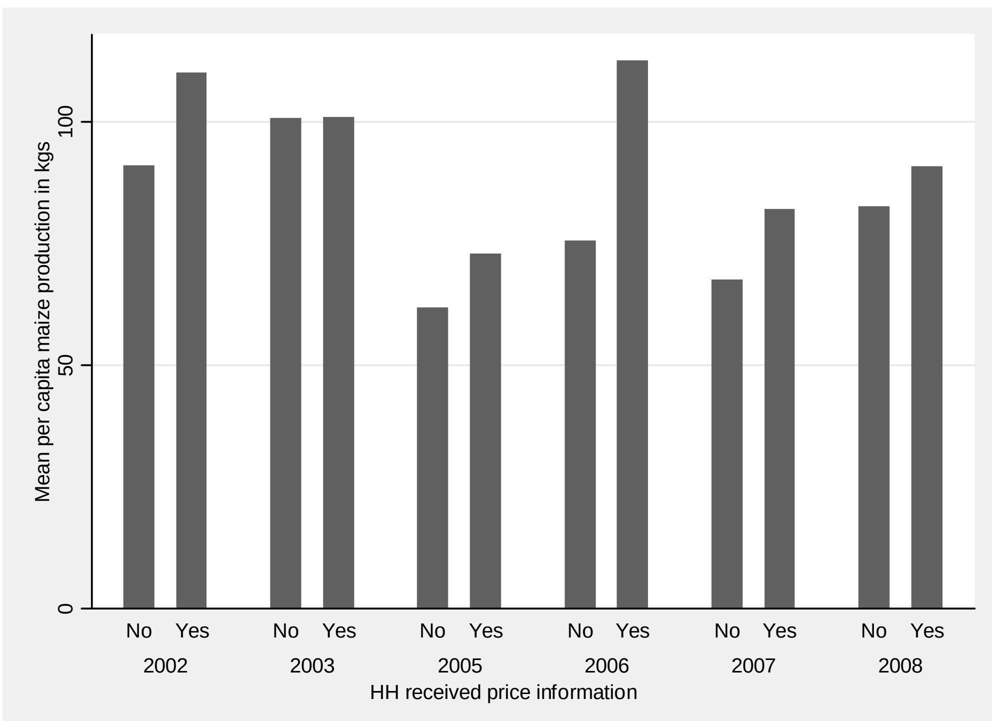

Figure 8. Mean per capita maize production by access to price information and year

5. Determinants of staple food crop availability

[6] Reverse causality may also play a role: more productive farmers may be in a better position to access price information.

In analyzing the determinants of staple food crop availability, a two-step decision making process is outlined. Rural households decide, first, whether or not to grow their main staple food crop. Next, they decide how much to sell, store or give out as gifts, which has an impact on the number of months with available staple food from own production. The model is estimated using the Heckman procedure (Heckman, 1979). The description of independent variables used, as well as the results, is presented in more detail in appendix 2.

The results clearly underline the importance of improved granaries in all three years. Food storage plays an integral part in ensuring household food entitlement (Thamaga-Chitja et al., 2004). High post harvesting losses, sometimes up to 40 percent of total quantity produced with traditional storage methods (Oluoch-Kosura, 2009) stresses the importance of improved granaries. Besides an emphasis on increasing crop production and productivity, subsequent strategic plans should have a strong focus on food storage and agro-processing. Nevertheless, cost/benefit analyses are warranted.

Landholding size is another important factor influencing the number of months with available staple food from own production. This is no surprise considering that a larger size is positively and significantly correlated with higher production levels. Poor households, however, may not be able to increase their landholdings, and adequate food supply has to come from either an increase in productivity or diversification into off-farm employment activities.

In terms of output market participation, households who purchased cooking oil in 2008 tend to have fewer months with available staple food crop from own production. This is in line with Engel’s law, whereby relatively wealthier households (usually those who can afford to purchase cooking oil in rural Mozambique) have more diversified food sources, and hence fewer months with staple food crops from own production.

6. Concluding remarks

This paper evaluates whether or not the PARPA II goal of significantly reducing poverty through the promotion of agrarian services is likely achieved. The results are drawn from six nationally representative surveys from rural Mozambique. Various factors suggest that PARPA II might have missed its goal of increasing agricultural production and productivity and thus reduce poverty. Many indicators set in PARPA II were not achieved, namely its irrigation target, number of farmers with access to price information, number of farmers with access to agricultural extension, increase the availability and access to improved seeds and fertilizers, among others.

We examine four main factors that could have influenced maize production, namely a technological progress, adoption of improved agronomic practices, expansion (or reduction) of cropped area, and rainfall distribution. We speculate that rainfall distribution is the main driving force of the variation observed in cereal production, considering that adoption of improved agricultural practices and improved technologies has been fairly constant over the last six years. The results suggest that PARPA II did not have the desired impact on cereal production in rural Mozambique.

Possible policy responses include promoting the adoption of improved technologies (including fertilizers, pesticides and drought-tolerant seeds), water conservation technologies, and the development of irrigation schemes. Nevertheless, additional studies on the costs and benefits of each of these interventions are warranted.

We also examine trends in food security, measured by variations on staple food crop availability from own production. Besides an emphasis on production and productivity, PARPA should place a stronger focus on food storage. Improved granaries are significantly and positively correlated with longer periods of staple food crop availability. Subsequent poverty reduction strategy plans should promote agro-processing, and diversification of both off-farm activities and crops.

Future research could use a variance decomposition approach to look at the drivers of maize production and productivity over time. It could also use a better proxy of food security, such as an indicator of total calorie availability per capita over time rather than the number of months with adequate staple food supply from own production.

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References

Barrett, C. Smallholders' market participation: concepts and evidence from eastern and southern Africa. Food Policy 33(2008): 299-317.

Boughton, D., D. Mather, D. Tschirley, T. Walker, B. Cunguara, E. Payongayong. Changes in Rural Household Income Patterns in Mozambique 1996-2002 and Implications for Agriculture's Contribution to Poverty Reduction. MINAG Working Paper, Maputo, Mozambique, 2006.

Boughton, D., D. Mather, C. Barrett, R. Benfica, D. Abdula, D. Tschirley and B. Cunguara. Market participation by rural households in a low-income country: an asset-based approach applied to Mozambique. Faith and Economics 50(2007): 64-101.

Burton, M., D. White. Sexual division of labor in agriculture. American Anthropologist 86(1984): 568-583.

Cunguara, B., K. Kajisa. (2009). Determinants of income and schooling investments in rural Mozambique, 2002-2005: A panel and cross-section analysis of the rice growing provinces. Chapter 8. In Otsuka, K., J. Estudillo, and Y. Sawada (eds). Poverty and income dynamics in rural Asia and Africa. New York: Routledge.

Cunguara, B. (2009) Pathways out of poverty in rural Mozambique. Lambert Academic Publishing, Germany.

Ellis, Frank and Freeman, H Ade. (2004). Rural Livelihoods and Poverty Reduction Strategies in Four African Countries. Journal of Development Studies,40(4):1-30.

Government of Mozambique. (2006). Plano de Acção de Redução de Pobreza Absoluta 2006-2009.

Heckman, J.J. Sample selection bias as a specification error. Econometrica 47(1979):153-61.

Heltberg, R., F. Tarp. Agricultural supply response and poverty in Mozambique. Food Policy 27(2002): 103-124.

Lawal-Adebowale, O., A. Oyegbami. Determinants of seasonal arable crop production among selected farmers in Ogun State. Moor Journal of Agricultural Research 5(1)2004: 49-58.

Leiva, A., J. Skees. 2008. Using irrigation insurance to improve water usage of the Rio Mayo irrigation scheme in northwestern Mexico. World Development 36(12): 2663–2678

Mather, D., D. Boughton, B. Cunguara, Household income and assets in rural Mozambique 2002-2005: Can pro-poor growth be sustained? MINAG Working Paper n. 66E, Maputo, Mozambique, 2008.

Maxwell, D., R. Caldwell, M. Langworthy. Measuring food insecurity: can an indicator based on localized coping behaviors be used to compare across contexts? Food Policy 33 (2008) 533–540.

Minten, B., C. Barrett. Agricultural technology, productivity and poverty in Madagascar. World Development 35(5)2008: 797-822.

MPF/IFPRI/PU (Mozambique Ministry of Planning and Finance/International Food Policy Research Institute/Purdue University). 2004. Poverty and well-being in Mozambique: the second national assessment (2002–3). Maputo.

Oluoch-Kosura, W. 2009. Institutional innovations for smallholder farmers' competitiveness in Africa. Lead paper prepared for presentation at the African Economic Research Consortium and University of California Berkeley Conference on Agriculture for Development, May 28th and 29th, Mombasa, Kenya

Thamaga-Chitja, J., S. Hendriks, G. Ortmann, M. Green. Impact of maize storage on rural household food security in northern Kwazulu-Natal. Journal of Family Ecology and Consumer Sciences 32(2004): 8-15.

Tiffen, M. Transition in Sub-Saharan Africa: Agriculture, urbanization and income growth. World Development 31(8)2003:1343-1366.

Walker, T., D. Boughton, D. Tschirley, R. Pitoro, A. Tomo. Using Rural Household Income Survey Data to Inform Poverty Analysis: An Example from Mozambique. Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006.

Walker, T., D. Tschirley, J. Low, M. Tanque, D. Boughton, E. Payongayong, M. Weber. Determinants of Rural Income, Poverty and Perceived Well-Being in Mozambique in 2001-2002. MINAG Research Report No. 57E, Maputo, Mozambique, 2004.

Appendix

1. OLS regression of per capita quantity of maize produced

Tabela A1. OLS regression results of maize production (dependent variable: log of per capita maize production)

Independent variables: Total rainfall (mm) in […]	2002			2003			2005			2006			2007			2008		
	Coeff	Std.E.	Pval.	Coeff	Std.E.	Pval.	Coeff	Std.E.	Pval	Coeff	Std.E.	Pval.	Coeff	Std.E.	Pval.	Coeff	Std.E.	Pval.
Head's gender (1=male)	0.115	0.051	0.023	0.156	0.054	0.004	0.142	0.053	0.008	0.162	0.055	0.003	0.198	0.051	0.000	0.067	0.071	0.341
Head's years of education	0.019	0.010	0.058	0.003	0.010	0.738	-0.007	0.010	0.466	0.009	0.008	0.285	0.010	0.008	0.245	0.028	0.010	0.005
Head's age	0.001	0.001	0.682	-0.001	0.002	0.683	-0.003	0.002	0.031	0.001	0.001	0.467	0.000	0.001	0.973	-0.004	0.002	0.048
Head is salaried	-0.102	0.057	0.073	-0.115	0.052	0.027	-0.048	0.053	0.357	-0.108	0.047	0.021	-0.036	0.045	0.414	-0.216	0.056	0.000
Head is self-employed	0.039	0.045	0.385	0.037	0.044	0.398	0.133	0.045	0.004	-0.027	0.043	0.530	0.058	0.041	0.151	-0.002	0.053	0.972
Total per capita cropped area	1.078	0.122	0.000	0.779	0.121	0.000	1.107	0.125	0.000	0.831	0.118	0.000	0.944	0.062	0.000	1.036	0.088	0.000
HH used fertilizers (1=yes)	0.095	0.093	0.308	0.147	0.097	0.131	0.190	0.099	0.056	0.135	0.079	0.090	-0.166	0.093	0.073	0.000	0.126	0.997
HH used animal traction (1=yes)	0.126	0.075	0.090	-0.014	0.072	0.848	0.137	0.091	0.131	0.210	0.069	0.002	0.147	0.076	0.052	0.441	0.089	0.000
HH received extension visits (1=yes)	0.129	0.053	0.015	-0.002	0.059	0.971	0.043	0.059	0.461	0.169	0.057	0.003	0.080	0.060	0.187	0.298	0.080	0.000
October	0.011	0.021	0.581	-0.044	0.008	0.000	-0.012	0.015	0.430	0.170	0.031	0.000	0.417	0.065	0.000	0.078	0.017	0.000
October – squared term	-0.002	0.001	0.003	0.000	0.000	0.000	0.000	0.000	0.274	-0.008	0.001	0.000	-0.006	0.001	0.000	0.000	0.000	0.000
November	-0.049	0.010	0.000	0.072	0.013	0.000	-0.008	0.007	0.243	0.034	0.012	0.004	-0.088	0.021	0.000	-0.081	0.012	0.000
November – squared term	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.417	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
December	0.014	0.007	0.048	0.000	0.005	0.986	-0.031	0.014	0.024	0.001	0.003	0.746	0.030	0.008	0.000	-0.028	0.006	0.000
December – squared term	0.000	0.000	0.913	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.631	0.000	0.000	0.000	0.000	0.000	0.000
January	-0.002	0.003	0.586	-0.006	0.008	0.461	0.023	0.007	0.001	0.017	0.007	0.012	0.036	0.005	0.000	0.013	0.012	0.278
January – squared term	0.000	0.000	0.133	0.000	0.000	0.430	0.000	0.000	0.000	0.000	0.000	0.137	0.000	0.000	0.000	0.000	0.000	0.723
February	0.008	0.003	0.024	0.032	0.009	0.001	0.010	0.011	0.349	-0.014	0.016	0.392	0.016	0.005	0.001	-0.016	0.006	0.006
February – squared term	0.000	0.000	0.013	0.000	0.000	0.051	0.000	0.000	0.477	0.000	0.000	0.209	0.000	0.000	0.000	0.000	0.000	0.192
March	-0.001	0.006	0.903	-0.009	0.005	0.045	-0.004	0.010	0.704	0.005	0.006	0.422	0.161	0.041	0.000	0.020	0.007	0.003
March – squared term	0.000	0.000	0.911	0.000	0.000	0.177	0.000	0.000	0.659	0.000	0.000	0.599	-0.001	0.000	0.000	0.000	0.000	0.000
Intercept	1.724	0.543	0.002	1.743	0.533	0.001	3.108	1.030	0.003	0.262	2.195	0.905	-5.080	0.719	0.000	5.399	1.314	0.000
Number of observations	3987			3910			3673			4218			4221			3304		
F statistic	27.40			22.40			20.47			26.75			304.3			23.97		
Prob > F	<0.01			<0.01			<0.01			<0.01			<0.01			<0.01		
Adjusted R square	0.432			0.386			0.370			0.412			0.389			0.456		

Notes: Std. E = Standard Error; Pval. = P values; District dummies were used but are not reported

Sources: Authors' calculations based on TIA02, TIA03, TIA05, TIA06, TIA07, TIA08 and Fewsnet (Famine Early Warning System Network) rainfall data

2. Determinants of staple food crop availability – Heckman approach

The dependent variable in the selection equation is whether or not the household grew the staple food crop. The choice of which crop to grow depends on demographic characteristics. For instance, female headed households may choose to grow less labor intensive crops due to their role as housekeepers and caregivers (Burton and White, 1984), while their male counterparts would tend to grow more marketable crops. It also depends on whether or not the household has access to improved inputs. Hence, the independent variables in the selection equation include some demographic characteristics (gender of household head, head's education, household size, and head's age), participation in off-farm employment, and which crop is considered to be the staple one.

The dependent variable in the levels equation is the number of months the household reported to have adequate staple food surplus (from own production). The duration of the lean season, however, is influenced by other factors beyond the control of the farmer, such as storage losses and the climate. Nevertheless, the number of months of adequate food supply can still be regarded as a choice decision considering that the length of the lean season is correlated with some of the decisions made by the farmer (agronomic practices used, cropped area, farming system, type of granary used, among others).

The independent variables in the levels equations include whether or not the household owns an improved granary. Those who own an improved granary can either store food for own consumption (hence have longer periods of available staple food from own production) or use it as a cash earning strategy and sell the staple food when needed (Heltberg and Tarp, 2002).

Food access can also be achieved through market participation (Barrett, 2008). We thus include some variables on market participation and whether or not the household head is engaged in off-farm activities as additional independent variables. We also include cultivated area (to control for the quantity produced), and location dummies (to control for provincial differences in terms of production and productivity). The results are presented in Table A2.

Table A2. Heckman model results of staple food crop availability

Number of months of adequate food supply	TIA05			TIA06			TIA08		
	Coeff.	Std. E	Pvalue	Coeff.	Std. E	Pvalue	Coeff.	Std. E	Pvalue
HH owns an improved granary	0.322	0.132	0.015	0.310	0.115	0.007	0.517	0.133	0.000
Head is engaged in salaried employment	0.006	0.117	0.962	0.003	0.102	0.979	-0.446	0.117	0.000
Head is self-employed	0.130	0.102	0.201	0.162	0.092	0.080	0.126	0.103	0.223
Total cultivated land in hectares	0.138	0.017	0.000	0.159	0.017	0.000	0.160	0.024	0.000
HH purchased maize (grains) during lean season	1.736	0.115	0.000	1.497	0.104	0.000	1.847	0.114	0.000
HH purchased maize flour during lean season	1.105	0.122	0.000	1.047	0.108	0.000	0.975	0.124	0.000
HH purchased rice during lean season	-0.178	0.125	0.156	0.001	0.113	0.991	-0.065	0.123	0.598
HH purchased cassava during lean season	0.826	0.138	0.000	1.070	0.119	0.000	0.586	0.133	0.000
HH purchased peanuts during lean season	0.032	0.146	0.826	-0.255	0.131	0.051	0.023	0.139	0.870
HH purchased beans during lean season	0.602	0.124	0.000	0.320	0.113	0.005	0.064	0.123	0.602
HH purchased cooking oil during lean season	-1.091	0.120	0.000	-0.534	0.111	0.000	-0.672	0.127	0.000
Location dummy: 1=Cabo Delgado	-0.404	0.237	0.088	-0.692	0.230	0.003	-1.022	0.228	0.000
Location dummy: 1=Nampula	-0.674	0.225	0.003	-1.936	0.217	0.000	-2.142	0.211	0.000
Location dummy: 1=Zambézia	-2.198	0.224	0.000	-1.437	0.216	0.000	-2.500	0.212	0.000
Location dummy: 1=Tete	-1.584	0.233	0.000	-1.313	0.224	0.000	-0.612	0.217	0.005
Location dummy: 1=Manica	-2.748	0.254	0.000	-1.757	0.232	0.000	-2.665	0.238	0.000
Location dummy: 1=Sofala	-2.537	0.257	0.000	-2.102	0.232	0.000	-1.232	0.243	0.000
Location dummy: 1=Inhambane	-2.409	0.305	0.000	-2.408	0.254	0.000	-1.596	0.265	0.000
Location dummy: 1=Gaza	-3.916	0.290	0.000	-2.865	0.230	0.000	-2.640	0.249	0.000
Location dummy: 1=Maputo	-3.741	0.352	0.000	-1.907	0.286	0.000	-2.457	0.285	0.000
Intercept	3.426	0.385	0.000	3.400	0.327	0.000	3.993	0.366	0.000
Selection equations									
HH grew the staple food crop	2.233	0.071	0.000	3.400	0.100	0.000	2.984	0.083	0.000
Head's gender (1=male)	-0.143	0.056	0.010	-0.101	0.083	0.223	0.095	0.065	0.144
Head's years of schooling	-0.001	0.009	0.955	-0.026	0.012	0.030	-0.036	0.009	0.000
Head's age	-0.021	0.001	0.000	-0.022	0.002	0.000	-0.024	0.001	0.000
Household size (# of members)	-0.036	0.005	0.000	-0.018	0.009	0.041	-0.038	0.008	0.000
Head is engaged in salaried employment	-0.287	0.051	0.000	-0.269	0.068	0.000	-0.318	0.058	0.000
Head is self-employed	-0.207	0.045	0.000	-0.242	0.063	0.000	-0.171	0.054	0.002
Rice is the main staple crop (1=yes)	-0.612	0.097	0.000	-0.557	0.112	0.000	-0.522	0.105	0.000
Sorghum is the main staple crop (1=yes)	-0.239	0.111	0.031	-0.073	0.159	0.646	0.395	0.216	0.067
Millet is the main staple crop (1=yes)	-0.228	0.146	0.119	-0.426	0.209	0.042	-0.774	0.238	0.001
Cassava is the main staple crop (1=yes)	0.207	0.068	0.002	-0.178	0.090	0.047	0.075	0.081	0.355
Sweet potatoes is the main staple crop (1=yes)	-0.034	0.374	0.929	-1.098	0.442	0.013	NA	NA	NA
Regional dummy: 1=central provinces	0.381	0.053	0.000	-0.076	0.081	0.348	-0.154	0.064	0.016
Regional dummy: 1=northern provinces	0.758	0.063	0.000	-0.041	0.084	0.622	0.074	0.073	0.309
Mills lambda	-.028	.377	0.941	.235	.765	0.759	.160	.556	0.773
Wald $\chi^2_{(21)}$	1568.2			1349.9			1247.9		
Prob > χ^2	0.000			0.000			0.000		
Number of observations	6136			6246			5961		
Number of censored observations	1609			909			1248		

Sources: Authors' calculations based on TIA05, TIA06, and TIA08 data