DOES SELLING FRUITS OR VEGETABLES PROVIDE A STRATEGIC ADVANTAGE TO SELLING MAIZE FOR SMALL-HOLDERS IN MOZAMBIQUE?

A DOUBLE-HURDLE CORRELATED RANDOM EFFECTS APPROACH TO EVALUATING FARMER MARKET DECISIONS

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ABSTRACT

DOES SELLING FRUITS OR VEGETABLES PROVIDE A STRATEGIC ADVANTAGE TO SELLING MAIZE FOR SMALL-HOLDERS IN MOZAMBIQUE? A DOUBLE-HURDLE CORRELATED RANDOM EFFECTS APPROACH TO EVALUATING FARMER MARKET DECISIONS

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Strong growth in per capita income combined with the highest urban population growth in the world is beginning to generate rapid changes in African food systems. Combined with high income elasticity for fresh produce among consumers in Mozambique, the focus of this thesis, demand for fresh fruits and vegetables (FFV) is expected to multiply between four and six times between 2000 and 2030, providing local Mozambican farmers a great opportunity, although this opportunity has not yet been realized by many. Meeting this challenge will require major changes in the structure of production, including a greater role for larger-scale commercial operations to complement increasingly commercialized smallholder production. Strengthening the ability of the local sector to meet rapidly rising fresh produce demand must take into account differences and similarities across fruit, vegetable and maize sellers, and can be done with the investments of both the public and private sectors.

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First, I acknowledge Christ Jesus, “for from Him and through Him and to Him are all things, to Him be the glory forever” (Romans 11:36), a statement as appropriate as ever in the case of this endeavor and season of my life.

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LIST OF ACRONYMS

APE	Average Partial Effect
CDF	Cumulative Density Function
ERS	Economic Research Service
ESA	Eastern & Southern Africa
GDP	Gross Domestic Product
FFV	Fresh Fruits and Vegatables
IAF	*Inquérito aos Agregados Familiares* - Mozambique National Expenditure Survey
IMR	Inverse Mills Ratio
MSU	Michigan State University
MTN	*Meticais Novos* (current Mozambican currency as of 2006)
PDF	Population Density Function
PE	Partial Effect
R&D	Research and Development
TIA	*Trabalho de Inquérito Agrícola* - Mozambique National Agricultural Survey
USDA	United States Department of Agriculture

Chapter 1: Introduction

Despite decades-long negative or stagnant growth in productivity and GDP levels, a rapid transformation is occurring among African countries since 2000**.** Among the top ten performing countries in the world in GDP growth during this period, six are in Sub-Saharan Africa (Angola, Nigeria, Ethiopia, Chad, Mozambique and Rwanda, *The Economist* 2011). Together with some of the highest urban population growth rates in the world, this income growth is driving even more rapid growth in demand for higher quality foods such as fresh produce, meat, and dairy products. With the rate of change these countries are seeing now, some projections have estimated the current levels of market demand for fresh produce alone will quadruple over the next 30 years, with growth estimates ranging up to six times the current market demand for fresh produce just in its raw form (Tschirley et al., *forthcoming*). In such a rapidly transforming economy, per capita growth in fresh produce production will have to rise very rapidly to keep pace with the rising demand. In Mozambique – the focus of this thesis - domestic production has even more room to grow because so much of the fresh produce supplied to the capital city of Maputo, the primary urban market, originates in South Africa. Based on estimated current import shares and likely growth in demand, more efficient production and marketing by Mozambican farmers that allows for import substitution could support growth rates in excess of 10% per year for 30 years.

In East and Southern Africa (ESA), it has been shown that, despite the success of export horticulture in some countries, and the great interest in replicating this in many countries, domestic and regional systems will contribute most to total growth in demand over at least the next 20 years. In addition, though supermarkets will continue to grow on the continent, the broad consensus is now that their take over of market share will be much slower than was anticipated by some, leaving the so-called "traditional" sector as the dominant marketing channel for fresh produce for many years to come (Humphrey 2007, Traill 2006, Minten 2008, Tschirley et al. 2010).

There are many possibilities that horticulture commercialization offers to smallholder farmers, however there are also many constraints smaller farmers face in order to take advantage of these opportunities**.** The value that can be gained from horticultural sales per unit of land is far greater than for widely marketable food crops and even for cash crops such as cotton and tobacco.[1] This very high production value per unit land area makes horticulture particularly attractive for land-constrained farmers -- who are the most likely to be poor. Since women frequently own the smallest plots, the ability to capitalize on horticultural production might also have the benefit of off-setting gender disparities in land access by enabling women to work their way out of poverty through agriculture. The fact that product can be sold from a single horticultural field multiple times over several weeks or months also provides built-in price risk management opportunities that typical staple or cash crops do not offer. However, some of the risks of horticultural marketing include (a) greater risk of losing one's crop to pest or disease, (b) high cost of inputs (fertilizer and pesticides) for a successful harvest, (c) very high price variability, and (d) higher post-harvest perishability than other crops that are more easily stored or can travel further distances to a market without spoiling.

[1] See Appendix A for a comparison of crop value and input costs in Zambia, performed by Chapoto et al. (forthcoming), which clearly illustrates the relative gross margins between maize, cotton and horticultural crops.

The question then emerges of what type of smallholder farmer is able to successfully exploit the opportunities provided by horticultural marketing, and whether these farmers look different from those able to successfully exploit marketing opportunities for other crops. Two recent analyses of the determinants of marketing behavior of Mozambican smallholder farmers highlight the importance of personal household characteristics and private assets in driving households' ability to participate in markets (Boughton, et al. 2007, Mather, Boughton and Jayne 2011) . These and other analyses are reviewed in chapter three. In this thesis, these two papers are built upon and extended by (a) examining a new crop group – fresh produce – that few if any authors have yet examined, and (b) testing an enhanced number of variables, especially new variables related to household location-specific characteristics. Given the differing characteristics of fresh produce compared to most other food staple crops and cash crops, explained above, it is hypothesized that the determinants of fresh produce marketing will differ from those of these other crops in the following ways:

- Land holdings will be substantially less important in explaining market participation, though it may remain important in explaining the value of sales;
- Controlling for land-holdings, a household's being female-headed will continue to have a negative impact on market participation and on the value of sales. This impact is, however, likely to be the result of other factors correlated with having a female household head that may not be perfectly controlled for in the analysis, such as ownership of productive assets and access to capital;

- Yet, because female-headed households are widely found to possess less land than male-headed households, findings overall will suggest that fresh produce provides opportunities to female-headed households that other crops do not;
- Measures of household education may be more important than for other crops, given the input- and knowledge-intensive nature of fresh produce production;
- Location-specific factors will be more important in explaining fresh produce market participation and value of sales. This will manifest itself in two ways: a greater need for close proximity to (a) urban areas and good roads due to the high perishability of fresh produce, and (b) bodies of water to support irrigation during the cool-dry season, which is when pest pressure is least pronounced for these crops;

This thesis proceeds as follows. Chapter two provides detail on the data sets used, then present a descriptive survey of fresh produce and maize production and markets in Mozambique over the last decade. Chapter three presents an econometric approach to help profile successful maize and fresh produce sellers and the results of this model, and implications of the study are summarized in conclusion (chapter four).

Chapter 2: Fresh Produce and Maize: A Descriptive Overview of Demand and Supply in Mozambique

This chapter begins by describing the data used in this study, continues by contextualizing this paper's topic within the ESA setting of population growth, rising urban per capita incomes and the effects of these on the demand for fruit, vegetables and maize. The succeeding sections then elaborate on the specific empirical record of the production and market activity of Mozambican commercialized sellers of fresh produce and maize, in taking advantage of the opportunities this local increasing demand offers.

2.1 Description of the Data

This section outlines the sources of data used in this paper, starting with the primary Mozambique survey data used in the empirical portions of this study, followed by a description of the supplemental datasets drawn upon in the introductory section 2.2, and ends with a section describing the spatial data used in the creation of five location–specific variables used in the descriptive and econometric analyses of rural Mozambican households found in sections 2.3 and 3.2 - 3.5..

2.1.1 Rural household survey data

Michigan State University has assisted in the collection of nationally representative rural household survey data in Mozambique called the TIA (short for the Portuguese *Trabalho de Inquérito Agrícola*) for many years. The data collected in years 2002 and 2005 constituted the most recent panel of this series. 4,908 households were interviewed in 2002. The 2005 sample created a panel with 2002 and added 1,241 households (for a total sample size of 6,149) to be fully representative of conditions in

2005. Because of attrition, 4,104 of the 4,908 households interviewed in 2002 were able to be re-interviewed in 2005. When presenting descriptive results in Chapter 2, the full 2005 data set is used. The econometric analysis presented in chapter three uses only the panel households. As of this writing, the most recent year in which TIA data was collected was 2008. Descriptive statistics using this most recent information are therefore also used in the descriptive section of this paper, noting the relevant year. Survey weights were applied according to the stratified sampling design of the survey in the case of each year's data for all computed statistics in this paper.

The data collected by the TIA includes household agricultural information on cultivation practices, production, area and ownership of fields, sales, receipt of agricultural price information, and prices at which sales occur for total value estimates among a large variety of crops. In addition to this information, a rich set of household and community level questions which are used to form variables in this analysis includes information on the gender, age, illness, death, education level, and farmer association membership of household head; family composition in terms of gender, ages, consumption, occupation, and income of household members; and the degree to which each community is affected by flood, drought, crop or livestock disease in the given year, and the community's proximity to primary natural water sources.[2]

[2] Data may be requested from Directorate of Economics, Ministry of Agriculture, Mozambique. The author can refer interested parties to MSU personnel that can facilitate such a request.

2.1.2 Supplemental Data

Income elasticities data from **USDA**: The Economic Research Service of USDA estimated income elasticities of demand for a variety of food groups over 127 countries, using national household expenditure survey data (see "International Food Consumption Patterns: Income elasticity for food subgroups," found at http://www.ers.usda.gov/data/internationalfooddemand). This data is used to demonstrate the expected magnitude and continued rise in demand for higher valued crops, including fresh produce.

Population Information from the **World Bank:** The World Bank has estimates of a variety of population statistics over the past 50 years for every country in the world. This study uses their data on population growth, urban share of population growth and urban population as a percentage of total population growth. These data can be found via their databank link at the website http://data.worldbank.org/topic/urban-development.

2.1.3. Spatial Data

This study uses a number of spatial variables created using the latitude and longitude coordinates of each of the 647 TIA villages. These coordinates were not always recorded very precisely in the original questionnaire. To resolve this problem, I use a list of over 10,000 village names in Mozambique and their accurate GIS latitude and longitude coordinates to reassign these verified coordinate points to the villages in the TIA, where possible. Of 647 villages, 236 are matched directly by name, 182 are matched after comparing the TIA names with the list of over 10,000 names and assigning matches where appropriate[3] and 229 are not able to be matched at all. In this latter case the original TIA coordinate data is used. When projected within ESRI's ArcMap10, 36 of the 647 villages are found to lie outside the national boundaries of Mozambique – all 36 are cases in which the original TIA coordinates were used and no match by village name to a more accurate coordinate point was made. These village-cases are eliminated from the map for the ensuing village variable creation, and their households are assigned the village-average variable values for the district in which they lie.

The village level variables created with these coordinate points (later assigned to all households within each respective village) include the following:

A. Average population density within a 10 km radius of the village. I generate this variable using the geoprocessing tools *buffer*, *clip*, and the "zonal statistics as table" feature within ArcMap10. The data used to create this variable are the United Nations' 2005 estimates given in population density grids of persons/square kilometer, urban extents, and "urban points"/settlement points, obtained from the Global Rural-Urban Mapping Project (GRUMP), all of which can be obtained from the website http://sedac.ciesin.columbia.edu/gpw/global.jsp.

B. Average elevation within a 5 km radius of the village. I generate this variable in a similar way as the population density variable. It uses v4.1 of the 90m digital elevation data collected by the Shuttle Radar Topography Mission (SRTM), originally produced by NASA and obtained from the Consultative Group on International Agricultural Research - Consortium for Spatial Information (CGIAR-CSI). These can be

[3] The author thanks Ellen Payongayong and David Tschirley for their help in verifying the accuracy of these matches.

downloaded in very large grid-by-grid files from the website http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp.

C. A land cover "irrigation potential" dummy variable. The 2000 Global Land Cover database produced by the Global Vegetation Monitoring Unit (a smaller component of the Global Environment Monitoring Unit) of the European Commission's Joint Research Centre contains 24 global land classifications. I use these data to establish whether a household resided within 1 km from a river or lake, within a swamp area (forest or bush/grass land) or was given the land cover classification of "irrigated cropland." This data can be obtained from the website http://bioval.jrc.ec.europa.eu/products/glc2000/products.php.

D. A variable for the total kilometers of primary or secondary road surface is created at the district level using Africa-wide Michelin road data which is not available for free online.[4] Road data obtained from the Digital Chart of the World also is used to supplement this road data within the borders of Mozambique. This data is free and can be downloaded from the website http://www.diva-gis.org/datadown.

E. Hours in travel time to the nearest town or city of 10,000 inhabitants or more is generated using the "cost distance" function in ESRI's ArcInfo10 Workstation. Parameters specifying the length of time it would take an individual to travel along roads of various qualities, or off-road, given land cover and elevation considerations (slope impedance values and speed of travel were assigned given assumptions about travel by foot, bike or car for example) are all incorporated in this raster analytic environment

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[4] These data were obtained from Jordan Chamberlin who had used them previously in several versions of cost-distance variable creation (see E in this section) in ESA countries while working for the International Food Policy Research Institute.

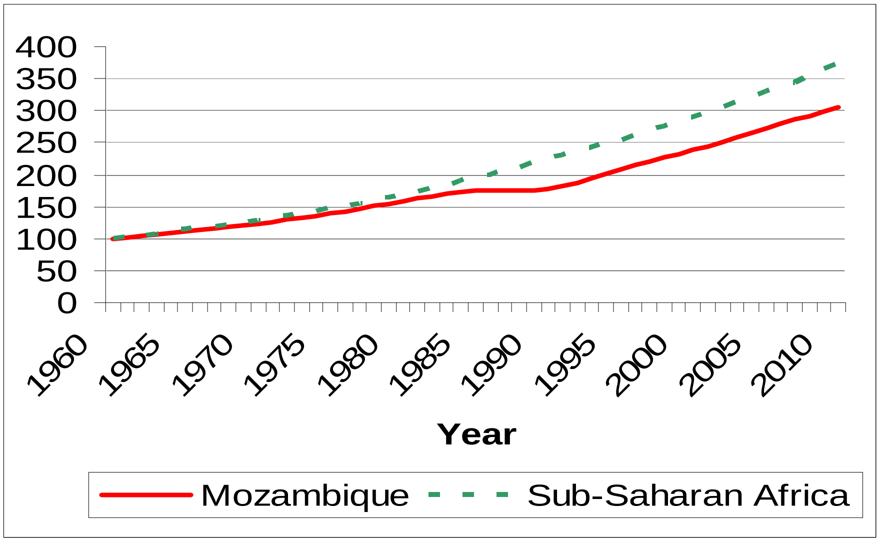
combining the elevation, land cover and roads data described above to calculate the number of hours to a center of population density greater than 10,000, using the GRUMP population data described above. The only data I use in the creation of this variable in addition to those described in A-D above are administrative/political country boundaries for which a general 30 minute delay was added in terms of added time to traverse. This is relevant for villages close to the border of the country who may be selling across the border. These Global Administrative Unit Layer (GAUL) maps are available through the Food and Agriculture Organization of the United Nations (FAO) and can be found at the website http://www.fao.org/geonetwork/srv/en/metadata.show?currTab=simple&id=12691 or from MSU's Food Security GIS Resources Website: http://www.aec.msu.edu/fs2/gis/boundaries.html. More information on the creation of this variable can be found in Appendix B.[5]

[5] The author thanks Jordan Chamberlin and Steven Longabaugh for their help and the various sessions held together to learn the process of cost-distance variable creation using ESRI's ArcMap10.

2.2 Strong Prospects for Fresh Produce Growth

The population in Sub-Saharan Africa has tripled over the past 50 years, starting at a little over 200,000,000 in 1960, and surpassing 850,000,000 by 2010 (World Bank). Figure 1 shows this increase in the form of an index, base year 1960 population = 100, for Mozambique and Sub-Saharan Africa as a whole. Moreover, urban population as a percentage of total population is also rapidly increasing. In Mozambique, this percentage has grown from 5% in 1960 to close to 40% in 2010 (Figures 2 and 3). Per capita income of these increasingly urban habitants is also projected to increase dramatically as industries continue to grow and develop, providing manufacturing job income to many who are leaving their rural homes for the higher wages provided in these sectors.

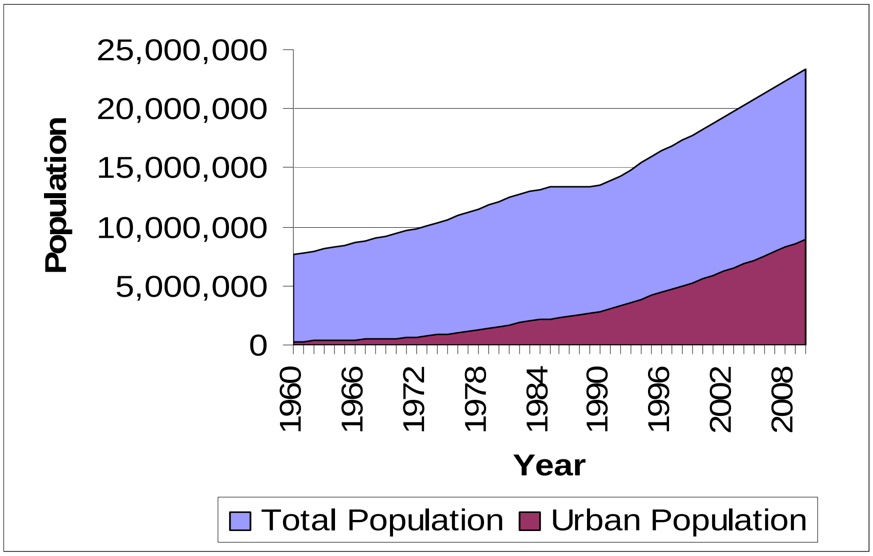
Figure 1: Population Growth, Index Base Year 1960



Source: World Bank

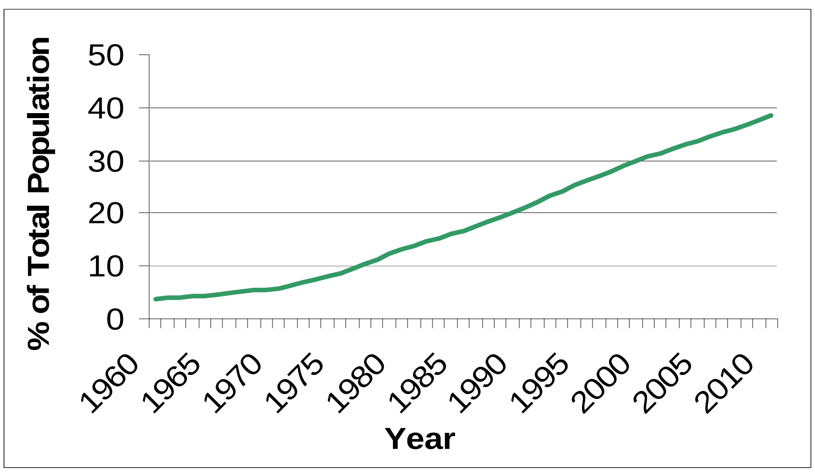
Note: For interpretation of the references to color in this and all other figures, maps or tables, the reader is referred to the electronic version of this thesis.

Figure 2: Urban Share of Population Growth in Mozambique, 1960-2010



Source of Data: World Bank

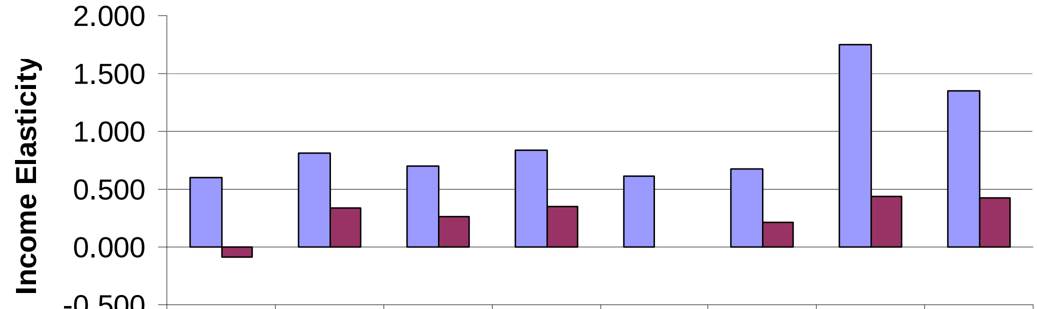
Figure 3: Urban Population as Percentage of Total in Mozambique



Source of Data: World Bank

Growth in income and urban population shares have led to a situation where expenditure on fresh produce, meat and dairy products is rising more rapidly across developing countries than anywhere in the world. In the long-run, as incomes rise, the income elasticity of demand for food falls. This can be represented by comparing the relative income elasticities for a variety of food groups in Mozambique to a higher-income country such as the United States, as is visually depicted in figure 4. The income elasticity for a crop represents the percentage change in consumption for a 1% rise in income. In every food category, the income elasticity of demand in the U.S. is less than the respective elasticity in Mozambique, meaning that if those in the U.S. received 10% more in income, their spending on food would rise less in percentage terms than the respective expenditures of an average African. The reason for this is intuitive: as incomes rise, proportionately less of one's salary needs to be spent on items such as food, and can be designated to functions or items that are less vital or necessary to life: this is Engel's Law. Bennett's Law represents a similar and related concept which is also evidenced by the elasticity patterns in figure 4: as incomes rise, the types of foods that are consumed tend to transition from cheaper and often less nutritionally-rich goods such as grains, to "luxury" food items such as dairy, meat, and fresh produce. All of the latter food types have higher income elasticities than the elasticity for cereal, which is actually negative in the case of the U.S. Given these two economic principles (Engel's Law and Bennett's Law) at work in lower-income developing countries such as Mozambique, expenditure on fresh produce is rising much more rapidly with increasing incomes in these countries than it is in more developed countries such as Europe and the U.S., and will continue to do so until incomes across the region are much higher.

Figure 4: Income Elasticity of Demand for Several Food Groups: Mozambique and the United States



	Cereals	Meats	Fish	Dairy	Oils/ Fats	Fruits	Other	Bev./To bacco
Mozambique	0.600	0.815	0.703	0.843	0.611	0.671	1.745	1.346
United States	-0.085	0.343	0.260	0.354	-0.001	0.210	0.438	0.424

Source of Data: USDA, Economic Research Service

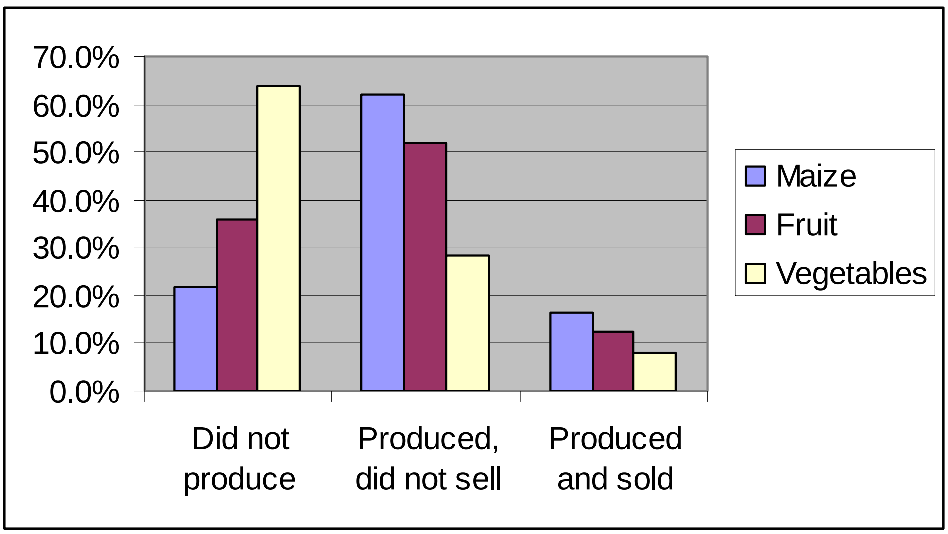
Figure 4 shows that the elasticity of fruit consumption in Mozambique is 0.67,meaning that for every 1% rise in income, expenditure on fresh produce in Mozambique rises by 0.67%. In the U.S., a 1% increase in income would only increase fruit consumption by 0.21%. The income elasticity of demand for fruit in Mozambique is greater than that for maize in Mozambique, at .60, and approaches the elasticity values of meat (.81), fish (.70) and dairy (.84). All of these indicators show that fresh produce, and fruit in particular, present strong prospects for growth as incomes rise in ESA, and this growth represents a major opportunity for domestic and regional supply (local farmers) to meet the burgeoning local demand.

2.3 Empirical Patterns

2.3.1 Which farmers are exploiting the opportunities presented by horticultural crops?

According to the national agricultural survey of Mozambique in 2008, 78% of all farming households in the country produced maize, 64% produced fruit, and 36% produced vegetables. Among these same crops, 16% of households sold maize, 13% sold fruit, and 8% sold vegetables (Figure 5).

Figure 5: Market Participation Decisions among Maize, Fruit and Vegetable Farmers



Source of Data: TIA 2008

Despite some government support to maize sellers[6] and private contracting support for cash crop sales, the percentage of those producing or selling either fruits or vegetables as a group were greater than those who sold maize (18% compared to 16%), or cash crops (information not reported here). The following tables report these numbers and show a number of household characteristics by each of these crop types (fruit in table 1, vegetables in table 2, all fresh produce – fruits and vegetables - in table 3, and maize in table 4) in terms of whether the household produced each crop, sold each crop, and at what quintile of sales value the household sold for each crops' selling group component.

[6] Government support for maize commercialization in Mozambique has included some extension assistance, seed provision, and recently, a pilot fertilizer voucher scheme, although in comparison with some of its neighboring countries, government assistance in Mozambique has been substantially less.

Table 1: Household characteristics by fresh produce production and sales behavior – Fruit

Group	Share of all HHs	HH value of fruit sales (US$)		Group's share of total national fruit sales	HH income per capita (US $)		Share of fruit sales in total HH income	% female headed HHs	Years formal education of HH head		Total land holdings (ha)	
		Mean	Median		Mean	Median			Mean	Median	Mean	Median
Did not produce	35.7%				$123	$56		25.2%	2.8	2.0	1.5	1.2
Produced but did not sell	51.8%				$175	$80		24.7%	3.1	3.0	1.7	1.3
All fruit sellers	12.5%	$32	$7	100%	$183	$97	5.4%	18.3%	3.1	3.0	2.1	1.6
Quintile 1 (sold the least)	2.6%	$1	$1	0.8%	$138	$71	0.1%	23.1%	2.3	2.0	1.6	1.3
Quintile 2	2.6%	$4	$3	2.3%	$133	$77	0.7%	19.5%	2.9	3.0	1.7	1.4
Quintile 3	2.3%	$8	$7	4.3%	$158	$101	1.6%	15.7%	3.3	4.0	1.8	1.6
Quintile 4	2.5%	$17	$15	10.5%	$188	$110	4.3%	18.6%	3.0	3.0	2.4	1.7
Quintile 5 (sold the most)	2.5%	$135	$69	82.1%	$301	$153	17.5%	14.0%	3.8	4.0	3.0	2.5

Source of Data: TIA 2008

Table 2. Household characteristics by fresh produce production and sales behavior – Vegetables

Group	Share of all HHs	HH value of vegetable sales (US$)		Group's share of total national veg. sales	HH income per capita (US $)		Share of vegetable sales in total HH income	% female head-ed HHs	Years formal education of HH head		Total land holdings (ha)	
		Mea n	Median		Mean	Median			Mean	Median	Mean	Median
Did not produce	63.8%				$150	$67		24.8%	2.9	3.0	1.5	1.2
Produced but did not sell	28.4%				$165	$83		24.7%	2.9	3.0	1.9	1.4
All vegetable sellers	7.8%	$65	$20	100%	$193	$102	8.4%	16.4%	3.4	3.0	2.4	1.9
Quintile 1 (sold the least)	1.9%	$2	$2	0.9%	$118	$85	1.8%	21.2%	3.3	4.0	1.8	1.6
Quintile 2	1.3%	$7	$7	1.8%	$185	$73	2.4%	17.7%	3.4	3.0	2.2	1.6
Quintile 3	1.6%	$20	$21	6.2%	$157	$110	4.9%	16.2%	3.1	3.0	2.5	2.0
Quintile 4	1.5%	$48	$45	14.2%	$197	$124	10.9%	19.8%	3.2	3.0	2.1	1.9
Quintile 5 (sold the most)	1.5%	$252	$165	76.9%	$327	$176	22.7%	6.2%	4.1	4.0	3.3	2.6

Source of Data: TIA 2008

Table 3. Household characteristics by fresh produce production and sales behavior - All fresh produce

Group	Share of all HHs	HH value of fresh produce sales (US$)		Group's share of total national fresh produce sales	HH income per capita (US $)		Share of fresh produce sales in total HH income	% female headed HHs	Years formal education of HH head		Total land holdings (ha)	
		Mean	Median		Mean	Median			Mean	Median	Mean	Median
Did not produce	24.9%				$119	$54		25.7%	2.8	2.0	1.4	1.1
Produced but did not sell	56.9%				$168	$75		25.4%	3.0	3.0	1.7	1.3
All fresh produce sellers	18.2%	$50	$10	100.0%	$176	$94	7.3%	17.8%	3.1	3.0	2.1	1.7
Quintile 1 (sold the least)	3.8%	$1	$1	0.6%	$112	$75	1.3%	22.0%	2.3	2.0	1.5	1.3
Quintile 2	3.7%	$5	$4	2.0%	$144	$78	2.0%	20.8%	2.8	3.0	1.7	1.3
Quintile 3	3.6%	$11	$11	4.4%	$154	$90	3.9%	21.2%	3.4	3.0	2.1	1.6
Quintile 4	3.6%	$31	$29	12.4%	$196	$131	7.5%	14.3%	3.1	3.0	2.4	2.0
Quintile 5 (sold the most)	3.6%	$203	$114	80.6%	$277	$140	22.2%	10.3%	4.0	4.0	3.0	2.5

Source of Data: TIA 2008

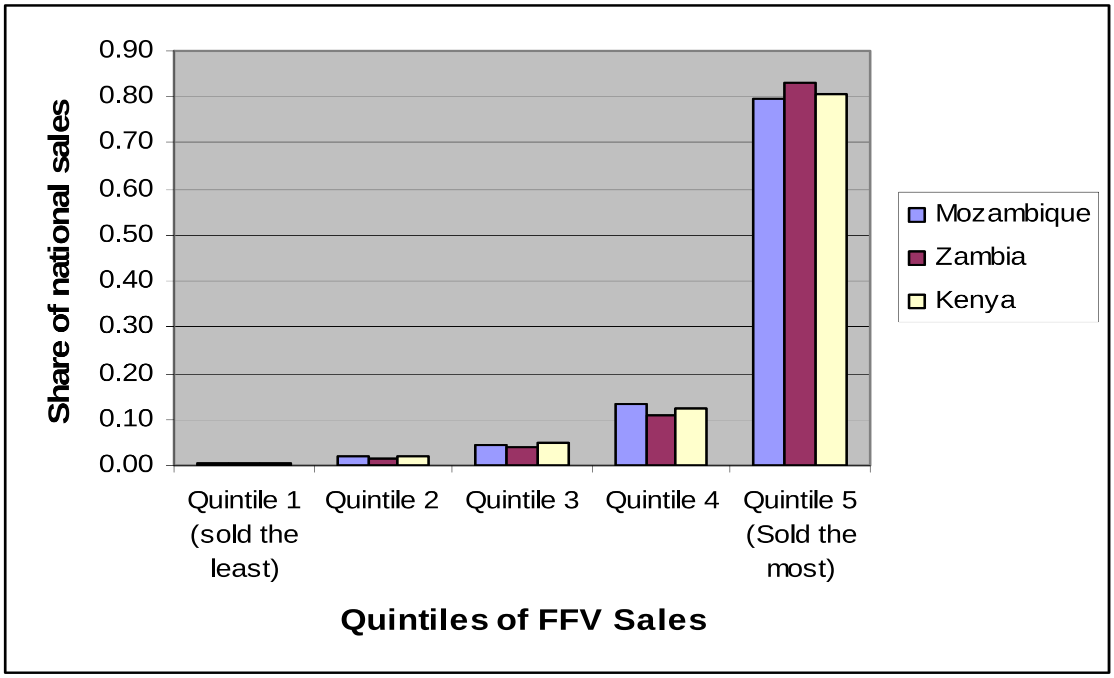
Table 4. Household characteristics by fresh produce production and sales behavior – Maize

Group	Share of all HHs	HH value of maize sales (US$)		Group's share of total national maize sales	HH income per capita (US $)		Share of maize sales in total HH income	% female headed HHs	Years formal education of HH head		Total land holdings (ha)	
		Mean	Median		Mean	Median			Mean	Median	Mean	Median
Did not produce	21.7%				$152	$60	6.8%	28.5%	2.9	2.0	1.0	0.8
Produced but did not sell	62.1%				$153	$73	25.8%	25.7%	2.9	3.0	1.7	1.4
All maize sellers	16.2%	$89	$28	100.0%	$181	$96	34.3%	12.1%	3.2	3.0	2.4	1.9
Quintile 1 (sold the least)	3.4%	$5	$6	1.3%	$105	$68	25.5%	22.4%	2.3	2.0	1.6	1.3
Quintile 2	3.2%	$14	$12	3.0%	$139	$92	26.8%	16.2%	2.9	3.0	2.2	1.8
Quintile 3	3.2%	$28	$28	6.2%	$122	$83	34.9%	8.2%	3.2	3.0	2.0	1.7
Quintile 4	3.3%	$58	$56	12.9%	$190	$105	36.7%	5.7%	3.6	3.0	2.6	2.1
Quintile 5 (sold the most)	3.2%	$345	$148	76.6%	$354	$198	47.8%	7.9%	3.9	4.0	3.8	3.1

Source of Data: TIA 2008

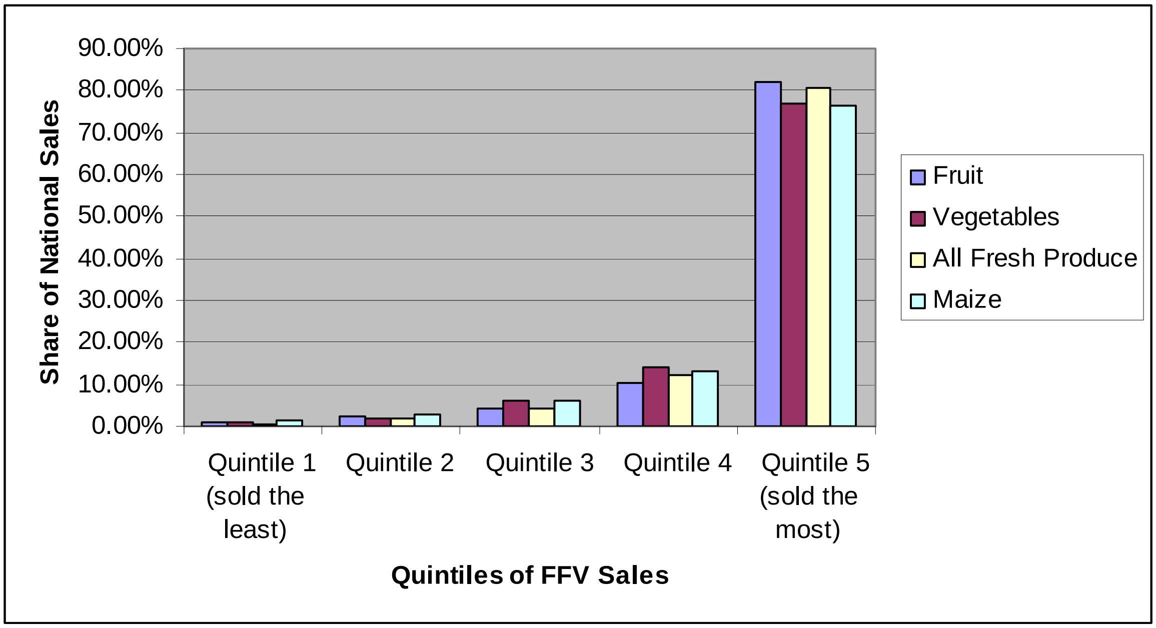
The first thing to notice about these tables (1-4) is the very high concentration of sales value. The top fifth of sellers in every category earns 80% or more of the smallholder share of national value obtained from these crops' sales. The bottom 60% of sellers account for only an average of 7% of the value for fresh fruit or vegetable sales, and these 60% do not earn more than an average $10-20 at best over the given survey year, with values higher for vegetable sales than for fruit. The bottom 60% of maize sellers has average sales ranging up to $20-30 in a year. Also among the commercialized top selling quintile, maize sellers are doing quite a bit better than fresh produce sellers, with average sales $30-145 higher than average sales for fresh fruits and vegetables (FFV). A cross-country comparison of the high concentration of sellers between Mozambique, Zambia and Kenya can be found in Figure 6, showing nearly identical concentration in each country. Figure 7 shows concentration across all three crop categories in Mozambique, demonstrating that all these crops' marketing pattern is similarly concentrated.

Figure 6: Share of fresh produce sales by quintile of sale value: Zambia, Mozambique, and Kenya



Source: Tschirley (2010). Mozambique data is taken from the TIA 2008

Figure 7: Share of sales by quintile of sales value: Fruit, Vegetables, Fresh Produce (Fruit and Vegetables Combined) and Maize



Source of Data: TIA 2008

Even the households that sell in the lowest quintile of fruit sale value have higher mean and median incomes per capita than those who did not sell fruit. This is not true of vegetable sellers, where households in the lowest quintile of sales have lower mean and median incomes per capita than non-sellers, similar to the distribution of maize sellers. Households who produce but do not sell retain higher average and median incomes per capita than those who do not produce among all three crops. These findings suggest that the production of maize, fruit or vegetables is indicative of a higher standard of living, but only in the case of selling fruit are sellers universally found at a higher income status. Households in the bottom quintiles of vegetable or maize sale values evidence lower household income than those who do not sell at all.

Among the top quintile of maize sellers, half of the household's income on average is accounted for by maize sales. The percentage of total income accounted for by

FFV sales is less, 22% of total income as compared to 46% of total income for maize. This percentage is driven by the higher values of vegetable sales, while top fruit sellers' fruit incomes only account for an average 17% of fruit-selling households' total income. This indicates that many farming families are either growing higher-value crops in addition to maize or fresh produce, or have income from off-farm activity, remittances or pensions.

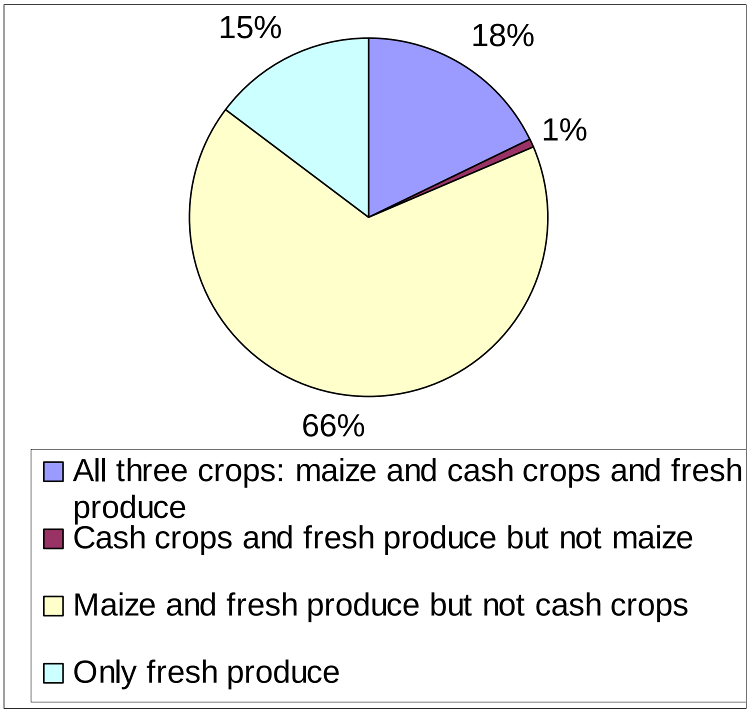
Between maize and FFV-sellers, female-headedness looks strikingly similar, with rapidly falling shares of female-headed households as one moves from the lowest quintile of sale value to the highest. There are also few differences between landholding or educational level between FFV sellers and maize sellers. Landholding ranges from 1.8 to 3.3 hectares for maize-sellers and 1.6 to 3.0 hectares for FFV sellers. Household head education levels range from 3.3 to 4.1 among maize-sellers and 2.3 to 3.8 among FFV-sellers, despite the higher knowledge or "know-how" requirements of producing fresh produce. These trends will be explored in greater detail in latter portions of this thesis. This next section will first consider the question of how many fresh produce sellers are also maize sellers, and vice versa.

2.3.2 Do selling households sell one crop only, or multiple crops, and how does this affect their performance?

According to data from the TIA 2005, 2/3rds of farmers that sell fresh produce do not sell maize or cash crops[7] – they specialize in fresh produce sales. These results closely resemble those generated from the TIA 2008, lending robustness to the percentages found (Tschirley 2011). Clearly, some farmers are finding fresh produce generates income they are not making from sales of other crops, especially given that farmers make these choices to only sell fresh produce despite producing either maize or cash crops on their fields they choose not to sell. These patterns can be seen in the figures below for production behavior (Figure 8) and market behavior (Figure 9) of four mutually exclusive groups of fresh produce sellers: (a) those that sell/produce fresh produce, maize and cash crops, (b) those that sell/produce fresh produce and cash crops but not maize, (c) those that sell/produce fresh produce and maize but not cash crops, and (d) those that only sell/produce fresh produce.

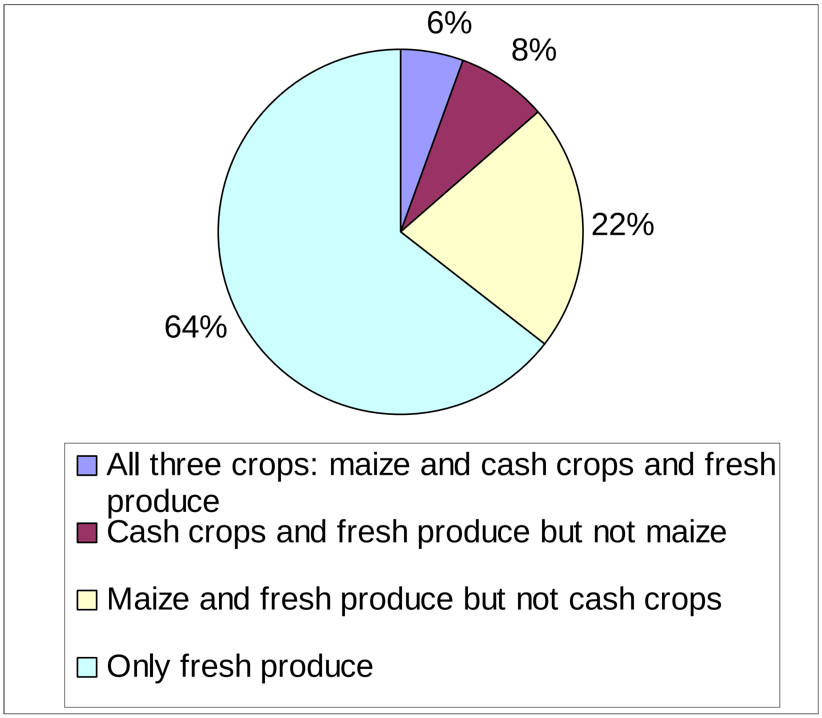
[7] The cash crops group includes cotton, tobacco, sesame, sunflower, coffee, tea, and paprika.

Figure 8: Production Behavior of Fresh Produce Sellers



Source of Data: TIA 2005

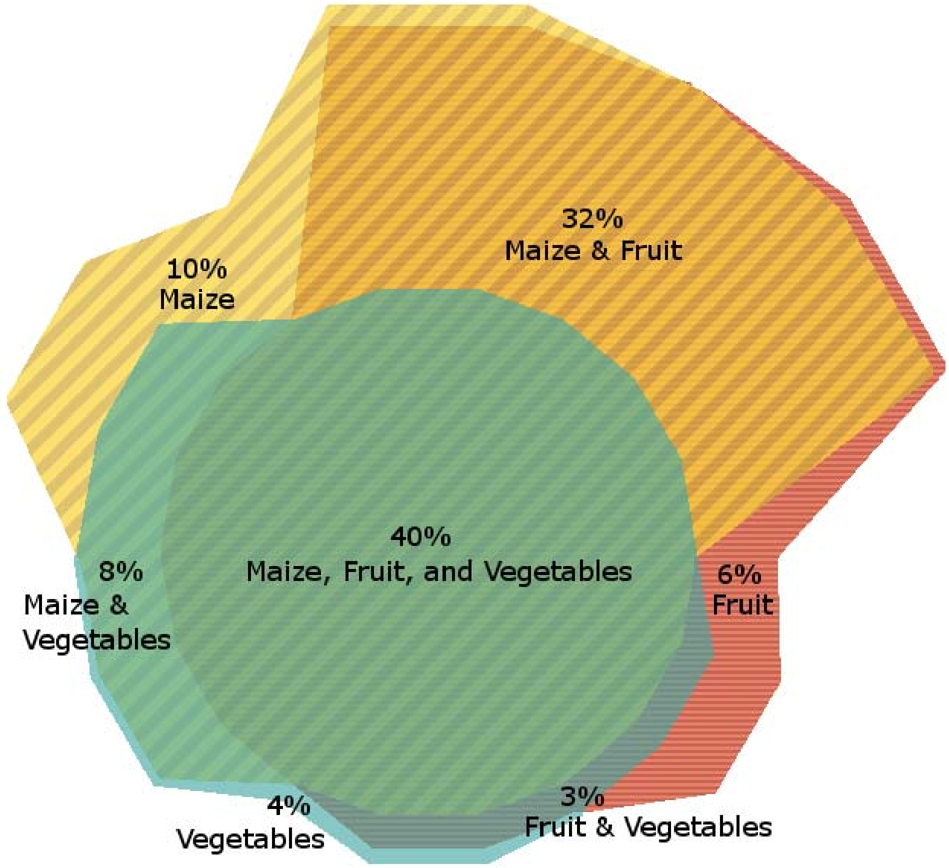
Figure 9: Market Behavior of Fresh Produce Sellers



Source of Data: TIA 2005

The following two depictions (figures 10 and 11) take a closer look at fruit and vegetable sellers separately as they compare to maize sellers by proportionately displaying the number of farmers who choose to produce and sell fruit, vegetables, or maize, and how many of these also produce or sell two or all three of these together on their land. These graphs are called Euler diagrams, and they are similar to Venn diagrams except they keep quantitative spatial relationships between three concentric "circles" intact.

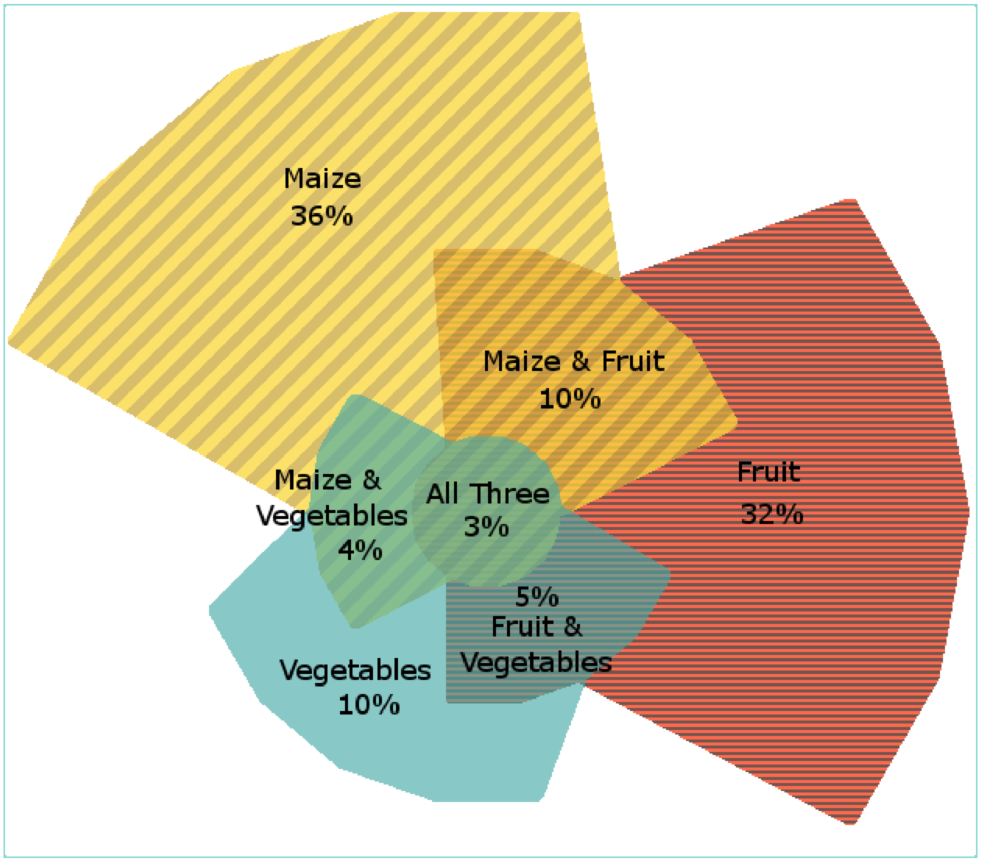
Figure 10: Maize, Fruit and Vegetable Production Behavior among Sellers of these Crops[8]



Source of Data: TIA 2005

[8] These diagrams are generated using the "Draw Euler" free software created by Stirling Chow -- senior java software developer for AlarmPoint Systems Incorporated. The author thanks Francis Smart for his help in creating them.

Figure 11: Maize, Fruit and Vegetable Market Behavior



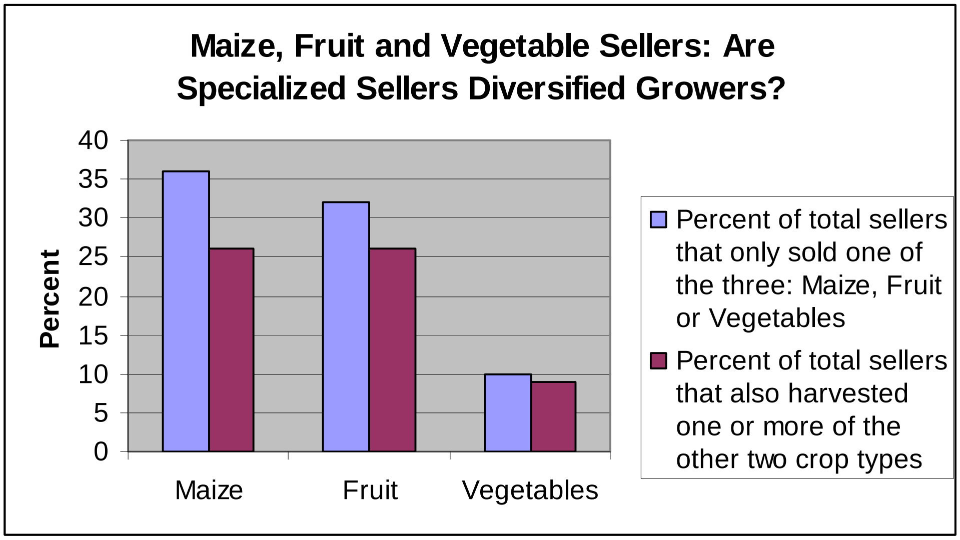
Source of Data: TIA 2005

It can be observed from these graphs that more farmers are selling fruit than vegetables, with fruit looking very similar to maize in terms of the number of farmers specializing in maize and fruit production and sales. Similar to what was found in the graphs looking at fresh produce sales as a whole above, 63% of those who sell fruit, only sell fruit, 45% of those who sell vegetables only sell vegetables, and the percentage of those who only sell maize among the maize sellers is only slightly higher than that of fruit – at 66%. This shows that production is much more diversified than sales, suggesting that different factors determine choice of commodity to sell than determine choice of commodity to produce.

Vegetables also seem rarely to be grown without another crop, and a mere 1% of farmers *only* produce vegetables. Given that the average value of vegetable sales is greater than the average value of fruit sales, the lack of specialization in vegetable sales probably relates to the fact that vegetables are very risky to grow, and farmers are diversifying their risk by growing other crops. It is also not certain that the net benefit of selling vegetables is greater than that of selling fruit.

Between maize, fruit and vegetables, farmers most frequently specialize in maize sales (36% of all FFV or maize sellers sold only maize) with fruit following close behind (32% only sold fruit). Farmers least frequently specialize in vegetable sales (10% of all fruit, vegetable or maize sellers). Proportionally, farmers who sell only maize are least likely to grow the other two crops on their fields than farmers who sell only fruit or only vegetables (72% of the group that specializes in maize sales also grows fruit or vegetables, compared to 81% that specializes in fruit sales that also grows maize or vegetables and 90% that specializes in vegetable sales, that also grows maize or fruit. This information is summarized in figure 12.

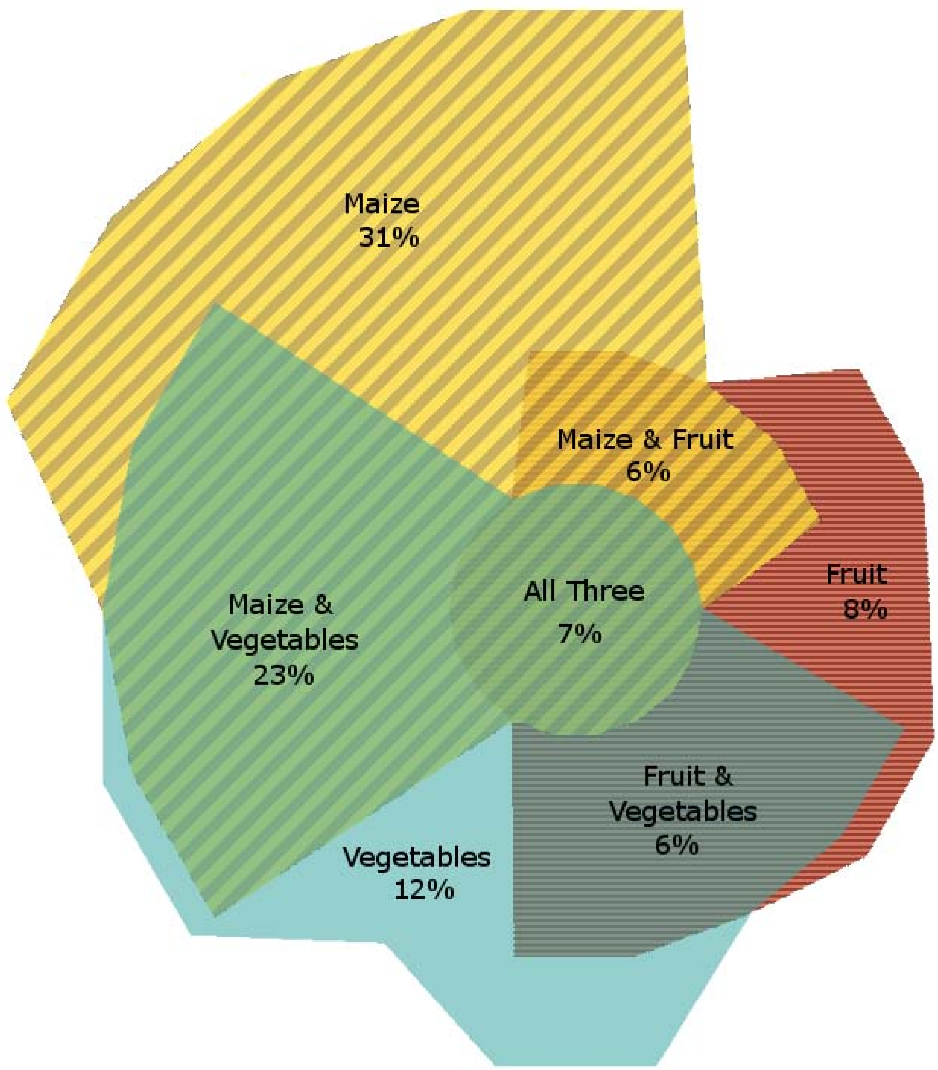
Figure 12: Are Specialized Sellers Diversified Growers?



Source of Data: TIA 2005

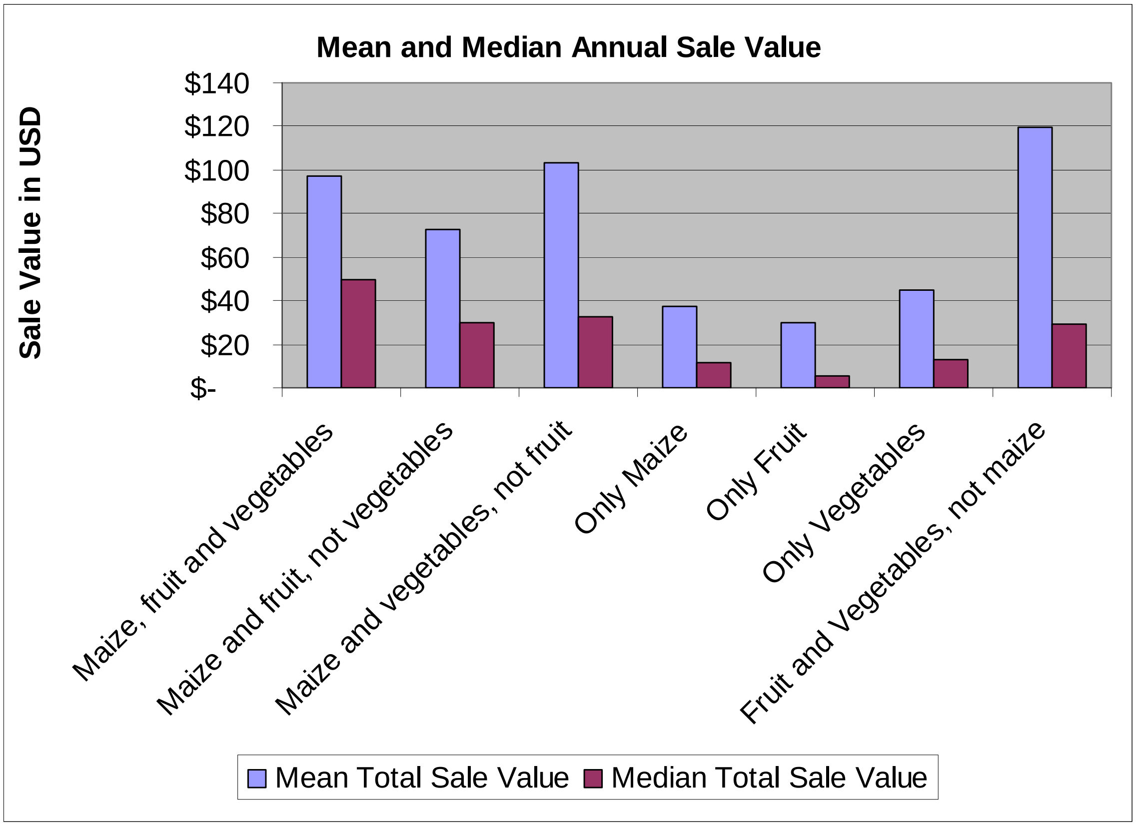
A Euler diagram is also used to depict, among fruit, vegetable and maize sellers, which groups earn the most for their sales out of the total value of all maize, fruit and vegetable sales in Figure 13. This graph makes it especially apparent that whereas fewer farmers commercialize their vegetable production rather than their fruit production, the value obtained from selling vegetables is far greater than the value obtained from fruit: fruit-only sellers (32% of all maize, fruit and vegetable sellers) only account for 8% of the total sales value, whereas vegetable-only sellers (10% of all sellers) account for 12% of the total value, and 23% of the total value of sales are obtained by farmers who grew both maize and vegetables. Between FFV and maize groups respectively, 31% of total sale value is obtained by farmers who specialize in only selling maize (no fruit or vegetables), and 26% of the value is obtained by farmers who specialize in only selling fruit, vegetables or both fruits and vegetables (no maize). This would indicate that the barriers facing vegetable sellers differ from those faced by fruit sellers, and the challenges for vegetable sales pose constraints less farmers have overcome than those who have overcome the barriers to participate in commercialized status of their fruit (or maize) production.

Figure 13: Total Value Obtained from Fruit, Vegetable and Maize Sales



Source of Data: TIA 2005

Figure 14: Mean and Median Annual Sale Values of Seven Crop Groupings



Source of Data: TIA 2005

Reflected in Figure 14, the mean value of sales over all crops (maize, cash crops, fresh produce) is lowest among the groups which sell only one crop. The mean value of sales is highest for farmers who sold fruit and vegetables together without maize, and the median value of sales is highest for farmers who sell fruit, vegetables and maize. These high market values give evidence of the existing (and growing) local demand for fruit and vegetables in Mozambique.

2.3.3 Persistence of Successful Fresh Produce or Maize Marketing

It was noted from section 2.3.1 that agricultural sales are highly concentrated in Mozambique. It was then shown in section 2.3.2 that many FFV sellers only sell fruit or vegetables, therefore cash income is being achieved by farmers in horticulture that is not being found by selling other crops. It is also worthy to note that of those that are in the top sales quintile of fresh produce or maize, very few remain in the top sales quintile over the course of time.

Between the two panel years of the TIA (2002 and 2005), only 3.17% of FFV sellers are in the top quintile of sellers in both years, and similarly among maize sellers, only 2.9% of sellers remain in the top quintile. Tables 5 and 6 take a closer look at the 4,104 farmers who were interviewed in both years of the TIA survey in regards to their marketing behavior, to better understand the proportions of farmers who sell in both years, those who are persistent top-sellers in both years, and the spatial distribution of these sellers. Tables 7 and 8 explore household characteristic differences between these groups to help understand if top sellers in maize look different from top sellers in fresh produce, as well as what distinguishes each top-selling group from the other farmers who sold.

Table 5. The percentage of households selling FFV and maize in each of the panel years of the TIA data used

% of HHs Selling	Nationally		Southern Region		Central Region		Northern Region	
	FFV	Maize	FFV	Maize	FFV	Maize	FFV	Maize
2002	31.2%	21.2%	31.6%	4.7%	42.4%	25.4%	27.4%	24.8%
2005	22.7%	17.8%	20.2%	2.7%	23.2%	23.4%	23.2%	20.5%

Table 6. Top-Selling Households by Region of Mozambique

Region	FFV	Maize
	----- % of HHs in top selling tercile during both years -----	
Southern	10.0	4.2
Central	10.1	5.2
Northern	2.5	4.9

These tables show that 17-31% of all farmers in both panel years sell either fresh produce or maize in either 2002 or 2005, with lower percentages of those selling in both crop categories in 2005 compared to 2002, due to a serious drought during 2005. Most maize sales are accounted for in the central and northern regions, whereas FFV sellers as a group are fairly evenly distributed across the country. Of households in the top *third*, or tercile, of either FFV or maize sales in both years, 5.46% of FFV sellers remain in the top selling group over the two years, and 4.97% of maize sellers remain in the top selling group over the two years. The percentage of top FFV sellers in both years is concentrated in the southern and central regions with both above 10% of the persistent top sellers, and only 2.43% in the northern region. The percentage of top maize sellers by region is fairly consistent across the country's regions, at 4.2-5.2% of sellers, even in the southern region where only 2-5% of farmers participate in maize marketing. These results generally show that there is only an incipient group of established commercialized FFV providers in Mozambique, and a wide window exists for market improvement.

Descriptive statistics for a variety of household-level characteristics are compared between (a) top selling FFV and maize groups (b) top selling FFV and non-top selling FFV groups, and (c) top selling maize and non-top selling maize groups. Table 7 displays percentages of discrete variables, table 8 displays means and medians of continuous variables, and the results are interpreted in terms of two congruent sets (one set for the discrete variables, and the other for the continuous variables) of five areas: market access, assets, agro-ecological factors, price/wealth effects, and demographic characteristics. The rationale for this grouping is described in the following chapter. In the remainder of this section, the term "top-selling" refers only to the group which sells in the top tercile of sale values among all sellers in both years of the panel dataset.[9]

[9] I move to terciles from this point forward for a more meaningful analysis of household characteristics between groups in the next section, due to the fact that the numbers of households in top sales quintiles during both years is so small (about 3%-4% of sellers, meaning less than 1% of the total population).

Table 7. Comparison of Fresh Produce and Maize Persistent Top-Sellers, Discrete Variables

	FFV Persistent Top Sellers (5.5%)	FFV Non-Top Sellers (94.5%)	Maize Persistent Top Sellers (5.0%)	Maize Non-Top Sellers (95.0%)	Top vs Top	Top vs Non-top FFV	Top vs Non-top Maize
Price Information	38%	38%	62%	42%	**		**
Association Member	18%	5%	4%	4%	**	***	
Manual irrigation	40%	14%	10%	9%	***	***	
Mech/Grav Irrigation	12%	1%	1%	1%	***	**	
Irrigat'n potent'l area	3%	4%	0%	3%	**		***
Close to river/lake	39%	38%	64%	46%	***		**
HH salaried worker	6%	5%	11%	4%			
HH-head is female	13%	21%	13%	20%		*	

Note: T-tests were used to determine whether the means between groups were statistically different, and asterisks reflecting these tests are given in one of three columns on the right side for each respective group comparison (p > 0.10*, p > .05**, p > .01***).

Market Access

One of the factors that differentiates maize top-sellers from maize not-top sellers is receiving price information: 62% of top sellers report receiving price information, whereas only 42% report receiving price information among not-top sellers. Market information is generally limited to food staples, and is not available for fresh produce items, however. The comparison between top-sellers and non-top sellers of FFV reflects this in a lower percentage of FFV-selling farmers, only 38%, who report receiving price information.

Assets

Important differences are found in regards to farmer association membership: 18% of the household heads among FFV top sellers are members of an association, whereas non-top sellers have a rate of 5%. A slightly lower average of 4% of both top maize sellers and non-top maize sellers participate in an association. Irrigation also plays a role for fresh produce sellers in a way that does not affect maize sellers: 40% of top FFV sellers reported using manual irrigation and 12% reported using mechanical or gravity irrigation compared to only 10% and 1% reported by top-maize sellers respectively. Not surprisingly, this variable is significantly different between top-FFV sellers and non-top sellers, the latter of which have rates of 14% and 1% manual and gravity/mechanical irrigation: only a fourth of their top-selling counterparts in each case.

Agro-Ecological Factors

A significantly greater percentage of households who sell in any FFV-selling tercile is more often located in an "irrigation potential area" – those that are identified with a land cover map as primarily lying in either an irrigated, watery or swampy area -- than households who sell maize, despite the very low prevalence of this variable across all households. None of the top-selling maize sellers are recorded as lying in these areas, however persistent top-sellers of maize have greatest access to or use of lake or river water for community or agricultural use of all of the categories, at 64% compared to 46% of farmers in the lower 2/3rds of maize sellers, and compared to 38-39% of fresh produce sellers.

Price/Wealth Effects

Slightly higher percentages of both FFV and maize-selling households report having a salaried worker in the household (6% compared to 5% for FFV and 11% compared to 4% for maize). None of these differences across crop groups or within groups are significant, however. This could be due to a dual effect: the additional income can help invest in the household's fields or reflect the amount of value that can be obtained from these investments, as well as the amount of outside experience or knowledge gained, but on the other hand, jobs off farm may take away from the labor requirements of the farm, especially in the case of FFV. This ambiguity in itself, in this way, may indicate both of these factors at play.

Table 8: Comparison of Fresh Produce and Maize Persistent Top-Sellers, Continuous Variables

	FFV Persistent Top Sellers (5.5%)		FFV Non-Top Sellers (94.5%)		Maize Persistent Top Sellers (5.0%)		Maize Non-Top Sellers (95.0%)		Top vs Top[10]	Top vs Non-top FFV	Top vs Non-top Maize
Var Name	Median	**Mean**	Median	**Mean**	Median	**Mean**	Median	**Mean**			
Hours to town, 10K+	3.3	**4.8**	5.5	**7.0**	6.5	**8.6**	6.3	**7.9**	***	***	
Km of district roads	21.2	**22.8**	22.6	**24.1**	31.0	**29.1**	24.7	**27.0**	***		
Population density	20.7	**41.2**	27.2	**41.7**	32.4	**42.5**	25.2	**34.4**			
Adult max education	4.0	**4.8**	3.0	**3.7**	4.0	**3.9**	3.0	**3.4**	*	***	
Number of fields	3.0	**2.8**	3.0	**2.7**	3.0	**2.7**	2.0	**2.5**			
Land area in hectares	2.3	**3.0**	1.4	**1.8**	1.9	**2.6**	1.4	**1.9**		***	*
Other assets (1-6)	3.0	**2.7**	2.0	**2.0**	2.0	**1.8**	2.0	**1.8**	***	***	
No. fruit trees	4.0	**4.6**	3.0	**3.1**	2.0	**2.7**	2.0	**2.1**	***	***	
Elevation (100 m)	10.0	**11.2**	10.2	**10.9**	10.0	**10.3**	10.2	**11.0**	***		**
Expected drought days	1.2	**1.5**	0.6	**1.0**	0.6	**0.8**	0.5	**0.8**	***	***	
Age of HH-head	42.0	**46.8**	41.0	**42.3**	36.0	**35.7**	39.0	**40.7**	***	**	***
HH consumption size	4.3	**4.8**	3.5	**3.9**	3.9	**4.1**	3.4	**3.7**	***	***	

[10] T-tests compare means, not medians Asterisks reflecting these tests are given in one of three columns on the right side for each respective group comparison (p > 0.10*, p > .05**, p > .01***).

Demographic Characteristics

The percentage of female-headed households among top FFV and top maize sellers is not significantly different, at 13% for both. FFV and maize non-top selling categories also look surprisingly similar, both are headed by females 20-21% of the time. Given that the smallest plots tend to be those governed by females, the opportunity for fresh produce sales among these households would seem to be particularly great. Female-headed households hold an average 1.2 hectares of land per household, significantly differing from the average 1.8 hectares owned per male-headed household.

Summarizing the key patterns among the discrete variables discussed, receipt of price information distinguishes top maize sellers from non-top maize sellers, access to irrigation and farmer associations distinguishes top-FFV sellers both from top-maize sellers and from their non-top counterparts, and top sellers of both crops are equally likely to be headed by males.

I now turn to the continuous variables included in Table 8 in identifying other distinguishing characteristics among the more and less successful fruit, vegetable and maize sellers.

Market Access

Top-FFV sellers are distinguished from top-maize sellers in a significant way through the number of hours in travel time to a town or city of greater than 10,000 inhabitants. The median distance in hours for top-FFV sellers is 3.3, and the median distance for non-top FFV sellers is 5.5, a value that is still smaller than the median value of top or non-top maize sellers, both of which fall between 6.3 and 6.5 hours. There is also significantly more average road density in top-selling maize districts of household residence than the comparative top-selling FFV group districts, by an average 63,500 kilometers of primary or secondary paved surface (standard deviation of 110,000 km). Uncertain of what exactly lies behind the second of these two conclusions, the first is quite clear and pronounced: both fruit and vegetables are highly perishable and thus cannot travel far distances to a market of meaningful size at which sales would more often occur. This characteristic both for fresh produce as a group compared to maize, as well as successful and persistent top growing fresh produce suppliers indicates the vital role of spatial positioning for a successful FFV-selling household, and some of the potential constraints which farmers may face in otherwise selling their fruits and vegetables compared to maize.

Asset Base

In terms of human capital/assets, top sellers in FFV have significantly higher average maximum household adult years of education achieved than FFV non-top selling households (4.8 compared to 3.7), while this relationship between maize top sellers and non-top sellers is not significant. Top FFV-selling household adults also have significantly more average maximum years than top maize-sellers (4.8 compared to 3.9 years for maize). Both of these results are expected for a knowledge/expertise intensive group of crops, as fruit and vegetables are more susceptible to pests and weather both during and after harvest, as compared to maize.

Top sellers of both maize and FFV have significantly larger areas of land than their non-top selling counterparts by around one hectare (average 3.0 compared to 1.8 for

FFV, and 2.6 compared to 1.9 for maize). Interestingly, maize top sellers do not have significantly more land than FFV top sellers, which is further evidence that small land-holders have not yet really entered the top-selling horticulture groups yet. The number of fields (around 3 on average) does not vary significantly across all the groups.

Other assets (a variable with a range of 1-6 for owning any of the following assets: storage facility, good roof, good walls, latrine, lamp, table) make a much larger difference for FFV sellers and do not make any difference among maize sellers. Top FFV-sellers have an average of three compared to two of the six items recorded by top maize sellers and non-top FFV sellers. And top-sellers in both crop categories consistently have more farm and livestock asset value than their non-top selling counterparts.

Not surprisingly, number of fruit trees is significantly higher for the successful fresh produce sellers compared to both the non-top fresh produces sellers and the maize top-sellers, with the median number of trees at 4, 3 and 2 for top FFV sellers, non-top FFV sellers and any maize seller respectively.

Agro-Ecological Factors

The number of expected drought days by the household for the given year (a description of how this variable was created can be found in the next chapter) is significantly higher on average for top FFV sellers than for non-top FFV sellers, and significantly higher for top FFV sellers than for top maize sellers. Since drought or less rain is a good thing for vegetable production as long as a household has access to irrigation, lower expected drought days in the year for top maize households makes sense. Average elevation is higher for the top-selling fresh produce group compared to the top selling maize group given the cooler areas in higher elevations where there are less pest problems than in some of the more tropical conditions where maize farmers can still do well. Nonetheless, the result on maize is somewhat counter-intuitive given that mid-altitude elevations enhance hybrid maize expression. Maps depicting both rainfall and elevation throughout the country to contextualize these findings can be found in Appendix C.

Demographic Characteristics

Top FFV-selling household heads are significantly older than top maize-sellers by an average of 10 years, and older than non-top FFV selling household heads by an average of 4 years. This stands in contrast to top maize sellers who are significantly younger than the non-top maize sellers by about 5 years on average. This is an unexpected finding, and is reversed in the regression analysis of chapter three. These results are further explored in section 3.6. Perhaps also related to age, top FFV sellers have significantly larger household sizes in adult consumption equivalents than top maize sellers. Top-FFV selling households also are significantly larger in consumption equivalents than non-top FFV selling households, by about the same degree. It is possible that the labor intensive requirements of fresh produce cultivation would be a reason for both larger household sizes and older household heads, who may have greater numbers of grown children working in the fields. There is no significant relationship between top and non-top selling maize households in their household size.

Summarizing the key patterns, this section interpreting Table 8 finds that market access in terms of fewer hours to reach a town of meaningful size, higher education levels of an adult household member, level of overall assets and number of expected drought-days are all significant in the case of top fresh produce sellers in comparison to non-top FFV sellers and maize sellers. Greater land size characterizes both top-selling maize and top-selling FFV households in comparison to their non-top selling counterparts, whereas number of plots shows no significant difference among any selling group. FFV top-sellers are found to succeed in higher elevations on average compared to maize-sellers, and the top maize sellers succeed in even lower elevations, compared to their non-top selling counterparts. Household head age and household size in consumption equivalents also yields mixed results between FFV and maize sellers: younger is better for maize sales, while older and larger is more common among successful fresh produce sellers, indicating a possibly larger labor base for the intensive production practices of a thriving fresh produce practice, and possibly the additional management practice gained with time or experience of an older household head.

The next chapter introduces a modeling approach that will allow a closer look at the effect of the variables already introduced and a number more, while controlling for the effect of the others.

Chapter 3: Modeling smallholder fresh produce farmer market participation decisions

This chapter first summarizes the market participation literature in Africa to motivate the modeling approach used in this empirical analysis. It then presents the chosen modeling approach in more detail, explains all chosen independent variables, and presents estimation results, before closing with a discussion of the implications of this study.

3.1 Summary of Market Participation Literature

Literature on market participation in ESA has well documented the importance to household commercial decision processes of (1) the level of market development in the environment facing the farmer, and (2) the farmer's private asset holdings. Research on both these areas can be traced to seminal contributions on smallholder market behavior made by De Janvry et al. (1991). In the first area, much work has been devoted to developing a better conceptualization and understanding of the effects of market access, infrastructure and transaction costs as they affect household market decisions. Key contributing authors in this regard include Goetz (1991), Key et al. (2000), Bellemare and Barrett (2006), and Barrett (2008), among others. In the second area concerning asset holdings and poverty traps, more recent literature by Barrett and others (Moser 2006, Carter 2006, Boughton et al. 2007, and Mather, Boughton, and Jayne 2011) has reemphasized the effect of asset holdings on households' market decision process. The major contribution from this work has been to show that improved market access by means of public goods such as road infrastructure or price information, for example, may not be sufficient to generate market sales if households are not able to accumulate enough private assets to generate marketable surpluses. Recommendations such as investing in productivity gains through research and development in crop science, improving farmer access to extension advice, cultivating greater tracts of land, and facilitating access to animal traction, among others, have been suggested to supplement efforts that have more traditionally been targeted at reducing market access constraints.

A third area of research assesses price and wealth effects on household marketing decisions. Findings by Singh, Squire and Strauss (1986) have been highlighted and built upon by Renkow (1990) and Sadoulet and de Janvry (1995) and show that the emphasis on evaluation of market access and transaction costs in market participation literature of the last two decades may not be the most useful approach when primarily semi-subsistence farmers are being considered. For smallholders who consume their agricultural production and who may or may not sell, depending on production outcomes and market conditions, these studies have shown that price increases may cause unexpected negative participation responses in the short-run as semi-subsistence farmers make decisions about storing their harvest for use throughout the year (Mather, Boughton and Jayne, 2011).

Two recent analyses that focus on Mozambican smallholder farmers are of particular interest for this thesis. Boughton et al. (2007) use nationally representative household data from Mozambique's 2002 TIA to identify the drivers of market participation in three very different crops: maize, cotton and tobacco[11]. Maize is a low value crop produced by independent farmers and sold into highly competitive (even atomized) private markets. Cotton is a more labor-intensive and somewhat higher-value

[11] These authors use a two-stage Heckman model to separately model the probability of participation and the value sold conditional on participation.

crop produced almost exclusively under contract farming arrangements in which farmers receive an input package on credit from a cotton ginning company and are legally required to sell their resulting crop to that company. Tobacco is produced under similar contract farming arrangements as cotton but differs from the latter in having a potentially much higher production value per unit of land, even higher requirements for labor and other variable inputs, and strong price differentiation according to quality.

Given these differing crop characteristics, one might expect to find meaningful differences in the profiles of farmers able to participate in output markets for each of these groups. Yet results were remarkably consistent across crops. Of particular interest to this paper are the following results:

- A household being female-headed had a strong and statistically significant negative effect on the probability of marketing all three crops, and a strong negative effect on the values of each crop sold (conditional on sales), though this latter effect was statistically significant only for maize;
- Household land holdings followed an identical, though positive, pattern: large positive and statistically significant effects on the probability of marketing each crop, and large positive effects on conditional marketed values of each, though significant only for maize;
- Road infrastructure, access to extension advice and access to market price information had inconsistent results across crops;
- Education had no significant effect except on the conditional value of tobacco sold

Overall, Boughton et al. concluded that “The consistency of these results across markets and crops suggests both the central importance of private assets to smallholders’ capacity to take advantage of commercial market opportunities and their [smallholder’s private assets] potential complementarity with public goods in regard to stimulating broader-based crop market participation or marketed supply expansion.”

Mather, Boughton, and Jayne (2011) focus on a single crop (maize) across three countries: Zambia, Mozambique, and Kenya. An advantage of their approach is that, in each country, they use panel data and so are able to control for unobserved variables that could, in principle, have biased the results from Boughton et al. In Mozambique, the authors use the same 2002 data as Boughton et al. along with data collected in 2005 in a nearly identical survey of the same households.[12] They further define the complementarity of smallholders’ private assets and investments in public good assets and how these affect the amount of surplus maize these households are able to bring to market. Five of the principle findings from their study are summarized below:

- Among maize sellers in all three countries, top and non-top sellers were just as close to markets, suggesting that maize sellers may already have adequate market access in terms of physical road infrastructure, as many do not even travel outside their village to sell.
- Improvements in price information flow has led to lower search costs even among traders in the most remote villages, given the rise of cell phone use.

[12] Mather, Boughton, and Jayne use a two-stage Cragg model to predict both the probability of sale and the conditional value of sales. See Wooldridge (2010) for perspective on the appropriateness of the Heckman model (used by Boughton et al) vs. the Cragg model for these types of analyses.

- Neither market access nor price information alone may be enough to improve marketed surpluses of maize without physical assets of land and livestock, especially livestock for animal traction. They note that in Mozambique, preventing animal disease among farmers largely dependent on animal traction is an important long-term investment for the utilization of large uncultivated tracts of land.
- Improving the productivity of existing land in operation is perhaps of primary immediate importance, however providing input subsidies or buying large supplies of maize surplus, as the public sector is sometimes apt to prefer, does not help generate a sustainable supply or demand system for which the same investment value may do much more by helping to make fertilizer more profitable for sellers. Four market-friendly alternative investments the public sector could contribute to complement private asset investments they suggest are
  - building input-supply port facilities and roads for buyers to reach them,
  - investing in research and development (R&D) for improved seed varieties which respond better to input use,
  - developing and disseminating recommendations for specific agro-ecological input packages, and
  - strengthening rural financial and credit systems.
- While performance among female and male headed households varied across countries for a variety of reasons, female headed households in Mozambique

achieved lower value of market maize sales largely due to their positioning in poor agro-ecological areas, and not due to lower land-holding sizes.

Mather, Boughton and Jayne conclude that the public sector has a strategic opportunity to help the demand for input use attract and sustain a competitive input market for rural smallholders, and this kind of short term investment in land quality, alongside the long term goal of increasing the quantity of land used through healthy private assets of livestock or alternative harvesting capital, are both needed for farmers to reach a greater capacity for surplus maize commercialization. Holding prices constant, these authors suggest that more land may not even have a positive effect on maize market participation or value of sales if farmers do not get the inputs to make their land more productive. Such improvements would then also better allow these farmers to take advantage of market access investments of road infrastructure and improved price information dissemination.

Effects of these key determinants on maize are similar to the anticipated implications on fresh produce in two ways, and differ in three: (1) Fresh produce sales would similarly be expected to benefit from improved market information flows. Even though FFV price information is not disseminated to the extent that staple price information is, lesser search costs also benefit farmers seeking to meet demand in their local or nearby market demand channels. (2) The emphasis on land *quality* before land quantity is especially important in the case of fruit or vegetable plots, which do not require large plots to achieve a higher value per unit. In addition to adequate labor supply needed for FFV, the accessibility of inputs for improved soil or crop productivity is also of paramount importance in the case of FFV, even more so than it is for maize..

Increasing productivity on fresh produce plots differs from increasing productivity on maize plots in several ways as well: (3) Improving fresh produce marketable yield relies less on livestock and other extensive harvesting equipment, and more on intensive practices requiring an adequate labor supply. (4) Improving the ability of farmers to sell fresh produce depends, to a greater extent, on the ability to produce a crop in the dry seasons, which is the best time to avoid the pest problems which are particularly destructive for the cultivation of many FFV crops for sale. In the absence of pump or gravity-fed irrigation systems, this effect evidences itself, again, in the greater demands of FFV cultivation on family labor than that of maize, if manual irrigation is used. (5) Road infrastructure or indicators of market access may have more of an effect on farmers' fresh produce market decisions than in the case of maize if a large part of the increasing demand is emanating out of urban centers with rising income elasticities of demand for fresh produce. This, combined with greater concerns of travel-perishability for fresh produce, would cause location-specific market access characteristics to have a much greater role in the case of FFV than for maize.

3.2 Explanatory Variable Descriptions and Hypotheses

The previous survey of the literature informs the choice of explanatory variables in the present study of market participation decisions made by smallholder farming households in Mozambique and specifically, how they are categorized. Each explanatory variable is included in one of the four groups: (1) market access or transaction cost factors, (2) strength of private asset base factors – labor, equipment, and land, with a specific sub-category of agro-ecological asset endowments, (3) price/wealth effect factors, and (4) demographic characteristics. The variables included in each of these categories and their anticipated effects as they relate to both FFV and maize marketing decisions are described in this section.

3.2.1 Market Access or Transaction Cost Factors

Two geographic proxies for the cost of a household member getting to a market and back are included, to capture market access/demand and the costs associated with participation. First, travel time in hours was estimated for each household to the nearest population center of at least 10,000 individuals (see Appendix B for detail on how this variable was created). This variable represents proximity to relevant market opportunities for farmers as well as smaller transaction costs of transportation, storage, the opportunity cost of time spent, and especially in the case of fresh produce, the potential harvest loss given the distance and time required for the product to reach market demand in good shape. The greater the time to travel to a town of at least this size, the less likely it is that a farming household will find it profitable to sell their harvest at market.

Second, population density at the district level is also used as a proxy for relevant market demand or opportunity since, even if a household is far from a center of 10,000 inhabitants or more, higher population density should increase the size of each village market and reduce transaction costs of connecting with potential buyers. As stated previously, it is expected that these indicators of physical market access would have a much greater impact for fresh produce market participation and value of sales due to the high perishability of these crops, whereas these measures of market access may have less effect on maize sellers, given the findings of adequate market access in these areas highlighted by Mather, Boughton, and Jayne in their 2011 study and maize's lesser perishability.

The non-geographic variable indicating whether the household received price information for market transactions is included as another market access factor. This variable is expected to have a positive effect on the value of sales earned by both maize and fresh produce sellers, as well as a positive effect on their decision to sell. However, because market information is *not* available for fresh produce items but is instead limited to food staples, this variable is best interpreted in the fresh produce regressions as a general indicator of a farmer's attunement to market information.

Table 9. Variable Descriptions and Names

			FFV Sellers		FFV Non-Sellers		Maize Sellers		Maize Non-Sellers	
Category	**Variable Name**	**Variable Description**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Market Access or Trans-action Cost Factors	Gt10k_hr	Travel time in hours from community to town of 10,000 persons or greater	**7.04**	6.30	**7.66**	6.35	**8.19**	6.83	**7.30**	6.19
	Pop_dens	Mean population density in a 10km radius around household's GIS location (persons/sq. km)	**40.0**	75.5	**48.7**	98.3	**35.2**	49.9	**49.2**	100.7
	HHprice	Household received price information	**0.36**	0.48	**0.35**	0.48	**0.44**	0.50	**0.33**	0.47
Asset Strength Factors	HHasoc	HH head participated in a farmer association	**0.05**	0.23	**0.03**	0.18	**0.05**	0.21	**0.04**	0.19
	Adltmax educ	Max years education of adults 18 or older in the household	**3.79**	3.93	**3.3**	3.72	**3.26**	3.68	**3.48**	3.81
	Ipam, Ipaf	Adult age 15-59 in the household was sick for 3 or more months the year of the survey	**0.01**	0.10	**0.01**	0.09	**0.01**	0.11	**0.01**	0.09
			0.02	0.12	**0.02**	0.13	**0.01**	0.11	**0.02**	0.13
	Dipam, Dipaf	Number of adult deaths due to illness in year of survey or up to two years prior	**0.01**	0.11	**0.02**	0.14	**0.01**	0.12	**0.02**	0.14
			0.03	0.19	**0.02**	0.13	**0.02**	0.13	**0.02**	0.15
	Dep_ratio	HH members younger than 15 or older than 59/by the total number of HH members	**0.48**	0.23	**0.48**	0.25	**0.48**	0.23	**0.48**	0.25
	Dmirrman	HH used manual irrigation	**0.20**	0.4	**0.06**	0.24	**0.09**	0.29	**0.10**	0.30
	Dmirrmech orgrav	HH used mechanized or gravity irrigation	**0.02**	0.13	**0.01**	0.11	**0.01**	0.11	**0.01**	0.12
	Lnfassetv	ln (Value of Farm Equipment in 2005 MTN)	**4.21**	3.15	**3.42**	3.2	**4.24**	3.18	**3.49**	3.20

Table 9 (cont'd.)

Category	Variable Name	Variable Description	FFV Sellers Avg	FFV Sellers SD	FFV Non-Sellers Avg	FFV Non-Sellers SD	Maize Sellers Avg	Maize Sellers SD	Maize Non-Sellers Avg	Maize Non-Sellers SD
Asset Strength Factors (cont'd.)	Othassets	Number of following assets held by HH: storage facility, good roof, good walls, latrine, lamp, table	**2.01**	1.39	**1.81**	1.39	**1.82**	1.34	**1.88**	1.40
	Lnliveval	ln (Value of Livestock Assets in 2005 MTN)	**5.19**	2.77	**4.70**	3.00	**5.21**	2.63	**4.74**	3.01
	Ftrees	Total number of fruit trees owned by HH	**3.53**	2.44	**1.87**	2.24	**2.13**	2.07	**2.39**	2.5
	Ftreessq	Number of fruit trees squared								
	Tot_area	Land area in hectares	**1.95**	2.03	**1.58**	2.23	**1.92**	2.71	**1.62**	2.02
	Nfields	Number of fields owned	**2.78**	1.4	**2.41**	1.27	**2.57**	1.3	**2.5**	1.33
	Pct_titfields	Percent of fields for which the household owned a title deed for the property	**0.02**	0.11	**0.01**	0.06	**0.01**	0.09	**0.01**	0.08
Agro-ecological Asset Strength Factors	Elev_mean	Elevation of primary sampling unit in 100 meters projected at 90m digital resolution, within 5 km radius of HH	**11.0**	2.8	**11.0**	2.5	**11.0**	2.4	**10.9**	2.6
	Edrtdaydk	Expected drought days: 6-year trailing district average including each survey year	**1.25**	0.93	**1.23**	0.99	**1.01**	0.74	**1.3**	1.02
	RivLake	Availability of river or lake (for irrigation): 1=river or lake not used as 1st or 2nd source of water for community, 2= river or lake is used but it is far away, 3= river or lake is used and it is close	**0.34**	0.47	**0.39**	0.49	**0.47**	0.50	**0.34**	0.48
	Lc_irrig_Dum	"Irrigation potential": 1= majority of land cover in 1 km radius of community is swamp forest, waterbody, irrigated cropland, or swamp bushland/grassland	**0.05**	0.21	**0.04**	0.20	**0.02**	0.15	**0.05**	0.21

Table 9 (cont'd.)

Category	Variable Name	Variable Description	FFV Sellers Avg	FFV Sellers SD	FFV Non-Sellers Avg	FFV Non-Sellers SD	Maize Sellers Avg	Maize Sellers SD	Maize Non-Sellers Avg	Maize Non-Sellers SD
		Village Shock Variables:								
Agro-ecological Asset Strength Factors (cont'd.)	Vflood4	Percentage of community affected by flood	**0.11**	0.29	**0.12**	0.30	**0.11**	0.27	**0.12**	0.30
	Vdrought4	Percentage of community affected by drought	**0.17**	0.36	**0.21**	0.39	**0.15**	0.34	**0.21**	0.39
	Vplgcrop4	Percentage of community affected by plague/severe disease affecting crops	**0.29**	0.41	**0.35**	0.43	**0.27**	0.39	**0.35**	0.43
	Vplglivstk4	Percentage of community affected by plague/epidemic affecting livestock	**0.69**	0.39	**0.63**	0.41	**0.68**	0.40	**0.64**	0.40
Price/ Wealth Effect Factors	PIratio	Price of output index, specific to the dependent variable crop group	**0.64**	0.32	**0.61**	0.30	**0.57**	0.15	**0.70**	0.32
	Dswage	Salaried Worker in the HH: (If a household includes a member which is a teacher, government official, etc.=1, if not = 0)	**0.05**	0.22	**0.06**	0.24	**0.05**	0.21	**0.06**	0.24
	Pensoa	Value of received pension in 1000 MTN, either sent from within the country to the household or from abroad	**0.23**	2.25	**0.20**	2.35	**0.23**	2.48	**0.20**	2.28
Demo-graphic Factors	Chefidad	HH head age	**43.1**	14.3	**42.2**	14.9	**40.4**	14.1	**43.0**	14.8
	Chefidadsq	(HH head age) squared								
	Chfsex	HH head is male	**0.81**	0.39	**0.75**	0.44	**0.81**	0.39	**0.75**	0.43
	M_prop	Number of adults age 15-59 who are male/total number of adults age 15-59	**0.44**	0.24	**0.42**	0.24	**0.44**	0.22	**0.42**	0.25
	Hhae	Size of the household in consumption equivalents	**3.97**	1.81	**3.74**	1.88	**3.72**	1.61	**3.83**	1.93

3.2.2 Strength of Asset Base Factors

Explanatory variables addressing a household's asset base are categorized by labor (A), equipment (B), and land (C-D).

A. Quality of labor indicators include household head participation in a farmer association (where agricultural knowledge, skills or social network opportunities could be attained) and maximum years of education of any adult member of the household. Membership in a farmer association is expected to show a positive relationship to market participation and value of sales obtained for fresh produce and maize, which both require improved inputs for greater marketed surplus to be possible and for whom farmer associations may provide a key means for sharing information on availability, access or use of these inputs (or improved combinations or packages of these inputs) on a location-specific level. Extension agents may target farmer associations for dissemination of information concerning farm practice, and these groups may have more opportunities for innovative credit solutions to finance agricultural improvements. Furthermore, fresh produce sellers may additionally benefit from farmer associations if there are opportunities for collaboration in terms of irrigation use in their vegetable plots from nearby water sources or wells, or even shared mechanized or gravity-fed water systems. Level of education may also be more important for fresh produce market participation and value of sales given that input and knowledge-use are particularly important for avoiding crop loss due to pests or disease among vegetables and fruit.

Negative factors affecting household labor availability include chronic illness or death due to illness experienced by any number of adults in the household, given as separate variables for the effects of illness on male adults and female adults. The dependency ratio - the ratio of household members, children or the elderly presumably requiring assistance by the able working-age household members -- is also expected to correlate negatively with the availability of household labor for agricultural activity and therefore also on the decision to produce surplus fresh produce or maize for market sales. The dependency ratio is calculated as the number of household members younger than 15 or older than 59 years of age divided by the total number of household members.

B. The availability of capital equipment, especially for irrigation, is of great importance for horticultural crop production. Variables for whether the household reported using (1) manual systems (typically buckets filled at the nearby stream) or (2) mechanized or gravity systems to irrigate were included separately. Both of these variables should, compared to no irrigation, have a positive influence on fresh produce and maize market participation and quantity sold through their effect on quantity produced. In principle, the magnitude of the effect should rise from manual to mechanized/gravity-fed. However, the very low prevalence of the latter (Table 9) may make it difficult to accurately capture their effect.

Other variables for capital equipment expected to have a positive relationship on market participation include (3) the value of all farm equipment, in 2005 MTN, which Mather et al. generated (2007)[13] using TIA data, (4) a similarly created livestock asset

[13] This variable combines owned farm equipment used for production (plow, sprayer, pump), processing (press, mill, thresher), and transportation (bicycle, cart, trailer, motorcycle, truck) into one variable, the log of farm equipment value. The TIA data did not actually give values for these items, so values were taken from the Mozambique *Inquérito aos Agregados Familiares* (IAF) expenditure survey (2002/03) and also some

valuation variable, also generated by Mather et al., in which regional price data for sales of live animals were applied to the number of animals owned by the household reported at the end of 2002 and 2005 respectively. Lastly, (5) a categorical variable was included that counts any other equipment assets not included in the farm asset valuation such as a storage facility, a latrine, a lamp, a table, a higher quality roof, or higher quality walls at the home.

Asset ownership and value of capital equipment is expected to have a positive effect on maize and fresh produce market participation and value of sales with the exception of livestock assets for fresh produce sales, given animal traction is generally not used in the intensive cultivation of these plots. Asset ownership may play a more important role for fresh produce market participation in comparison to maize market participation in managing the larger risk considerations fruit or vegetable sellers face. As many authors have more recently emphasized, levels of asset ownership may even have a larger role in determining whether households can use commercialization of agricultural product to pull themselves out of poverty than market access does. A critical collective asset-holding level may be required to overcome a poverty trap (Dean et al. 2005, Banerjee and Duflo 2011).

C. Quantity and quality of land, as differentiated from the variables describing the agro-ecological properties of each household's location, described in the next section, are accounted for with variables for the number of fruit trees (clearly important for

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values from survey data collected by MSU's food security group in Zambia, and these values were then converted to value each asset in MTN. The author thanks David Mather for providing both "value of farm equipment" and "value of livestock asset" variables for use in this analysis.

participation in fruit sales in particular), the total area of land owned by the household in hectares[14], the number of fields owned that were in production, and the percentage of those fields for which the household possessed a land title deed. All of these variables would be expected to play a positive role in the ability and decision of farmers to commercialize their harvested produce, even among farmers specializing in the labor intensive crops such as vegetables and fruit (Tschirley et al. *forthcoming*).

Walker et al. (2004) found the number of fields in production to have a significant and positive effect on income in Mozambique, using the TIA 2002-2005 panel. Their hypothesis was that the number of fields is an indicator of more entrepreneurial farmers who strive to find fields with particular characteristics to maximize their yields. Such an entrepreneurial attitude would also be expected to lead to greater market participation and value sold by farm owners of both maize and fresh produce plots.

D. Exogenous indicators of the agro-ecological land properties owned by farming families also have an important role to be accounted for in this study.

1. Higher elevation of the community would be expected to have a positive effect on vegetable sales via improved harvest conditions, due to the cooler climate which reduces pest problems for the vegetable varieties which do well in temperate climates. Cold air holds less moisture so moist air releases its moisture as it hits a

[14] Total area in hectares was evaluated using TIA data and a "farmer adjustment method" described in Mather, Cunguara and Boughton (2008). This adjustment is used because TIA enumerators used global positioning system (GPS) units to measure one field per household for 25% of TIA households. Coefficients from a regression of these measured field areas on area declared by the household for the same field, the household head's education, and district dummies were used to adjust declared field area for which no measurements were taken. The area variable used in this study uses the same 'farmer adjustment' method in both years.

hill or mountain and has to rise. On the other hand, higher elevation would possibly be expected to have a negative effect on fruit market participation, as many of the fruit trees are tropical and thrive in lower elevation humid areas closer to the coast. Controlling for geographic region, elevation would also be expected to increase maize participation and sales given maize's superior yield in mid-altitude areas if hybrid varieties are used. Note that the majority of maize sellers in Mozambique are located in the higher elevation and rainfall areas of the central and northern regions of the country.

2. Expected number of drought days was computed at the district level using a six year trailing average of number of days of rain/drought per year, including each survey year respectively. This district-year-specific number of expected drought days per district was calculated by Mather, Cunguara and Boughton (2008, p 60-61)[15] It is specific to the 150-day principal maize growing season, and therefore may show higher significance in the maize probit regression, reflective of farmer decisions about planting or selling maize. Given that too much rain could also negatively affect a maize harvest, and the average number of drought days between top sellers and non-top sellers of maize in chapter 2.3.3 is not significantly different, there is no anticipated sign of this effect. Expected drought days could also have either a positive or negative effect on the decision to sell and value of sales obtained of vegetables if rainfall affects the natural water sources from which irrigation is

[15] The author thanks David Mather for providing the relevant datasets for this expected drought-days variable, as well as the syntax he used to create the variables household member salaried worker, household member death and illness and community village shock variables, also used in this analysis.

derived either by too little or too much. And less anticipated rain in a region, while it may play a larger role for annual crops, its detrimental effects are expected to play an even lesser role among annual fruit tree crops, similarly to the detrimental effects of flooding.

3. The variable *RivLake* accounts for a river or lake having been reported as a primary or secondary source of water in the community (as compared to private wells, collective wells or shared "holes"). This, in addition to the proximity of the community to a waterbody, swamp, or bush/grassland area variable *lc_irrig_dum*[16] are expected to have a positive effect on FFV sales, especially that of fruit. Both variables serve as proxies for irrigation potential, potentially including the ability to use *zonas baixas* for vegetable production. These are low-lying areas that maintain soil moisture well into the dry season and thus support vegetable production for longer periods of the year without the need for irrigation. Again, the low prevalence of the number of households found within 1 kilometer of the group of landcover types listed above (Table 9) may make it difficult to accurately capture the effect of the *lc_irrig_dum* variable.

4. Agro-ecological factors which would be expected to have a negative effect on participation in maize or fresh produce market activity and value of sales include whether flood, drought, crop disease, or a livestock epidemic affected the village. These indicators were collected during each panel year and included in this analysis

[16] Further detail regarding the creation of this land cover variable can be found in data section 2.1.3 C.

to help control for adverse agro-ecological community-specific factors. They were generated as 0-1 variables interpreted in 25 percentage intervals of the community affected by the village shock, 0%, 25%, 50%, 75% or 100%.

3.2.3 Price or Wealth Effect Factors

Output prices are captured in a price ratio index at the province level. This ratio uses the median of a basket of output prices for FFV, vegetables, fruit, or maize (depending on the dependent variable used) weighted by relative importance of the respective crop group in sale value. This weighted value is divided by a similarly weighted basket of "all other crop" median sale values for a province-specific relative price ratio of crop-group-type prices to all-other-crop-type prices by share in total sale values. I expect this variable to have a positive effect on each respective crop category: higher relative prices in expenditure share should incentivize farmers to participate in market sales. However, literature suggests the existence of perverse price responses in cereals among low income households who may be net buyers of grains and choose not to sell, or to sell less and store more as prices increase. This effect has not yet been tested for within fresh produce to the knowledge of the author. The mean and standard deviation of each price index group is given in Table 10.

Table 10. Mean and Standard Deviations of each Price Index group

	Mean	Std. Deviation
PIratio FFV	**0.62**	0.30
PIratio Maize	**0.67**	0.29
PIratio Fruit	**0.32**	0.12
PIratio Vegetables	**0.81**	0.43

Other factors affecting the wealth dynamic of the household, aside from their fixed asset holdings each year are (1) if any pension was received by a household member, and (2) if any member of the household held a salaried off-farm job such as an elected government official or school teacher. The effect of either of these variables may be difficult to interpret. The additional income may serve to dampen supply response for subsistence farming families who might rather reserve more of their own food for consumption than sell it. And additionally, it could be expected that even if such an effect were at work, it would have less relevance for many horticultural crops than for crops with a longer "shelf life," such as maize. Other factors that could affect the decision process include household preference of cash flow to fruit and vegetable consumption as compared to maize. Given a combination of these competing hypotheses at work, it is expected that the sign and significance of these wealth effect variables may not be clear.

3.2.4 Demographic Factors

Finally, several demographic characteristics were included to help control for heterogeneity among households: age and gender of the household head, the gender composition of household adult members, and the relative size of the household in consumption equivalents based on the caloric requirements of the typical male or female of a certain age. It could be argued that having more adult males in a household could provide more labor and thus enable market participation, although the opposite could also be true if males consumed more of the household maize or produce consumption than a family with more adult females would, leaving less maize or FFV to sell. The greater the size of household consumption equivalents is expected to have a possibly negative effect on participation levels, if, indeed, more food is needed for household subsistence consumption overall. Female-headedness is expected to have a negative impact on market participation and on the value of sales, although the reason for this is not entirely clear, nor should it be prescriptive.

Regional (Northern, Central, or Southern area of Mozambique) and time dummy variables were also included and interacted to control for spatial or temporal correlation across geographic region and year.

3.3 Modeling Approach

Generating reliable econometric estimates of the correlates of fresh produce market participation must take into account the fact that many households choose not to sell any of their production. For example in 2008, only 18.2% of farmers in Mozambique sold maize, 16.2% sold fresh fruits or vegetables, 12.5% sold fresh fruit, and 7.8% sold vegetables (see tables 1-4 in Chapter 2). This results in many observations of zero sales, combined with a continuous distribution of positive sale values. Estimating the correlates of such variables using regular OLS imposes linearity on a model that is not linear, given the skewed distribution of the dependent variable. This means that linear projections of conditional means are often poor approximations (Wooldridge 2010).

Previous studies on market participation in Mozambique by Heltman and Tarp (2002) for fresh produce sales and Benfica, Tschirley and Boughton (2006) for tobacco sales have used a variation on the Heckman two-step approach used by Goetz (1992). This approach treats cases where households have no positive sales value as a sample selection (censored sample) problem. Yet in the African context, zero sales must be treated as a choice by the farmer, not a case of missing data: farmers choose not to sell due to insufficient production or low prices. In Wooldridge's terminology (2010, p.667), these situations are referred to as "corner solutions," recognizing that a sales value of zero represents a valid economic choice.

Two estimation procedures can be used in these corner solution circumstances. The Tobit model accounts for the "pile-up" of data at zero while estimating a single set of coefficients to explain both the decision (in this case) to sell and the amount sold. The disadvantage of the Tobit is that it assumes the same set of variables affect both the decision to sell and the quantity decision in the same way. This present study uses the second modeling option: Cragg's more flexible double-hurdle (1971) alternative to the Tobit. Like the Tobit, this model is appropriate when the decision to sell and the quantity (or value) decision are determined jointly. The benefit of using Cragg's version is its ability to allow each stage to be determined by a different process and sometimes a differing set of explanatory variables while still jointly analyzing the whole. As such, it produces separate estimates of coefficients and partial effects for each explanatory variable in both stages separately, and can also be used to generate overall "average partial effects" that take into account both stages together (Burke 2009a). Examples of this approach include Burke 2009b, Mather, Boughton and Jayne 2009, Goeb 2011, Mason 2011, and Ricker-Gilbert, Jayne and Chirwa 2011.

The Cragg model interprets the dependent variable sequentially in two tiers. The first tier interprets the dependent variable as a binary response of an event having occurred or not occurred. The second tier interprets the dependent variable as a continuous and (in this case) positive set of values for cases in which the event did occur. In this study, these two stages are (1) whether a household participates in selling fresh produce or maize, and (2) the value of sales obtained (in MTN), conditional on a positive decision to sell. The structure can be given as follows, where p_{it} represents the (K x 1) vector of binary observable household decisions to participate in market sales, p_{it} * represents the binary latent, or unobservable, vector of household decisions to participate; v_{it} * represents the observable market value of sales per household, and v_{it} represents the latent, anticipated value of sales per household.

Stage 1 $$p_{it}* = \psi^1 + x_{it}^1\beta^1 + e_{it}^1 \qquad e_{it}^1 \mid x_{it}^1 \sim \mathrm{N}(0, \sigma^2) \qquad (3.1)$$

where $p_{it} = 1$ if $p_{it}* > 0$; otherwise $p_{it} = 0$,

Stage 2 $$v_{it}* = \psi^2 + x_{it}^2\beta^2 + e_{it}^2 \qquad e_{it}^2 \mid x_{it}^2 \sim \mathrm{N}(0, \sigma^2) \qquad (3.2)$$

where $v_{it} = v_{it}*$ if $v_{it}* > 0$ and $p_{it} = 1$; otherwise $v_{it} = 0$.

The subscript *it* refers to the *i*th household during period *t* (t = 2002, 2005 in this study), the superscripts 1 or 2 refer to the respective first or second stages of the model, ψ^1 and ψ^2 are the intercept terms, β^1 represents a K x 1 vector and β^2 represents a L x 1 vector of estimated parameters in each respective stage for each explanatory variable in (1 x K) vector x_{it}^1 and (1 x L) vector x_{it}^2. These x variables are assumed to be exogenous in their participation and sale value equations, and do not need to each contain the same elements.

The Cragg Double Hurdle also assumes that the processes that determine $p*$ and $v*$ are conditionally independent, that is, the decision to sell is independent of the value of sales obtained. This can be summarized by the statement D($v* \mid p$, **x**) = D($v* \mid$ **x**), concerning the latent variable's distribution (Burke 2009a, Wooldridge 2010: Chapter 17).

3.4 Estimation Proceedure

The Cragg model is implemented in four steps: (1) a probit estimation on the entire sample, (2) a truncated estimation (either truncated normal or log normal[17]) limited to the non-zero values of the dependent variable, (3) computation of the average partial effects (APEs) across all households and time periods and (4) simulation of standard errors for the APEs (to allow proper inference) through a bootstrapping routine. The first two steps follow the modeling approach in (3.1) and (3.2) above. The third step, calculating APEs, first requires the calculation of partial effects (PEs) specific to each household, illustrated in following equations (3.3) to (3.5).

The equation to calculate the conditional PE of x_j using the maximum likelihood estimated beta coefficients (β^1) from the probit first stage regression is:

$$\frac{\partial p_{it}\left(v_{it} > 0 \mid x_{it}^1\right)}{\partial x_j} = \beta_j^1 \phi\left(x_{it}^1 \beta^1\right) \tag{3.3}$$

where ϕ is the standard normal probability density function (PDF), and $x_{it}^1\beta^1$ is the matrix of first stage explanatory variables and their respective parameter coefficients.

[17] The second stage of the double-hurdle is estimated as a log-normal. After performing a Vuong test, this form was specified as more appropriate to use in comparison to using the truncated normal in the case of this data.

The equation to calculate the conditional PE of x_j using the maximum likelihood estimated beta coefficients (β^2) from the truncated second stage regression is:

$$\frac{\partial E\left(v_{it} \mid v_{it} > 0, x_{it}^2\right)}{\partial x_j} = \beta_j^2 \left(1 - \lambda\left(\frac{x_{it}^2 \beta^2}{\sigma}\right)\left(\frac{x_{it}^2 \beta^2}{\sigma} + \lambda\left(\frac{x_{it}^2 \beta^2}{\sigma}\right)\right)\right) \quad (3.4)$$

where λ represents the inverse mills ratio (IMR): the probability density function divided by the cumulative density function. β_j^2 is the estimated coefficient of x_j from the truncated regression and σ is the estimated variance from the truncated regression. The result of this equation is the PE of a given variable on fresh produce sales among those who chose to sell. The household-specific PEs from equations (3.3) and (3.4) are then used to calculate APEs over the entire sample and the sub-sample that sold, respectively.[18]

Finally, the equation to calculate the unconditional partial effect of x_j can be understood in two additively separable parts, each of which uses estimated beta coefficients from stages 1 and 2 together (β^1 and β^2) to determine the effect of x_j on expected sales (in this case) among all households in the sample, not just those who sold:

[18] Note that, because PEs are calculated for each household, APEs can in principle be calculated for any subset of the sample that the analyst wishes. For example, APEs could be calculated by total sales quintiles, or by land holding category, or by any other disaggregation that may be of interest.

$$\frac{\partial E\left(v_{it} \mid x_{it}^1, x_{it}^2\right)}{\partial x_j} = \beta_j^1 \phi\left(x_{it}^1 \beta^1\right) \cdot \left(x_{it}^2 \beta^2 + \sigma \lambda \left(\frac{x_{it}^2 \beta^2}{\sigma} \right) \right)$$

(part 1) (3.5a)

$$+ \quad \Phi\left(x_{it}^1 \beta^1\right) \cdot \beta_j^2 \left[1 - \lambda \left(\frac{x_{it}^2 \beta^2}{\sigma} \right) \left(\frac{x_{it}^2 \beta^2}{\sigma} + \lambda \left(\frac{x_{it}^2 \beta^2}{\sigma} \right) \right) \right]$$

(part 2) (3.5b)

where Φ represents the cumulative density function (CDF). (These equations follow the examples given by Burke 2009a, with some notational differences.)

The average partial effects (APEs) of all three outcomes (3.3, 3.4 and 3.5) for x_j are then computed across all household-time specific observations. These APEs are reported as APE1 for the conditional average partial effects in the first stage, APE2 for the conditional average partial effects in the second stage, and UAPE for the unconditional average partial effects, taking both stages into account in the results section below.

The fourth part of the estimation procedure is to simulate standard errors for these partial effects through a bootstrapping routine, to allow for proper inference. The bootstrapping procedure is replicated approximately 700 times for each set of estimated parameters, using a stratified and clustered approach according to the complex survey design of the TIA.

3.5 The Problem of Unobserved Heterogeneity due to Unobserved Variable Bias

A common problem in econometric estimation is that some variables such as effort, cognitive ability, family upbringing, motivation, or in the case of the household unit, its managerial structure or quality are not observable and therefore cannot be controlled for in the analysis, even though many of them may have important effects on the modeled variable. Fixed effects or Random effects (FE/RE) estimation is the most common way to deal with this problem. Wooldridge (2010), however has shown that the FE Probit estimator (which the Cragg approach uses in the first stage) is inconsistent, and Greene (2004) has shown that the FE Truncated Normal estimator (Cragg's second stage) is biased when the number of time periods (two in the case of this study) is less than five.

The assumption of independence from unobserved variables can be relaxed by modeling the unobserved heterogeneity, denoted c_i (in vector notation), using a correlated random effects approach, otherwise known as the Mundlak-Chamberlain device (after the work of Mundlak (1978) and Chamberlain (1984)). To use this device in this paper's model, the correlation between the unobserved factors and the explanatory variable is assumed to take the identical form:

Stage 1 $$c_i^1 = \overline{x}_i^1 \xi^1 + a_i^1 \qquad a_i^1 \mid x_{it} \sim \mathrm{N}(0, \sigma^2) \quad (3.6)$$

Stage 2 $$c_i^2 = \overline{x}_i^2 \xi^2 + a_i^2 \qquad a_i^2 \mid x_{it} \sim \mathrm{N}(0, \sigma^2) \quad (3.7)$$

where $\overline{x}_i^1$ is the 1 x K vector of the household specific time-mean of each time-varying explanatory variable in x^1, and $\overline{x}_i^2$ is the 1 x L vector of the household specific time-mean of each time-varying explanatory variable in x^2 ; ξ^1 and ξ^2 are their associated K x 1 and L x 1 vectors of parameter coefficients, and a_i^1 and a_i^2 are each equation's respective error terms. Adding the c_i specification to the right hand side of equations 3.1 and 3.2 above yields the following, with transformed error terms u_{it}^1 and u_{it}^2, where $u_{it}^1 = e_{it}^1 + a_i^1$ and $u_{it}^2 = e_{it}^2 + a_i^2$:

Stage 1 $p_{it}* = \psi^1 + x_{it}^1\beta^1 + \overline{x}_i^1\xi^1 + u_{it}^1 \quad u_{it}^1 \mid x_{it}^1 \sim N(0, \sigma^2)$ (3.8)

where $p_{it} = 1$ if $p_{it}* > 0$; otherwise $p_{it} = 0$,

Stage 2 $v_{it}* = \psi^2 + x_{it}^2\beta^2 + \overline{x}_i^2\xi^2 + u_{it}^2 \quad u_{it}^2 \mid x_{it}^2 \sim N(0, \sigma^2)$ (3.9)

where $v_{it} = v_{it}*$ if $v_{it}* > 0$ and $p_{it} = 1$; otherwise $v_{it} = 0$.

Since $\overline{x}_i^1$ and $\overline{x}_i^2$ have the same value for each household across both years (the average of the values in each year by household), but differ across households, when all the variables are included and estimated in the same regression, any *time-constant* unobserved heterogenaity that follows equations 3.7 and 3.8 is controlled for. This also achieves the same outcome as a random effects estimation using a panel data linear model (Ricker-Gilbert, Jayne and Chirwa 2011, Goeb 2011, Mather, Boughton and Jayne 2011).

3.6 Empirical Results

The introduction to this paper discussed the characteristics of fruits and, especially, vegetables, that make their production and marketing qualitatively different from that of field crops such as traditional food crops (maize, beans, groundnuts, and others) and traditional cash crops (cotton, tobacco, and others). The results of each set of regressions on market participation in maize, fruit, vegetables, and FFV together, are summarized in tables 11 - 12[21].

Market Access

Hours of travel time to a town of at least 10K persons evidences a significantly negative effect on the decision to sell. Its unconditional effect on quantity sold is also negative and significant for both fruit and vegetables separately and FFV together. This result is as expected, given the high perishability of fresh produce. For every hour closer to a town/city center, a household is 0.5 percentage points more likely to sell fruits or vegetables and the value of sales unconditional on the decision to participate in market activity for FFV as a group is 2.9% higher for each hour closer. Also as hypothesized, the maize market regressions show no significant effect among the three partial effect estimates.

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[21] Controls were also included of geographic region two and three of three regions in Mozambique, year 2005, region two interacted with year 2005, and region three interacted with year 2005.

The coefficients on **population density** are small and not significant, even though a significant and positive relationship to market participation was anticipated.

Receipt of **price information** performs as hypothesized, yielding positive effects on both participation and market sale values within maize and FFV crop categories. Farmers are 4.1 percentage points more likely to sell fresh fruits or vegetables, and 2.7 percentage points more likely to sell maize if they have received price information. The unconditional effect on value of FFV sales is 28.5%. Values rise by a slightly greater unconditional 32.5% among maize sellers. Because market information is *not* available for fresh produce items but is instead limited to food staples, this variable is best interpreted in the fresh produce regressions as a general indicator of a farmer's attunement to market information and to a general commercial orientation.

Table 11. Cragg Double-Hurdle Results, Maize and Fresh Produce

	Maize Probit		Maize Log Normal				FFV Probit		FFV Log Normal			
	Dep't variable = 1 if HH sold maize, 0 otherwise		Dep't variable = ln(value of sales)				Dep't variable = 1 if HH sold FFV, 0 otherwise		Dep't variable = ln(value of sales)			
	APE of X_j on P(y>0)		APE (Conditional) of X_j on lny, given y>0		APE (Unconditional) of X_j on lny		APE of X_j on P(y>0)		APE (Conditional) of X_j on lny, given y>0		APE (Unconditional) of X_j on lny	
Independent variables	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**
Hours to town, 10K+	-0.001	0.390	-0.004	0.533	-0.010	0.314	-0.005	0.000	-0.005	0.457	-0.029	0.003
Population density	0.000	0.401	0.001	0.127	0.000	0.758	0.000	0.478	0.000	0.339	-0.001	0.202
Price information	0.027	0.094	0.141	0.226	0.325	0.076	0.041	0.024	0.065	0.620	0.285	0.104
Association member	-0.001	0.971	0.431	0.047	0.425	0.174	0.057	0.023	0.375	0.056	0.790	0.023
Adult max education	0.004	0.507	-0.016	0.626	0.007	0.892	-0.010	0.055	0.007	0.842	-0.043	0.290
Male HH ill adults	-0.014	0.780	-0.057	0.828	-0.137	0.719	0.025	0.653	1.117	0.250	1.397	0.310
Female HH ill adults	0.018	0.686	-0.020	0.946	0.094	0.838	-0.013	0.739	-0.265	0.226	-0.314	0.171
Male illness deaths	-0.018	0.686	0.296	0.403	0.180	0.689	0.041	0.364	-0.205	0.513	0.008	0.985
Female illness deaths	-0.062	0.162	-0.460	0.158	-0.851	0.043	0.062	0.140	0.074	0.789	0.393	0.262
Dependency ratio	0.085	0.086	0.302	0.410	0.840	0.087	-0.015	0.776	-0.162	0.662	-0.237	0.615
Manual irrigation	-0.016	0.563	0.082	0.697	-0.027	0.913	0.141	0.000	0.599	0.040	1.881	0.005
Mech/grav irrigation	-0.024	0.731	0.163	0.846	-0.012	0.993	-0.023	0.714	1.232	0.394	0.973	0.433
Ln(equipment assets)	0.004	0.218	0.041	0.021	0.063	0.015	0.003	0.355	-0.016	0.462	-0.002	0.953
Ln (livestock assets)	0.007	0.026	0.019	0.407	0.064	0.039	0.006	0.069	0.048	0.029	0.079	0.004
Other assets (1-6)	0.024	0.009	-0.067	0.371	0.083	0.390	-0.002	0.852	0.086	0.137	0.078	0.306
No. fruit trees	-0.004	0.503	-0.042	0.322	-0.064	0.230	0.058	0.000	0.067	0.039	0.362	0.000

* P-values less than or equal to 0.10 in value are highlighted yellow.

Table 11 (cont'd.)

	Maize Probit		Maize Log Normal				FFV Probit		FFV Log Normal			
	Dep't variable = 1 if HH sold maize, 0 otherwise		Dep't variable = ln(value of sales)				Dep't variable = 1 if HH sold FFV, 0 otherwise		Dep't variable = ln(value of sales)			
	APE of X_j on P(y>0)		APE of X_j on lny, given y>0		UAPE of X_j on lny		APE of X_j on P(y>0)		APE of X_j on lny, given y>0		UAPE of X_j on lny	
Independent variables	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**
Land area in hectares	0.003	0.517	0.047	0.345	0.066	0.250	0.000	0.995	0.005	0.887	0.005	0.908
Number of fields	0.011	0.151	-0.017	0.724	0.051	0.432	0.015	0.037	0.030	0.558	0.108	0.099
Pct. fields w/ titles	0.060	0.397	-0.044	0.937	0.334	0.611	0.104	0.167	0.301	0.461	0.834	0.123
Elevation (100 m)	-0.005	0.039	-0.014	0.438	-0.045	0.071	0.000	0.900	0.010	0.607	0.008	0.760
Expct'd drought days	0.058	0.001	-0.031	0.786	0.334	0.057	0.011	0.574	-0.087	0.486	-0.033	0.844
Close to river/lake	0.050	0.000	0.149	0.102	0.511	0.002	-0.006	0.684	0.055	0.525	0.023	0.853
Irrigat'n potent'l area	-0.086	0.002	-0.089	0.718	-0.563	0.013	-0.020	0.610	0.311	0.368	0.183	0.628
Village flood	-0.023	0.510	0.029	0.894	-0.118	0.703	0.015	0.677	0.020	0.930	0.097	0.760
Village drought	-0.027	0.392	-0.021	0.914	-0.191	0.443	-0.020	0.482	0.104	0.583	0.001	0.996
Village crop disease	-0.023	0.356	-0.058	0.706	-0.206	0.326	0.012	0.599	0.139	0.344	0.202	0.304
Vil. livestock disease	0.013	0.578	-0.168	0.243	-0.086	0.689	0.034	0.159	0.008	0.964	0.182	0.385
Price index ratio	-0.151	0.047	1.623	0.023	0.665	0.437	0.032	0.082	0.117	0.442	0.280	0.165
Pension value rec'd	0.000	0.078	0.000	0.029	0.000	0.012	0.000	0.125	0.000	0.151	0.000	1.000
HH salaried worker	-0.012	0.736	-0.064	0.849	-0.136	0.741	-0.015	0.676	0.039	0.906	-0.043	0.916
Age of HH-head	0.001	0.710	-0.011	0.444	-0.007	0.710	-0.003	0.101	-0.015	0.139	-0.031	0.028
HH male proportion	0.011	0.806	0.273	0.430	0.342	0.444	0.035	0.490	0.365	0.281	0.543	0.219
HH-head is male	0.020	0.583	0.362	0.243	0.486	0.236	-0.002	0.967	0.244	0.388	0.239	0.485
HH consumption size	-0.009	0.257	0.062	0.295	0.003	0.966	-0.004	0.614	-0.004	0.948	-0.024	0.726

Table 12. Cragg Double-Hurdle Results, Fruit and Vegetables Separately

	Fruit Probit		Fruit Log Normal				Veg Probit		Veg Log Normal			
	Dep't variable = 1 if HH sold fruit, 0 otherwise		Dep't variable = ln(value of sales)				Dep't variable = 1 if HH sold vegetables, 0 otherwise		Dep't variable = ln(value of sales)			
	APE of X_j on P(y>0)		APE (Conditional) of X_j on lny, given y>0		APE (Unconditional) of X_j on lny		APE of X_j on P(y>0)		APE (Conditional) of X_j on lny, given y>0		APE (Unconditional) of X_j on lny	
Independent variables	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**
Hours to town, 10K+	-0.004	0.000	0.002	0.820	-0.028	0.022	-0.002	0.031	-0.011	0.294	-0.030	0.030
Population density	0.000	0.545	-0.001	0.290	-0.001	0.177	0.000	0.409	0.000	0.404	0.000	0.934
Price information	0.019	0.220	0.111	0.412	0.260	0.189	0.030	0.018	-0.192	0.258	0.154	0.499
Association member	0.040	0.050	0.377	0.054	0.804	0.029	0.023	0.169	0.153	0.538	0.470	0.271
Adult max education	-0.011	0.012	0.045	0.299	-0.039	0.450	0.000	0.921	-0.036	0.462	-0.041	0.548
Male HH ill adults	0.014	0.759	0.523	0.287	0.679	0.439	0.016	0.660	1.276	0.460	1.723	0.526
Female HH ill adults	-0.020	0.560	-0.485	0.040	-0.563	0.022	0.018	0.556	-0.112	0.795	0.085	0.888
Male illness deaths	0.023	0.572	-0.413	0.233	-0.242	0.622	-0.023	0.513	0.529	0.345	0.266	0.703
Female illness deaths	0.039	0.331	-0.003	0.992	0.287	0.498	0.040	0.212	-0.124	0.782	0.343	0.552
Dependency ratio	-0.004	0.927	-0.289	0.477	-0.319	0.560	-0.046	0.266	0.427	0.440	-0.110	0.881
Manual irrigation	0.039	0.172	0.010	0.970	0.314	0.450	0.158	0.000	0.432	0.147	3.806	0.016
Mech/grav irrigation	-0.040	0.407	1.122	0.425	0.534	0.667	0.010	0.824	-0.080	0.949	0.033	0.978
Ln(farm equip assets)	0.003	0.279	-0.033	0.192	-0.011	0.735	0.002	0.414	-0.026	0.424	-0.004	0.919
Ln (livestock assets)	0.003	0.318	0.047	0.082	0.071	0.042	0.006	0.011	0.056	0.059	0.132	0.002
Other assets (1-6)	-0.001	0.904	0.012	0.864	0.005	0.962	0.011	0.085	0.074	0.388	0.208	0.078
No. fruit trees	0.061	0.000	0.085	0.023	0.539	0.000	0.011	0.003	0.015	0.761	0.142	0.025

Table 12 (cont'd.)

	Fruit Probit		Fruit Log Normal				Veg Probit		Veg Log Normal			
	Dep't variable = 1 if HH sold fruit, 0 otherwise		Dep't variable = ln(value of sales)				Dep't variable = 1 if HH sold vegetables, 0 otherwise		Dep't variable = ln(value of sales)			
	APE of X_j on P(y>0)		APE of X_j on lny, given y>0		UAPE of X_j on lny		APE of X_j on P(y>0)		APE of X_j on lny, given y>0		UAPE of X_j on lny	
Independent variables	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**	**APE1**	**p-value**	**APE2**	**p-value**	**UAPE**	**p-value**
Land area in hectares	0.002	0.702	-0.004	0.910	0.008	0.863	0.000	0.935	-0.028	0.568	-0.030	0.585
Number of fields	0.002	0.754	0.024	0.734	0.040	0.653	0.019	0.000	0.019	0.809	0.242	0.012
Pct. fields w/ titles	0.064	0.316	-0.013	0.975	0.460	0.454	0.062	0.167	-0.067	0.915	0.655	0.458
Elevation (100 m)	-0.002	0.389	-0.012	0.495	-0.027	0.255	0.001	0.786	0.037	0.118	0.042	0.236
Expct'd drought days	0.025	0.135	0.037	0.797	0.222	0.263	-0.023	0.159	-0.232	0.211	-0.497	0.072
Close to river/lake	-0.006	0.624	0.131	0.229	0.085	0.587	-0.001	0.892	0.042	0.717	0.027	0.880
Irrigat'n potent'l area	0.025	0.504	0.457	0.188	0.731	0.221	-0.006	0.836	-0.381	0.120	-0.427	0.243
Village flood	0.020	0.531	-0.142	0.624	0.008	0.984	0.005	0.829	0.452	0.218	0.510	0.298
Village drought	-0.020	0.429	0.011	0.963	-0.135	0.652	-0.003	0.864	0.138	0.630	0.100	0.802
Village crop disease	0.015	0.449	0.007	0.968	0.116	0.616	0.010	0.516	0.154	0.465	0.271	0.366
Vil. livestock disease	0.020	0.371	-0.021	0.906	0.125	0.625	0.025	0.176	-0.192	0.454	0.102	0.785
Price index ratio	0.016	0.845	-0.378	0.623	-0.259	0.787	-0.191	0.002	0.063	0.940	-2.157	0.062
Pension value rec'd	0.000	0.265	0.000	0.081	0.000	0.643	0.000	0.378	0.000	0.500	0.000	0.823
HH salaried worker	-0.031	0.262	-0.110	0.709	-0.315	0.375	0.013	0.665	-0.028	0.950	0.128	0.872
Age of HH-head	-0.003	0.130	-0.014	0.225	-0.035	0.068	-0.002	0.118	0.004	0.859	-0.019	0.508
HH male proportion	0.019	0.649	0.090	0.826	0.228	0.677	0.017	0.654	0.561	0.212	0.760	0.239
HH-head is male	0.028	0.450	0.056	0.868	0.258	0.563	-0.014	0.578	0.343	0.503	0.210	0.737
HH consumption size	-0.005	0.442	0.039	0.479	0.001	0.989	0.001	0.912	-0.115	0.172	-0.108	0.373

Labor Assets

Membership in a farmer association shows a significant and positive relationship to maize and fruit market earnings conditional on market participation, by 43.1% for maize and 37.5% for FFV. Membership also plays an important role for participation in market activity for FFV, driven by fruit, whereas this is not the case for maize. This result supports the hypothesis that household associations may have a special role in enabling fresh produce farmers to be able to produce and market surplus value. Membership is associated with an increased likelihood of selling FFV of 5.7 percentage points, with an unconditional partial effect on sale value of 79.0%, again driven by sales of fruit. Because this variable is likely correlated with unobserved variables that may also have a bearing on market behavior, such as social connections in a community, perhaps overall wealth, and access to extension, we cannot consider this a pure effect of membership however.

The regression results show a positive but insignificant unconditional partial effect of education years of household adult on several maize and FFV coefficients. This positive sign is expected especially among fresh produce farmers, given input and knowledge-use are particularly important for avoiding crop loss due to pests or disease among these crops. Unexpectedly, however, the results show significantly small and negative effects of education level on participation in selling FFV, driven by a significant and negative effect on participation in sales of fruit. This could indicate that more educated individuals are seeking to exploit off-farm opportunities or other alternatives than maize or fresh produce sales. These inconsistent results on education are consistent with the typically insignificant effect of education on agricultural outcomes found in other studies (Mather, Boughton and Jayne 2011).

Chronic illness or death due to illness of household adults produces only negative significant effects, as expected. Female adult illness in the household significantly reduces the unconditional value of fruit sales by 56.3%. Maize sellers receive 85.1% less in value for each household female illness-related death unconditional on the decision to participate in market sales. It may be important to note that no significance was found in any category for the impact of household male adult illnesses or deaths. The reason for the difference across gender is not clear.

The dependency ratio correlates negatively with fruit and vegetable participation and value outcomes as expected, but is not significant. Higher dependency ratios positively and significantly affect the decision to participate and unconditional maize market value obtained, however, generating unconditional returns 84.0% higher for every dependent to non-dependent in the household. This indicates, contrary to what is typically expected, that children or men and women of greater than 60 years in age may actually be providing a meaningful source of household labor among households able to market maize surpluses.

Capital equipment assets

As expected, all partial effects of **manual irrigation** are positive on fresh fruit or vegetable market participation or value. Only 20% of farmers selling fresh produce irrigate manually, however the unconditional effect on FFV sale value of doing so is 188%, driven by vegetables. In contrast, irrigation variables are not significant on FFV or maize. **Pump or gravity-fed irrigation** used does not return any significant results, however, due to very low levels of use and lack of variation in the variable's data to generate a significant effect.

Farm equipment assets other than irrigation equipment significantly affect only maize market sales, with inconsistent signs and insignificant estimates for the other crop groups. A 10% increase in farm equipment value benefits the unconditional value obtained from maize sales by 0.63%, reflecting the direction expected.

Increasing **livestock asset value** by 10% similarly increases unconditional maize sale values by 0.64% for farmers of this land extensive crop, which can greatly benefit from livestock for animal traction farming techniques. Unexpectedly, livestock value also has a significant and positive effect on all three PEs (participation, conditional value given participation and unconditional value despite participation) for FFV sales. A 10% increase in livestock asset value is associated with a 0.79% increase in FFV sale value, not conditional on the decision to participate in market activity, greater than that of maize, and driven more by the vegetable crop category than by fruit,.

Owning more of the assets included in the variable **"other assets"** (storage facility, latrine, lamp, table, higher quality roof, or higher quality walls) is also significantly associated with fresh produce market decisions, specifically by those selling vegetables. Farmers are 1.1 percentage point more likely to sell vegetables and earn 21% higher value unconditional on market participation for each additional asset of this category owned. The same variable has an effect on maize market participation of a greater 2.4 percentage points, although it does not have a significant effect on value of maize sales obtained. Owning another asset did not have any significant effect on fruit sale outcomes, however. These results for fresh produce, driven by vegetables, should be interpreted as general evidence of the capital intensity of production for the market, rather than as specific effects of each individual asset class.

Land assets

The effect of **land area in total hectares** is positive for maize and fresh produce sales, but not significant for any of the four crop groupings (maize, FFV, fruit or vegetables). The lack of significance on the fresh produce regressions is not unexpected, although the lack of significance on the maize regression is surprising, indicating that land-holding size is less important in terms of market participation behavior when other factors are held constant, despite the fact that sellers of FFV or maize tend to have larger plots than their non-selling counterparts (Tables 9 and 10). This may reflect Mather, Boughton and Jayne's observation in the case of their study on Mozambique, that holding prices constant, more land may not have an effect on maize market participation or sale values in the absence of access to agricultural input supply.

Having a greater number of fields has a positive effect on the decision to participate in fresh produce sales and the unconditional value obtained, as expected, and driven by vegetables, where having an additional field may reflect a more entrepreneurial attitude among farmers who seek out fields with specific characteristics to maximize their yields. For every additional field recorded, the likelihood of selling vegetables increases 1.9 percentage points and the unconditional sale value of vegetable sales 24.2%. No significant effects were found among the maize market decision regressions. Also**,**

holding title to land has generally positive but insignificant effects across all crop groups.

Finally, the last variable in this subgroup of assets, the expected positive relationship of **number of fruit trees** is significant for fruit and vegetable farmers in their decisions to participate in market activity and in the value obtained from their sales. Each additional fruit tree increases the likelihood participation in fruit sales by 6.1 percentage points and increases the unconditional value of fruit sales by 53.9%. In contrast, this variable produced negative and insignificant coefficients for the maize regressions.

Location-specific agro-ecological land properties

The **elevation** variable produces consistently positive results for vegetables and negative results for fruit, as expected, although none of these results are significant. Farmers receive 4.5% less value in maize sales unconditional on the decision to sell for every 100 meters of greater elevation (mean of 1,020 and standard deviation of 200-300 meters), and are 0.5 percentage points less likely to sell. Agro-ecologically, this result is not expected, since maize tends to produce higher yields in mid-elevation areas compared to the low elevation that characterizes most of Mozambique. Factors negatively associated with maize marketing are likely correlated with elevation, thus confounding this result.

The **number of expected drought days** significantly affects the decision to sell maize and the unconditional value of maize sales obtained, in a positive direction. This, the strongest relationship among the crop groups, is as anticipated given that this variable was created for the 150-day maize growing season, although the direction of the effect is difficult to understand. Less unconditional value is obtained from sales of vegetables by 49.7% for every additional average expected day of drought, over a 6 year period of time (standard deviation of about 1). Expectations concerning drought/level of rainfall could also be affecting farmers who depend on low-lying water-absorptive areas for naturally irrigating their vegetable fields in dry seasons or high elevations. These mixed results could also be attributed to any of three combined factors: (1) this variable varies only slightly between the two years (2) it is constructed at the district level and (3) only regional variables are included to help control for spatial variability. This could indicate that other unobserved district-level factors may be getting picked up by the measure than the actual effect of the expected number of drought days, accounting for positive direction within maize sales and negative within vegetable sales.

The **land cover "irrigation potential"** variable produces a significant negative result on maize market participation only. Due to very low prevalence, it is likely that there is not enough variation in this variable across households to really capture a meaningful relationship. **Proximity to a river or lake** used as a primary or secondary water source in the village affects maize market participation and unconditional value of sales positively, and the unconditional partial effect on FFV is positive but not significant. This may indicate that even in the presence of a river or lake, farmers may be facing other constraints than having accessible irrigation sources to produce marketable surpluses of horticultural production.

Village shock variables for flood, drought, crop or livestock disease were included to control for adverse exogenous agro-ecological characteristics. Estimates for these variables were not significant in any crop category.

Price or wealth effects

The crop-group-specific **relative price ratio** has mixed effects on maize and fresh produce market behavior. As a group, significantly higher relative prices for fresh produce compared to all other crops' value positively affect the decision to sell fresh produce (a greater 3.2 percentage points for every 1 standard deviation index increase), but the relative price ratio of vegetables has a significantly negative effect on the decision to sell vegetables (less 19.1 percentage points per standard deviation) and on the unconditional value of sales. A rise in the relative price ratio of maize by 1 standard deviation decreases participation by a significant 15.1 percentage points, but increases sale values conditional on participation by 162.3%. What may be driving the seemingly converse relationship between fruit and vegetable relative price responses is uncertain, however the negative participation then positive unconditional value of maize sales reflects the expectations presented by a perverse price response among households who may be net buyers of grains, or farmers who choose to sell less while storing their harvest to anticipate future price increases.

Value of pension received as a wealth factor affecting household decisions has a significantly positive effect on maize market participation and sales value, both conditional and unconditional on the first stage decision. Effects on fresh produce are not consistent nor significant, indicating that farmers who receive a pension are more willing to spend additional money on efforts to commercialize their maize production on average, than invest in commercializing their fresh produce production. This may also be attributed to the possibility that pensioners represent families with less young labor to devote to the rigors of intensive fresh produce farming.

Presence of a salaried off-farm working adult in the household has generally negative, although insignificant effects on crop market decisions. As stated previously, the additional income can play a dual role in all of these crop groups: potentially providing additional resources to invest in the household's fields or reflecting the amount of value that can be obtained from these investments, as well as the amount of outside experience or knowledge gained to help in management. On the other hand, jobs off of the farm may take away from the labor requirements of the farm work, which is especially problematical in the case of fresh produce. This latter influence appears to be the overriding effect evidenced especially in the case of this study, whereas these two competing reasons may be contributing to the lack of significance shown by any one coefficient.

Demographic Characteristics

Having more **adult males in the household** produces consistently positive coefficients in the case of all crop category estimates, although none of these results were significant. **HH size in consumption equivalents** also yields insignificant results, with no consistent direction of relationship.

FFV and maize selling households look surprisingly similar again in the case of the regression results for **male-headedness**: with no significance within any crop group.

Given that the smallest plots where intensive horticultural commercialization could yield the greatest benefit tend to be those governed by females, however, the opportunity for fresh produce sales among these households would seem particularly great. As Mather, Boughton and Jayne point out, the greatest barriers to female-headed households participating in marketing crop surpluses may be location-specific agro-ecological potential constraints. The significantly negative effects on participation and sale value among fruit and maize regressions only among female household adult sickness and death may also indicate the strategic opportunities women may already be contributing in terms of farm management decisions, and at the very least, in their labor contributions.

Finally, it appears that it pays-off for fresh produce farming household heads to be **younger** especially in the labor intensive fields of fresh produce, with this result driven by fruit market behavior. Participation in FFV sales decreases by 0.3 percentage points for each additional year older the household head becomes, and value of sales deteriorates by 3.1% for FFV as a group, and 3.5% specifically in the case of fruit, for each year of household head age. Results were insignificant in the case of maize.

Chapter 4. Key Findings

Strong growth in per capita income combined with the highest urban population growth in the world is beginning to generate rapid changes in African food systems. Combined with high income elasticity for fresh produce among consumers in ESA, demand for FFV is expected to multiply between four and six times between 2000 and 2030, providing Mozambican farmers a great opportunity, although this opportunity has not yet been realized by many.

In an assessment of feasible paths to increase FFV productivity and average land area in Mozambique, Zambia and Kenya, Tschirley et al. suggest that, in addition to a greater role for regional and international trade, "meeting this challenge will likely require major changes in the structure of production, with a much greater role for larger-scale commercial operations to complement increasingly commercialized smallholder production." This study did not find some of the sharp differences originally expected between sellers of fresh produce and maize in Mozambique. Especially striking was the lack of difference with respect to total land holdings and female-headedness: we had hypothesized that these variables would have strongly positive and negative effects, respectively, on maize market participation and sales but potentially no significant effect on fresh produce. In fact, this study found no significant impact on any crop. Bivariate results showed the expected positive- and negative associations but showed this for both crops, failing to show any meaningful difference between maize sellers and fresh produce sellers. This lack of differentiation across the crops (with regard to these variables – others did show a difference, see below) is attributed to the greatly under-developed state of agriculture in the country and to the incipient – at best – development of a truly commercialized cohort of smallholder horticultural farmers. Yet the fact remains that earnings per unit land area can be vastly higher for fresh produce than for maize, and that female-headed households systematically hold less land; the promise of fresh produce for female-headed and land-constrained households thus remains.

Strengthening the ability of the local sector – and especially land-constrained and female-headed farmers - to meet rapidly rising fresh produce demand, must take into account differences between fruit, vegetable and maize sellers, and can be done with the investments of both the public and private sectors. This paper concludes with four primary points concerning the FFV and maize market decisions of Mozambican farmers in the areas of market access, price information, land-holding, asset base, and gender of household head:

1. Spatial positioning - proximity in hours of travel time to a town or city of meaningful size - plays an important role for a successful FFV-selling household. This is not the case for maize.
2. FFV price information dissemination (alongside the distributed staple price data) will continue to be an important area to develop and improve.
3. Selling FFV does present a special opportunity for land-constrained farmers and female-headed farmers compared to selling maize, though the data we have was unable to show that this promise was being exploited by these groups. We do know, however, that a (very small) incipient group of farmers are realizing the benefits of more intensive crop land-use through sales of fresh produce.
4. Improving land productivity is important for potential maize and FFV sellers alike. The kinds of assets or household characteristics that benefit the ability to

generate marketable surplus differs by crop group, however. In other words, possession of one determinant may be important for successful participation in one crop category, but not in another.

The following sub-sections (4.1 – 4.4) explore these five points in greater detail:

4.1. Market Access

Driven by the high perishability of fresh produce, proximity to a market of meaningful size makes a substantive difference in the ability of potential fruit and vegetable sellers to succeed. Fewer hours to a town or city with a minimum population of 10,000 has a significant and positive effect on fruit and vegetable sale decisions in both stages of participation and value obtained, with this effect more pronounced in the case of vegetables. This stands in contrast to maize, where the number of hours in travel yields small and insignificant results. Summarizing results from chapter two, top FFV sellers are significantly closer in hours of travel to a meaningfully-sized town or city compared to top maize sellers by an average 1.2 hours, and significantly closer than their bottom $2/3^{rd}$ –selling counterparts by an average of 2.2 hours. These results show that spatial positioning in terms of market access plays a vital role for a successful FFV-selling household, and also presents a potential constraint which FFV farmers may face if they live far from a market of meaningful size. This is a factor that is not of critical importance in the case of maize selling decisions, given maize can travel over longer distances without damage to quality.

4.2. Price Information

Even though FFV price information is not disseminated to the degree staple price information has been made available in Mozambique, lesser search costs through improved price information and higher farmer attunement to commercial opportunities benefit maize and FFV farmers alike as they seek to meet demand in local or nearby market demand channels. Fruit and vegetable price information dissemination is and will continue to be an important area for improvement as the rising income elasticities for fresh produce of a growing urban population double to quadruple fresh produce demand. The lack of better price information dissemination may also contribute to the poor or adverse price responsiveness found in this study.

4.3. Land-Holding and Female-Headedness

In regard to the partial effects of total land-holding and female-headedness on fresh produce and maize sales decisions, all crop groups look similar – with no significance found for any estimated regression coefficient. This indicates that, despite the fact that sellers of FFV or maize tend to have larger plots and are less likely to be headed by a female than their non-selling counterparts, these two factors are less important in terms of market participation behavior for maize or FFV when other factors are held constant. Selling FFV, therefore, does seem to present a special opportunity for land-constrained and female-headed farmers compared to production of maize, as fruits and vegetables are crops that have the potential to generate far greater value per hectare of area cultivated than maize.

Unlike among maize sellers, the variable for “number of fields owned” (representing a more entrepreneurial attitude among farmers who seek out fields with specific characteristics to maximize their yields) generates a positive effect on FFV market decisions, both in participation and in sale value. In an environment where very few land-constrained farmers have begun to foray into commercialized horticultural production, a significant relationship between strategically using ones’ fields and increased market participation and sale value among fruits and vegetables sold (and not for maize) suggests an incipient group of farmers may be realizing the benefits of more intensive crop land-use on smaller plots, at least on some portion of their fields, and are having success in doing so, with greater unconditional value of sales higher for vegetables than for fruit.

4.4. Asset Base and Land Productivity

Improving the productivity of existing land in operation is clearly of primary importance for farmers’ capacity to produce marketable surpluses of maize or fresh produce. (1) Improved inputs or input packages and, most importantly, the liquidity to purchase them, is one clear area of attention that would benefit FFV and maize farmers (although not without some concerns about the potential environmental damage from the use of some of these chemicals). (2) What characterizes a sufficient asset base to succeed as a commercialized grower varies by crop type, however. (a) Whereas maize sellers depend less on the qualifications of their labor (often employing children, for example), FFV-sellers depend to a greater extent on adult labor to manage their fields well; (b) also in contrast to maize, fruit and vegetable sellers need a means of irrigation to harvest in the dry seasons of the year when pests and disease pose fewer problems; and (c) sufficient capital assets to diversify risks of commercialization are needed most notably in the case of successful vegetable sellers. These similarities and differences among crop groups are explored in greater detail in the next paragraphs.

4.4.1 Improved inputs or input packages and the liquidity to purchase them is one clear area of attention that would benefit FFV and maize farmers.

In a country that is nearly bereft of formal credit options, the liquidity for farmers to buy fertilizer, pesticide, or improved seed varieties to enhance soil or crop productivity when needed is very important for both maize and FFV production. Providing input subsidies or buying large supplies of these crops, as the public sector is sometimes apt to prefer, does not help generate a sustainable supply or demand system, as much as investments that could help input sales be more profitable for input sellers, such as those Boughton et al. suggest: (a) supporting rural financial and credit systems, in a cautious and considered manner, (b) developing recommendations for types or packages of inputs best suited per specific agro-ecological zone, and distributing these recommendations through extension services, or (c) investing R&D in varieties that respond better to input use (2007).

The use of inputs has a greater impact for a successful fresh produce harvest than their use on maize, and the growing reliance on toxic plant protection chemicals also raises its own risks and challenges. With the combination of very limited regulatory ability the part of governments, limited knowledge among poor farmers and likely rapid growth in use, the proliferation of these agricultural inputs in ESA is a major concern (Tschirley et al., *forthcoming*).

4.4.2. FFV-sellers need adult labor to manage their fields correctly, whereas maize sellers depend less discriminately on the qualifications of their labor.

In contrast to maize, sufficient labor supply (and specifically, adult and female labor) factors prominently for fruit and vegetable suppliers, driven by the fruits crop category. Adult illness and death are most prominent in the fruit regressions, performing negatively as expected, and are only significant in the case of female household heads. In contrast to the importance of the input adult women, in particular, offer in terms of market success, and the lack of significance shown by dependency ratio variable among fruit and vegetable regressions, the dependency ratio performed positively in the maize regressions, where children may actually be providing a meaningful source of household labor composition among households able to market maize surpluses. Adult labor may figure more prominently in the case of fruit commercialization given the challenges of managing horticultural crops, in general, compared to maize, and it is possible that females may be more frequently providing a level of farm management or care that surpasses their male counterparts in the areas of these crops.

There is also an important role among fresh produce sellers of farmer associations, where education about input use and management practices may most likely be taking place. FFV production (as well as maize production, to a lesser extent) requires the correct use of improved inputs for greater marketed surplus to be possible, and farmer associations may provide a key means for sharing information on availability, access or use of these inputs (or improved combinations or packages of these inputs) on a location-specific level. In addition, extension agents may target farmer associations for dissemination of information concerning farm practice, and these groups may have more opportunities for innovative credit solutions such as solidarity group models (like the Grameen Bank), or cooperative-based participatory models to finance agricultural improvements. Obtaining credit in these ways has the benefit of building upon existing social networks which reduces the costs of delivering credit and increases the likelihood of repayment (Lapenu 2007, Tschirley et al. *forthcoming*). Furthermore, fresh produce sellers may additionally benefit from farmer associations if there are opportunities for collaboration in terms of irrigation use in their vegetable plots from nearby water sources or wells, or even shared mechanized or gravity-fed water systems.

Since the government will likely not provide major support farmer extension services in horticulture, facilitating information-sharing and collaboration through membership in farmer associations (or improving similar endeavors of farmer organization) may be an important investment area for non-governmental organizations or the private sector. Recently developing models in agricultural lending are suggesting that technical assistance should become an integrated component of the value chain at the level of the input dealer, built into loan or insurance product sales (Tschirley et al *forthcoming*). This could be another strategic means for needed management practices to be passed on to largely illiterate farmers to help improve their ability to succeed in a commercialized fresh fruit or vegetable enterprise.

4.4.3. Fruit and vegetable sellers need a means of irrigation to harvest in the dry seasons of the year when pests and disease pose fewer problems.

In contrast to maize, improving the ability of farmers to sell fresh produce depends to a significant extent on whether irrigation is feasible and can allow the farmer to produce in the dry seasons or in dry or cool climates. The reason for this is because fewer pests or diseases affect crop production during the dry season, and these menaces are particularly destructive to the cultivation of a marketable surplus of FFV. In the absence of pump or gravity-fed irrigation systems, the importance of this element evidences itself, again, in the greater demands on labor for FFV cultivation, if manual irrigation is used.

4.4.4. A sufficient capital threshold to diversify risks of commercialization is needed most notably in the case of successful vegetable sellers.

Compared to fruit sales, the ability to succeed as a vegetable seller relies more on capital equipment and less on labor assets, which figure prominently in the case of fruit sales (these include wellness of adult household members, and association membership of household heads in particular). Given the intense input needs for a successful harvest, the particular risks of post-harvest perishability, and the greater value per unit prices of vegetables compared to fruit or maize, the significant capital equipment asset results for vegetable sale decisions may indicate existence of a risk-management capital asset threshold (for which further studies would need to perform relevant tests). If this is the case, without a certain level of fixed assets to help couch the effect of a bad harvest, a vegetable producer may be much more hesitate to participate in market ventures. The variables in this model, including livestock value and ownership of any of six "other assets," affect both participation and value of vegetable sales stages indiscriminately.

The differences in the type of assets which have an effect on the decision or ability to produce FFV for sale between these three crop groups is valuable to consider in the types of asset-based challenges farmers face to meet the burgeoning FFV demand of the next 50 years.

APPENDICES

Appendix A: Comparison of Crop Values and Input Costs, Zambia

Table 13: Crop Values and Input Costs in Zambia in 2011 Prices

Farmer categories	Input costs ($/ha)	Yield (kg/ha)	Output value ($/ha)
Maize			
Top 50% of sales	261	3,393	625
Bottom 50% of sales	202	2,074	382
Cotton			
Top 50% of sales	28	1,581	1,012
Bottom 50% of sales	27	822	526
Horticulture			
Rape (kale)	400	n.a.	1,600
Tomato, from seeds	1,600	n.a.	7,000
Tomato, hybrid seedlings	4,400	n.a.	14,000

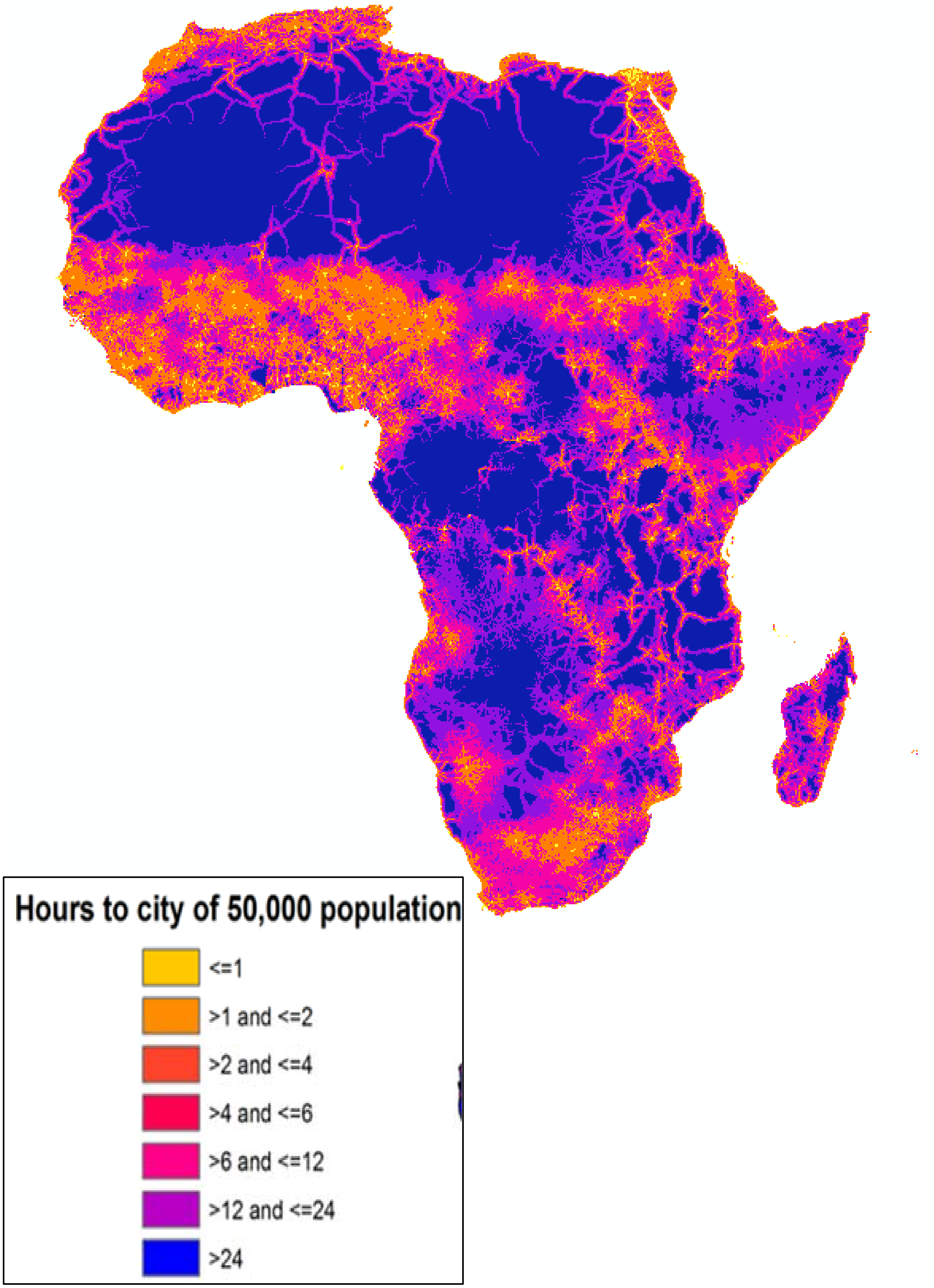
Source: Chapoto, et al. (*forthcoming*)

Appendix B: Cost-Distance Travel Time Variable Creation

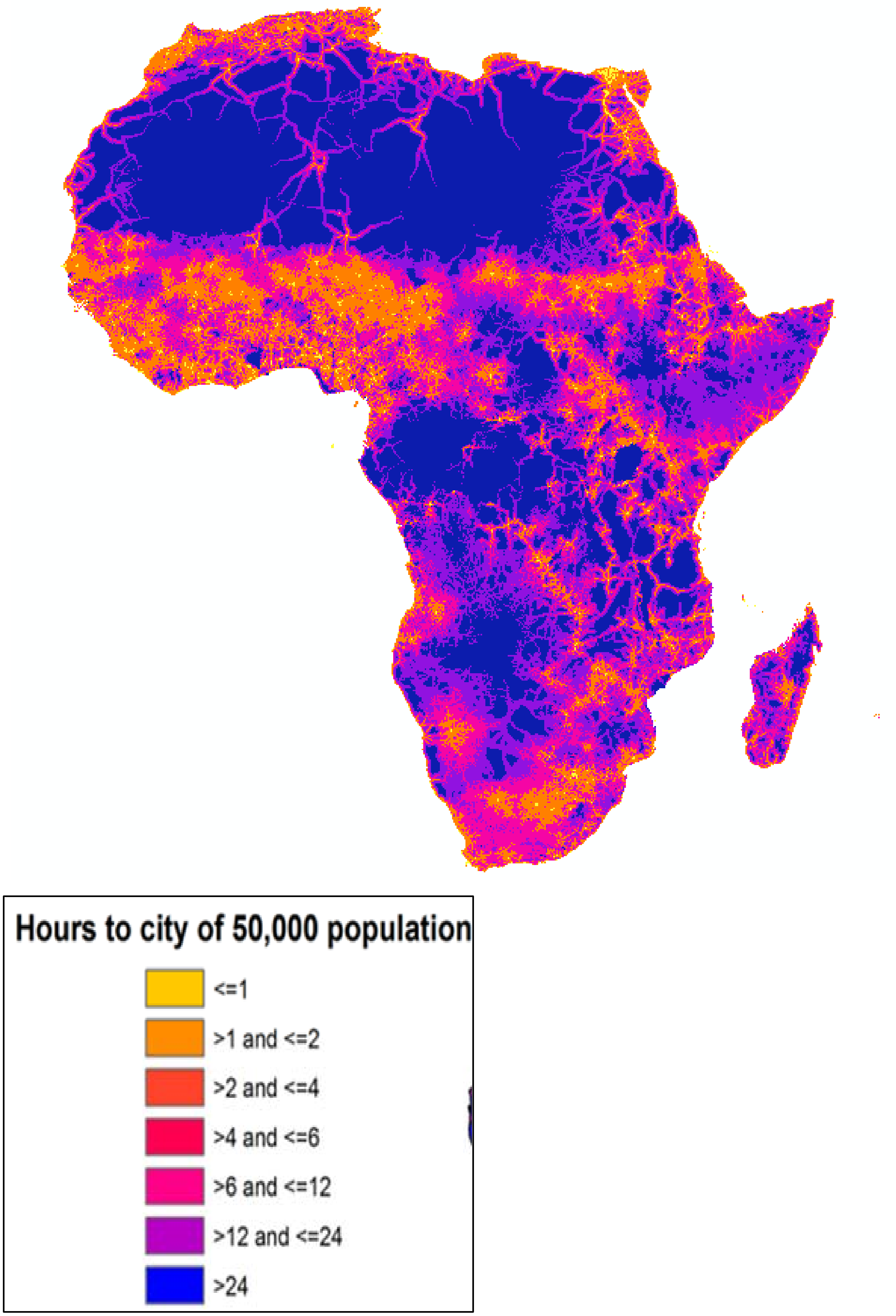
For the travel time variable to nearest town of 10,000 or more individuals, a number of parameters are specified. Travel is assumed to be taken by the fastest route possible, by motor vehicle when traveling by road, and by non-motorized transport or by foot when off road (Deichmann 1997). On-road transportation times are then estimated on the basis of road quality and modified by slope (where the steeper the slope, the larger the speed discount). In a similar way, off-road transportation time estimates are modified using land cover type in addition to slope. For example, these coefficients reflect the assumption that it takes longer, on average, to walk through a swamp than a forest, and longer to walk through a forest than through agricultural lands, etc. A cumulative, cost-distance model implemented in a raster analytical environment (using the *costdistance* function in ArcInfo Workstation) is used. Individual communities are overlaid with this surface, and values are calculated. Visual depictions of some of these map layers can be viewed in Maps 2-7 for travel time to a city of 50,000 inhabitants or more.

Map 1: African Cities of population 50,000 and greater

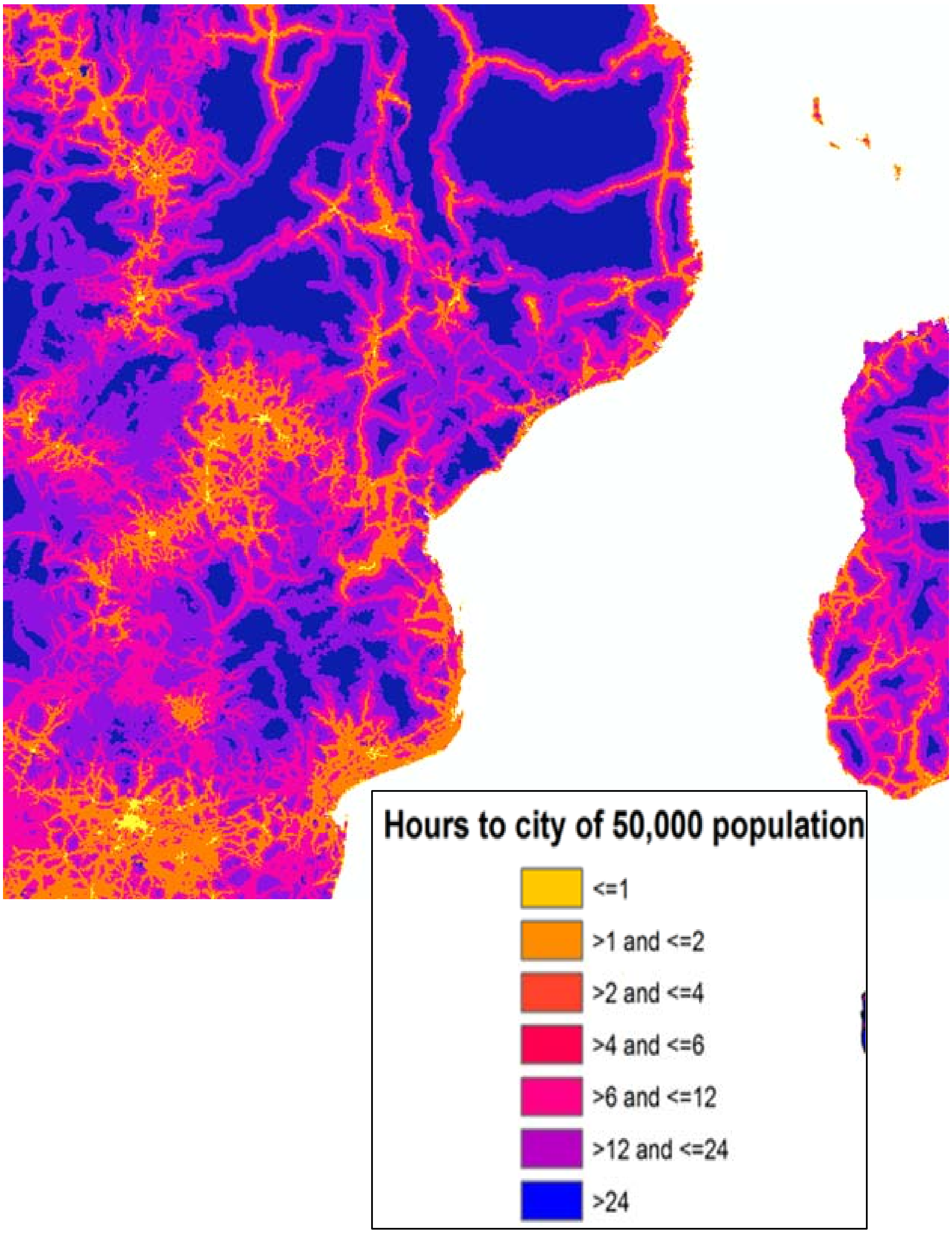
Map 2: Cost Distance Surface using Africa-wide Michelin Road Data



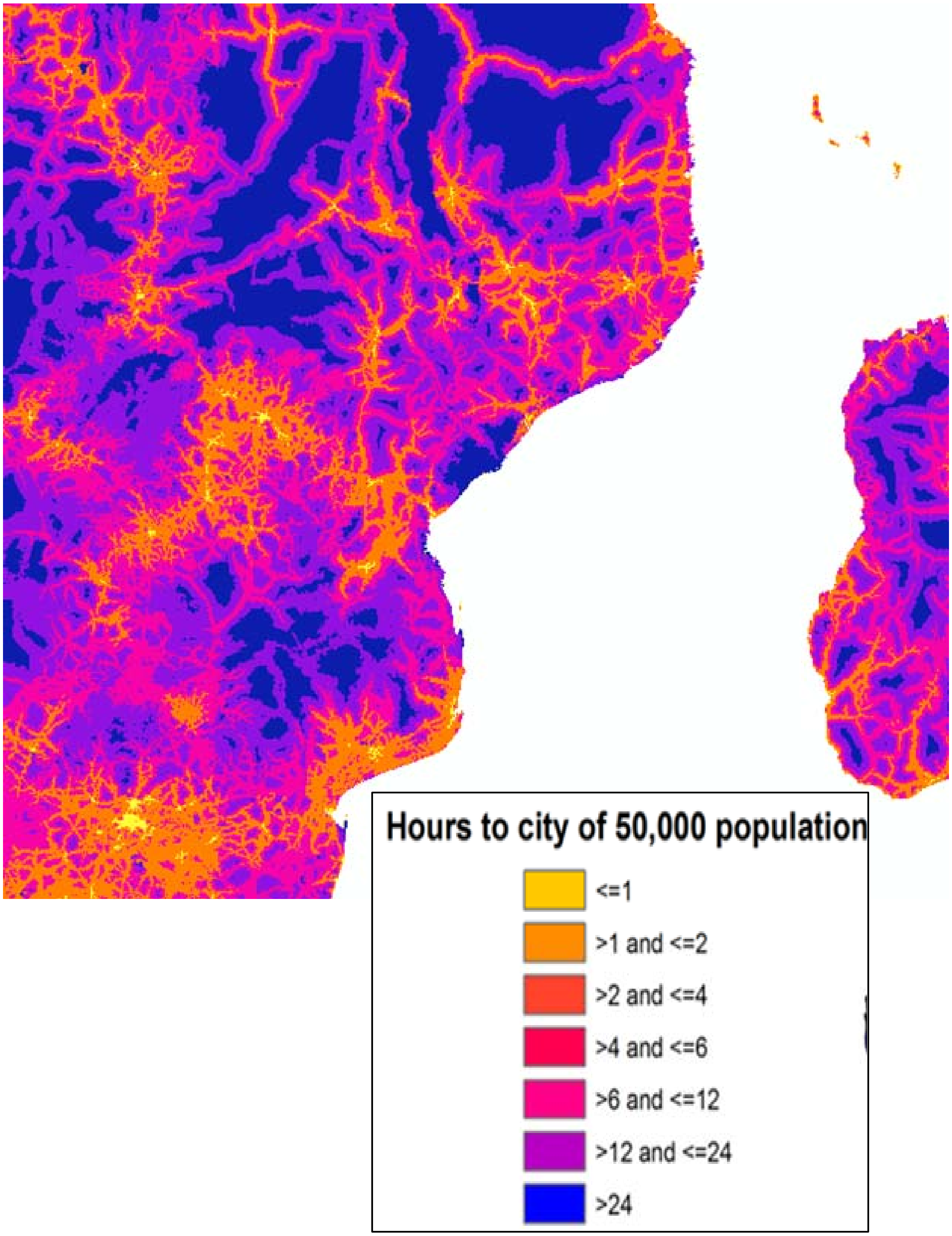
Map 3: Cost Distance Surface using Africa-wide Michelin Road Data PLUS higher resolution Mozambique road data obtained from the “Digital Chart of the World”



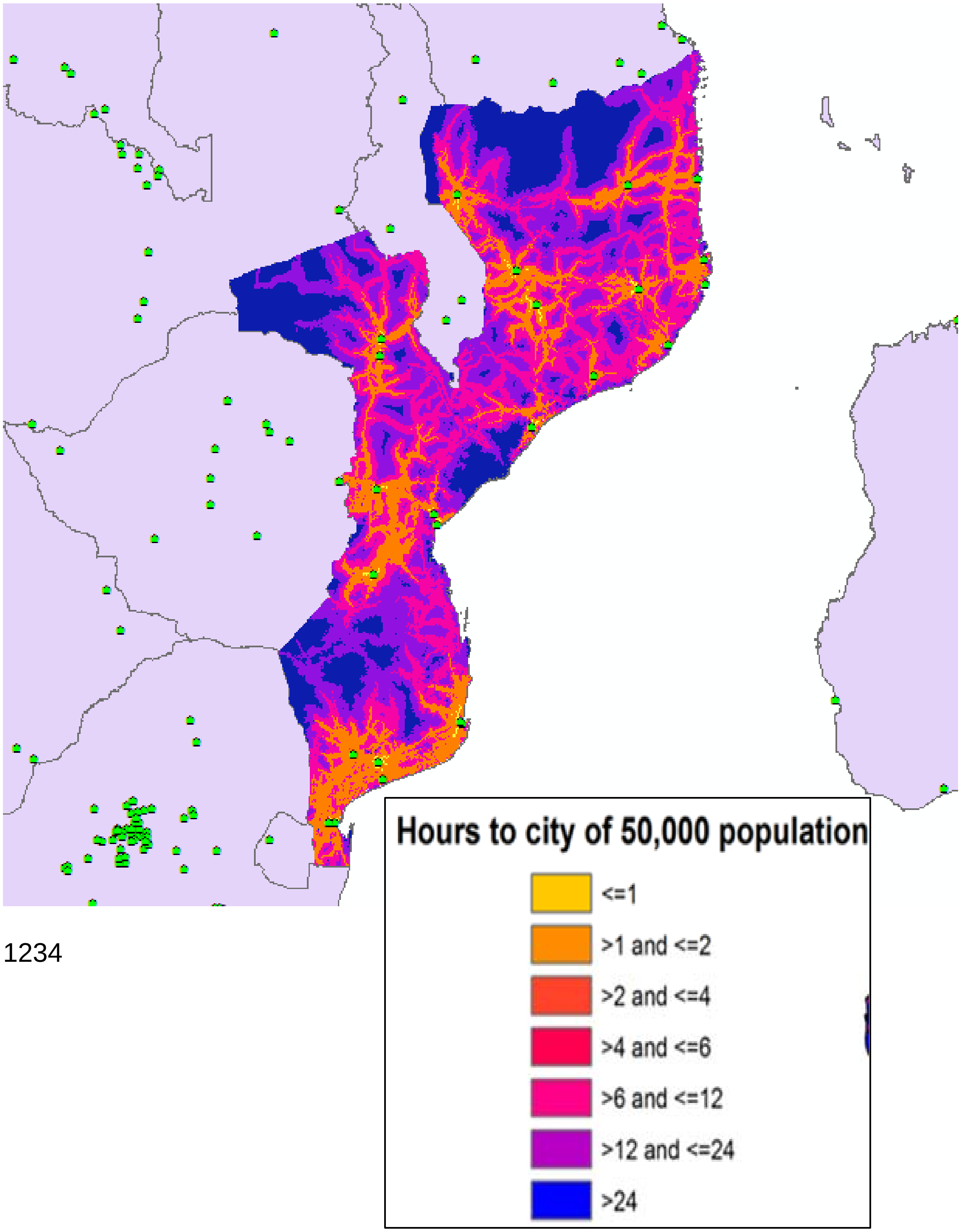
Map 4: Cost Distance Surface using Michelin Road Data only (close-up)



Map 5: Cost Distance Surface using Africa-wide Michelin Road Data AND Mozambique-specific road data (close-up)

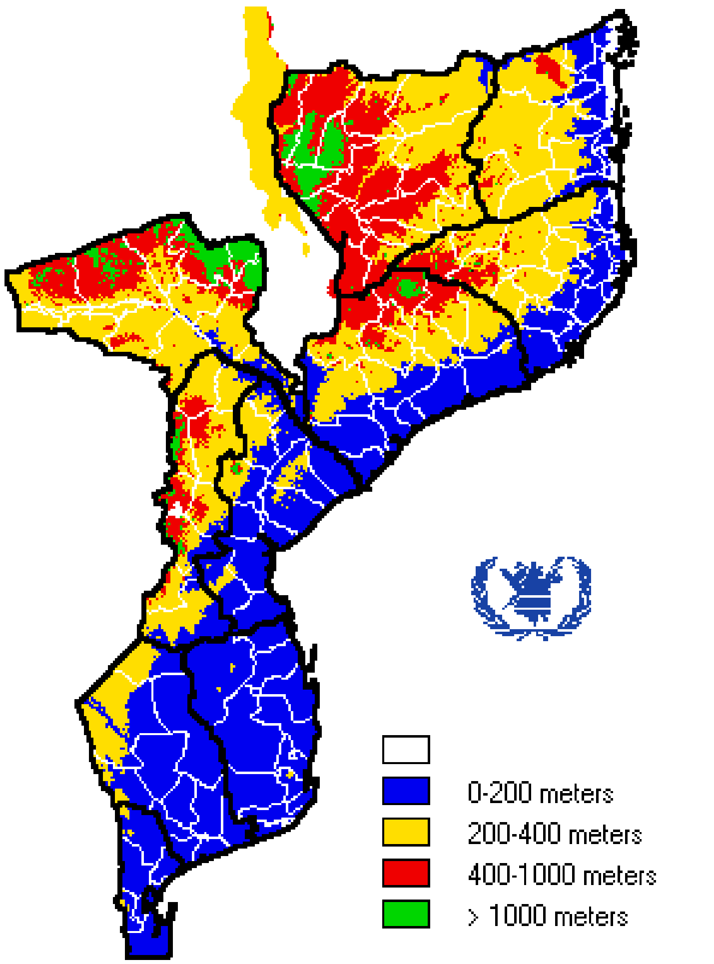


Map 6: Cost Distance Surface using Africa-wide roads data and higher resolution road data for Mozambique, with cities greater than 50,000 also shown



Appendix C: Maps of Elevation and Rainfall

Map 7: Elevation Classes of Mozambique

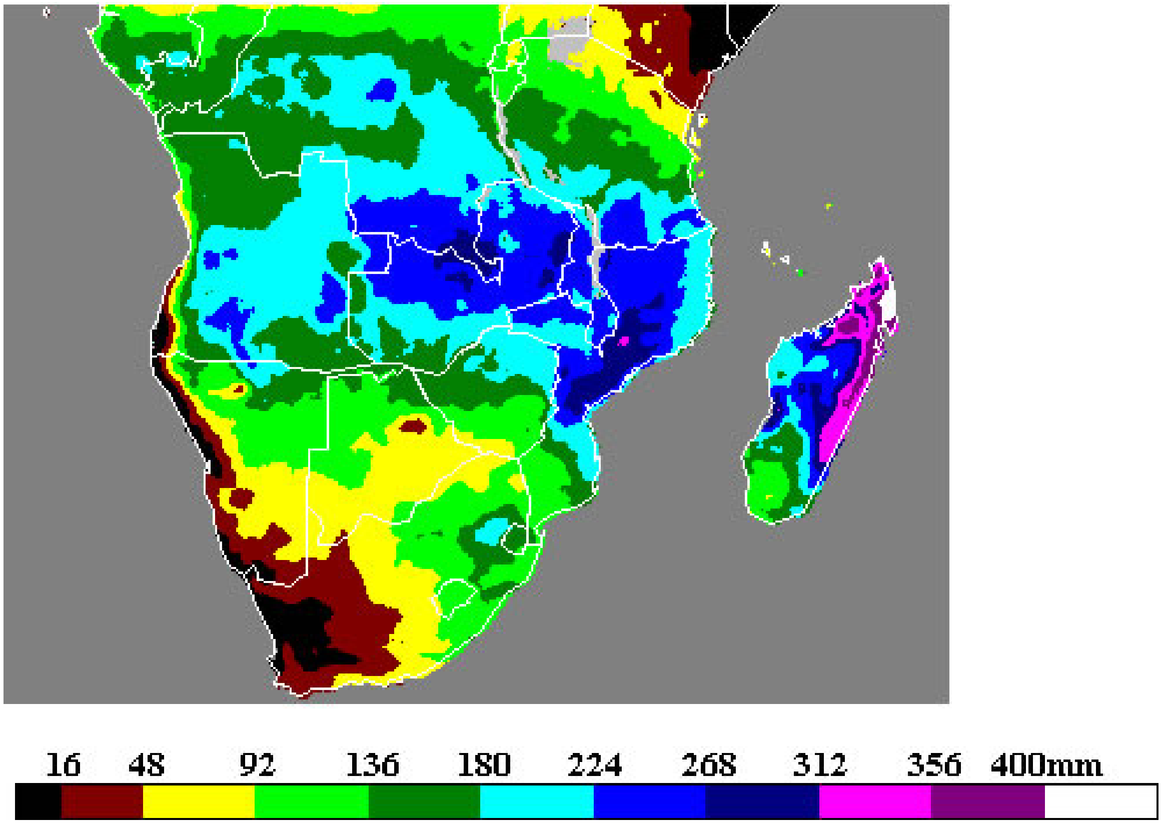


Map prepared for UN-World Food Program, Mozambique

Source: World Food Programme <http://reliefweb.int/node/2133>

Map 8: Rainfall in Southern Africa in January
(month of highest rainfall for most of the region).

Mozambique is outlined on the eastern side of the continent.

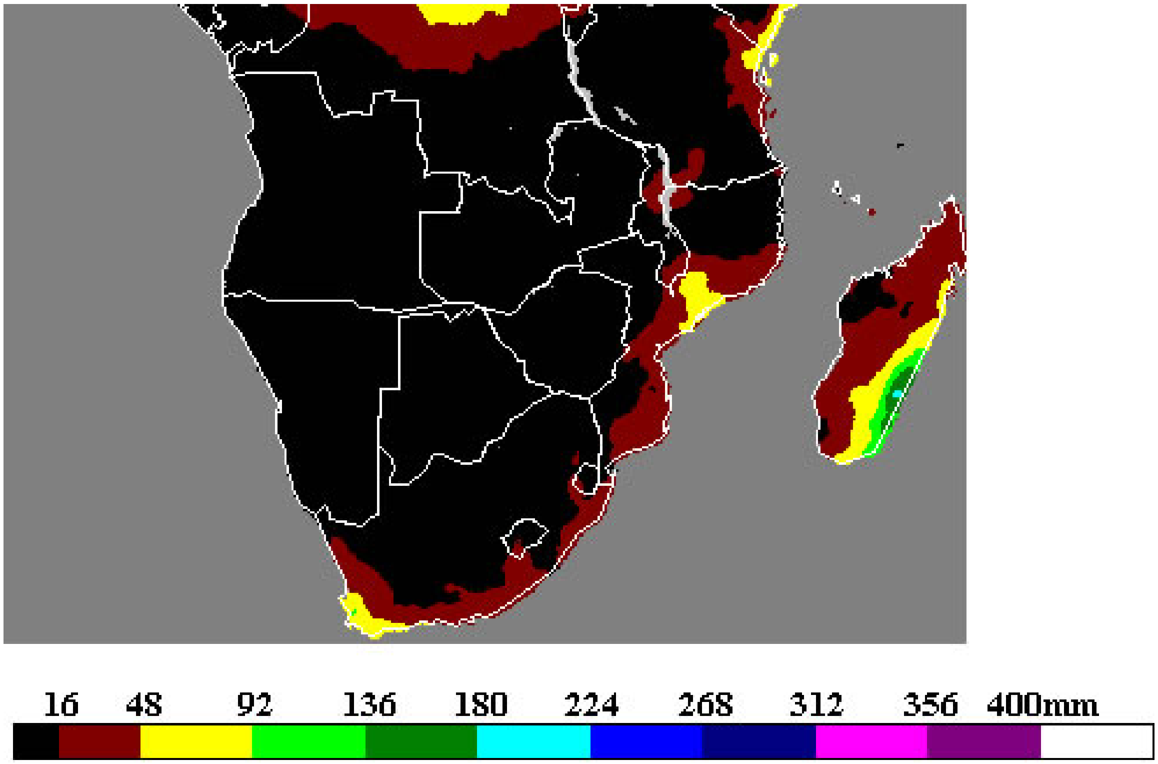


Source: Michigan State University's "Exploring Africa!" Curriculum Resources, Unit 4, Module 20.

< http://exploringafrica.matrix.msu.edu/students/curriculum/m20/activity2.php>

Map 9: Rainfall in Southern Africa in July

(month of lowest rainfall for most of the region)



Source: Michigan State University's "Exploring Africa!" Curriculum Resources, Unit 4, Module 20.

< http://exploringafrica.matrix.msu.edu/students/curriculum/m20/activity2.php>

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