Cooperação Trilateral

SPECIAL ISSUE COLLECTION OF SHORT PAPERS FOCUSED ON HORTICULTURAL PRODUCTION IN THE AREAS SUPPLYING MAPUTO

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EXECUTIVE SUMMARY

The "Flash" research and outreach publications are a series of short papers closely focused on issues of relevance for understanding the Mozambican food and agricultural system. This special issue is a compilation of four reports which were already released in the "Flash" series, along with six additional short reports, all of which form a combined output generated by the socioeconomics component of the Trilateral Cooperation. The Trilateral Cooperation, between the countries of Mozambique, Brazil and the United States, is a three year project, from 2012-2015,with the objective of strengthening the institutional capacity of Mozambique in the area of horticultural production. This collection of reports is designed to give context to and elucidate results found regarding the horticultural producers supplying Maputo, the capital city of Mozambique and its surrounding areas, using data collected from producers in the green zones of Maputo (commonly referred to as the *zonas verdes*) and the nearby districts of Moamba and Boane.

This collection proceeds as follows. Chapter 1 discusses the topic of horticultural diversification and its effect on income, using the Simpson's Diversity Index and data collected from a sample of 68 producers of the districts of Ka Mavota and Ka Mubucuana within the *zonas verdes* of Maputo from October to December of 2009 by IIAM researcher Tomas Sitoe. The first several sections of this contribution give historical context to the land areas in the *zonas verdes* supplying Maputo and Matola.
This study shows significant differences between farmers in these areas in terms of their capabilities for crop diversification. This finding is corroborated by the results from the baseline data of the Trilateral project that producers with the smallest land areas generally hold the least diversified sold-crops portfolio.

Solely on the basis of the baseline data collected by the trilateral project in 2013 we then go on to chapters 2 and 3. Chapter 2 first offers a number of general characteristics of horticultural farmers included in our baseline study and their crop sales, then goes on to explore these farmers' input purchase channels in terms of their formality, frequency, location and value, as well as methods of irrigation used. Chapter 3 follows on the heels of Chapter 2 with an explanation of how an overall farmer typology was generated on the basis of ranked farmer technological sophistication, defined by indicators of experience, training, access to information, diversification in horticultural crop production and sales, input expenditures and farm management practices, post-harvest activities, crop loss, and pesticide management and toxicity awareness. The typology introduced in chapter 3 then goes on to serve as the basis for comparing these ranked "clusters" of farmers in the pesticide use and costs of production studies to follow.

Across clusters and land area quintiles, focus is brought to studies highlighting the alarming evidence surrounding pesticide management practices and perceptions (chapter 4), as well as the comparison of these to results from a sister survey performed among horticultural producers in the neighboring country of Zambia in the context of future projections of pesticide active ingredient used across Sub-Saharan Africa (chapter 5). Findings include that producers, generally speaking, have the perception that almost all pesticides are highly toxic (even those that were not), but regardless, most of them wash their equipment in the farm irrigation canals, leave their used pesticide receptacles splayed on the ground in farm areas, and often use boots as their only protective clothing while spraying. More technologically advanced farmers are found to generally purchase a more diverse set of pesticides as well as use smaller per-hectare quantities of any given one. Furthermore, 87% of farmers are found to use chemicals classified by the World Health Organization as highly toxic. Chapter 6 explores what sources of information are most common and which are most influential among producers in Maputo in regards to their perceptions of pesticide toxicity and the pesticide safety precautions they take.

Chapter 7 introduces and elaborates the concept of the value chain as a whole, in both structural and graphical form, and chapter 9 introduces and characterizes the study and calculation of costs of production, both chapters written by EMBRAPA specialist André Cribb. Each of these chapters is followed by a case study using data collected from the trilateral project. Chapter 8 presents the value chain of tomato in Moamba illustrating the conceptual and procedural method presented in chapter 7, and in Chapter 10, a detailed comparison is given across the cost, sales and margin calculations of lettuce and kale in the areas of the *zonas verdes*, and of onion and tomato in the areas of Moamba and Boane districts of the baseline study. The data to perform this last study were collected in 2014 by the socioeconomics team of the Trilateral project as part of a multiple visit survey visiting a partial panel of the producers which were part of the selected sample of the baseline study each week to two weeks over the course of the 4.5 months constituting the cool/dry season of the year. Again, clusters are used in both the selection and interpretation of the results of this study, where findings indicate that within each technological sophistication bracket, higher costs spent are correlated with less gross income earned. The greatest cost of those earning the largest gross margins per kilogram harvested across crops is for seed and/or seedling, and these farmers also evidence an increased share of costs spent on labor, particularly salaried labor.

Through these studies, we see great diversity among the horticultural farmers supplying Maputo's markets. We also see many opportunities for the farmers of our study to improve production practices and increasingly reclaim the horticulture market in cities such as Maputo, as well as others across the country, from dominance upon imported product. Hopefully this volume will serve to (1) orient continued study of these producers' practices and production potential via open access to the data we have collected and by offering here a broad characterization of their production and commercialization practices, as well as (2) provide a resource for future policy decisions affecting a population of hard-working farmers as they strive to meet the fast-increasing demands of consumers with growing incomes and preferences for these highly perishable yet abundantly nutritious food crops.

TABLE OF CONTENTS

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CHAPTER 1

The Effect of Horticultural Diversification on Income: Evidence from Small Producers in the Green Belt of Maputo

Tomás Adriano Sitoe

Technological development, crop diversification and the expansion of cultivated area are important components of economic growth. In Mozambique, agricultural crop diversification plays a crucial role due to the fact that land expansion through rudimentary technology has reached its limit and the fact that there are market opportunities resulting from demand and supply factors. Aiming to examine the magnitude and effect of crop diversification on income, this study sought to analyze the effect of horticultural diversification on farmer's income in Maputo's *zonas verdes*. Random and representative sampling techniques were used to select 68 farmers. Results of the Simpson's Diversity Index suggest significant differences between farmers in terms of their capacity for crop diversification. However, there are not significant differences between income among farmer quintiles, suggesting that crop diversification has little impact on income. Properly implementing these policy recommendations presents a significant challenge for the agricultural sector in Mozambique.

1. Introduction

Agricultural diversification means the cultivation of various crops in an area. The implementation of agricultural diversification is one of the most effective methods to developing resilience against climate shocks in agricultural systems. Diversification can be implemented in various forms and to varying degrees, allowing producers to choose a strategy that enhances resilience while also providing economic benefits (Lin, 2011). In Mozambique, productive diversification takes on greater importance given two reasons: (i) Land area expansion, which for several years constituted the primary growth component of production, has reached the maximum limit. The average acreage per family has been decreasing at a national scale: in 2005 and 2006, the average acreage per family was 1.7 hectares; in 2007 it was 1.6 hectares, and in 2008, it was 1.5 hectares (MPD / DNEAP, 2010), suggesting that although the country has abundant land, families have reached the limit in terms of their ability to expand in land area without the use of additional technology. (ii) Market opportunities resulting from supply and demand: domestic production of major vegetables only meets 51% of demand in potato, 62% of onion and 70% of tomato demand (MINAG, 2011).

This deficit in production makes the country continue to depend on regional and international markets to supply the domestic market throughout the year. While at the same time, vegetable sales of domestic farmer production continue as a small percentage: around 3-4% of producers in rural areas sell their production. This percentage is extremely low if we consider that in Kenya for example, this ratio is 15% (Tschirley et al., 2011). So there is still a great opportunity for growth in the horticulture market of Mozambique.

In this context, this study aims to analyze the effect of horticultural diversification on the income of producers in the green belt of Maputo. In the literature, the importance of horticulture for improving income, job creation and poverty alleviation is recognized by several authors (Weinberger & Lumpkin, 2007; Bhattacharyya, 2008; Mehta, 2009). However, greater number or diversity of crops in and of itself will not ensure higher incomes (Heady, 1952). Increased productivity is key to poverty reduction (von Braun et al,. 2004), but this depends on many factors: land access policies, availability of inputs (mainly improved seeds and postharvest technologies), and credit opportunities (Weinberger & Lumpkin, 2007).

Most studies on production diversification focus on price as one of the main factors that drive the decision of producers to diversify. However, heterogeneity in terms of producing assets and access to inputs and production also plays an important role in the decision-making process (Mehta, 2009). Not the least reason of which is because the expectation of receiving higher prices is linked to development and integration in the markets, which in turn influences the use of inputs and productivity.

The fundamental assumption of this study is that producers make their decisions to diversify production taking into account the context of the production possibility frontier available to them, price expectations, and felt risks, both in agronomic and market terms (World Bank, 1990). The decision of what to produce and how to produce has a strong influence on family welfare in terms of income and variability of returns (Heady, 1952). Observing how producers achieve diversification may be important to be able to trace the interventions that can be effective in reducing poverty and vulnerability. It is hoped that this research will contribute to a knowledge base that can be useful to support the design and implementation of policies with the objective of improving production and living standards in the green belt of Maputo.

The potential users of the results of this study include researchers (primarily those in academia), policy makers, organizations of civil society, etc.

After the introductory section, the second section of this report describes the historical context of crop diversification in the *zonas verdes* which is intrinsically linked to the history of Mozambique. Section 3 describes the methodological procedures adopted for the study. Section 4 presents a literature review on the topic, section 5, results and their discussion, and finally section 6 ends with conclusions.

2. The Historical Context of Diversification in the *Zonas Verdes* of Maputo

Due to its geographical location, the *zonas verdes* of Maputo play an important role in the production and supply of vegetables to the cities of Maputo and Matola (the capitals of Mozambique and Maputo Province, respectively). A variety of vegetables are produced here (kale, lettuce, tomatoes, onions, eggplant, etc.), for consumption and sale in the markets of these cities. Before independence in 1975, a significant portion of the vegetables and small animals produced in the *zonas verdes* were by the colonial "settlers," where they had made their farms. After independence, the farms that had been generally owned by settlers became occupied by the Mozambican population. However in the 1980s, civil war affected the move of many people from the countryside to the major cities and their urban areas, where relative security was greater. As a result of this movement, the occupation of space in the *zonas verdes* and the production of vegetables by those living there was intensified.

Aiming to boost production and ensure the availability of food in the cities where supply had deteriorated due to civil conflict and drought, the state, with support from partners like the Italian Cooperation, developed projects to stimulate the development of agriculture in the *zonas verdes*. Under these projects, various types of equipment (rotary cultivators, motor pumps, sprinklers, etc.) and agricultural inputs were made available to producers in ways it was easy for them to access.

However since 1987, the government liberalized the economy and gradually limited its intervention in the market. Before the liberalization of the economy, the state maintained great control of economic activity - they had control over the exchange rate, product prices, interest rates, and import and export taxes. Structural changes have the greatest impact on the economy, society, general welfare and the natural environment.

In the *zonas verdes*, the reduction of state support to producers, as well as the outbreak of swine flu which decimated thousands of farm animals, contributed to the deterioration of the situation producers found themselves in. Today, it is common to find producers who previously had up to 2,000 pigs and a tractor however have virtually no prospect now of returning to that past. Currently, although there has been some increase in small animals (mainly chickens), these farmers generally only grow kale and lettuce for consumption and sale in local markets. The main aspects that currently affect the development of agriculture in the area are:

- Lack of state support in terms of credit facilities and technical assistance;
- Soil salinization (mainly in the Infulene Valley);
- Inadequate practices to combat pests and crop diseases, mainly those affecting kale;
- The risk of product theft in the fields;
- The risk of disasters and dependence on favorable climatic conditions for the realization of agricultural activity;
- An abundance of agricultural products in only one season of the year (the winter), which depresses prices through the mechanism of oversupply;
- The lack of infrastructure and means of transport for the marketing of products to local markets, etc.

It should be noted that currently most vegetables (especially garlic, onions and potatoes), eggs and meat supplying the cities of Maputo and Matola are imported from South Africa and Swaziland.

3. Methodology

The green areas of Maputo comprise six urban districts, each numbered one through six[1]. There are around 12,000 farmers organized in 32 associations of producers, mostly women who work individually in small fields. Although horticultural production takes place in the majority of the districts, districts 4 and 5 are the ones who mostly supply the markets of Maputo and Matola. Mahotas and Infulene Valley are the two most representative localities within these districts and comprise 32 associations and approximately 10,000 farmers who cultivate around 1,052 hectares of land.

A representative sample of 68 producers selected at random in eight associations in Mahotas and Infulene Valley was drawn-up for interview. A total of 44 selected producers in Mahotas and 24 in Infulene Valley. The interviews were preceded by a meeting with 10 leaders of producer associations to establish a

[1] At the time of this data collection, between October and December 2009, the process of the changing the names of urban districts was currently underway. As of the writing of this text, district 4 is now called Ka Mavota and District 5, Ka Mubucuana.

calendar of scheduled visits to the associations. In each association that was visited, the leader invited 10 farmers to be interviewed[2].

The effect of horticultural diversification in income was estimated using ANOVA[3] analysis of variance between the income of vegetable producers in different quintiles of diversification, given by the Simpson Diversity Index (SDI). The SDI is widely used to measure the biodiversity of an ecosystem and agricultural diversification (Joshi, et al, 2003; Mehta, 2009), and is expressed by following formula:

$$SDI = 1 - \sum pi^2$$

Where: pi is the proportion of income from vegetable "i" over the total horticultural revenue for each producer. If there is only one crop, pi = 1 and SDI = 0. As the number of crops or sources of income increases, the "pi" ratio decreases, also decreasing its sum of squares.

In the absence of the accounting of agricultural activity by producers, horticultural revenue was estimated by asking each producer the amount and frequency of production of each crop, by season, and the average value of sale in each season. To estimate the horticultural income, production costs (mainly spending on seed, pesticides and labor) were subtracted from revenues.

Data were analyzed using the SPSS computer program (the Statistics Program for Social Sciences). The analysis of descriptive statistics was done with this program - comparison of means, correlation matrices, and regression analyses. In addition to the quantitative analysis, examination of the subjective understanding of the meaning that producers give to their lives required additional observation of behavior and interpretation of its meaning, and the analysis of the farmers' speech and actions, essential elements of qualitative analysis.

4. Literature review

What, when and how to produce are the main decisions of farm management (Van & Keller, 2006). To answer these questions the producer or manager needs to decide on the use of alternative resources available to it. This decision directly or indirectly affects the total production level of the productive unit (Mehta, 2009). The choice of crop type is one of the most important decisions that producers face (Blank, 1990). Producers need to know ahead of time, how to use risk management strategies to select the crops that best suit their needs (Weimar & Hallam, 1988).

One of the most popular approaches to risk management is to reduce exposure to risk through diversification (Barry, 1980; Irwin, 1988). For many farmers, this approach leads to the practice of growing a series of crops that differ in their production and / or sellable characteristics; however, methods that reduce risks generally also reduce expected net returns (Blank, 1990). Therefore, when designing risk

[2] In some cases not all persons participated who were invited to attend, or not all persons were interviewed of those who attended when answers among them did not vary substantially. Interviews with producers were discontinued when it was found that the answers to the questions in the questionnaire did not differed significantly (especially in the Valley of Infulene); in light of this, it was decided to stop interviewing with the number 68.
[3] Analysis of variance, based on the decomposition of the total variation of the response variable into parts that can be assigned to treatments (between-group variance) and the experimental error (within-group variance).

management strategies, is important to take into account both returns and risk of loss (Walker & Lin, 1978).

When a producer decides on the number of crops to plant, such a decision influences the level of cropping concentration or dispersion of cropping, which in turn determines the extent of specialization in the production area. The cropping change can be made by substitution of crops; extensification of area or by intensification of it. Greater dispersion of crops is synonymous with the highest level of diversification. It is considered that a producer is more diverse if he does not primarily depend on only one crop (Rahman & Talukder, 2001). But the increase of the number of crops or greater cropping diversity by itself does not ensure greater income and/or the reduction of risk (Heady, 1952).

Diversification can be done in different ways: (i) by producing different crops for one period or season; (ii) by producing different crops in different locations at the same time; or (iii) by cultivating crops over the course of successive periods.

While the producer decides on the number of crops and the level of cropping diversification, another important decision has to do with the type of crops to produce and how much land is allocated to each one. There may be different combinations of crops: low-value crops versus high-value crops or a mixture of subsistence and cash-crops. There is a positive relationship between the level of commercialization and crop concentration, such that producers with high levels of self-subsistence tend to have more diversified production, where those that are more market oriented tend have more concentrated production. This concentration may represent a diversification into higher value crops, but not a diversification into multiple crops (Mehta, 2009).

Cropping dispersion or diversity influences production through its impact on income and risk through one of the following: (i) increased crop yields that have relatively high prices and offer margins greater than production costs; (ii) reduction of production costs of all the crops, spreading fixed costs over a greater number of crops without materially increasing variable costs, and (iii) ensured greater livelihood of the producer and his family through the production of products for domestic consumption (Grimes, 1929).

From an economic point of view, diversification is treated in two analytical perspectives: (i) as a question of determining, at given prices, the optimum combination within the production possibility frontier; and (ii) as a mechanism of incorporating risk aversion into decision-making, concerning which specialization could indicate greater income instability due to income, production and price variance (World Bank, 1988). There are two aspects to mention in this regard about diversification, the first has to do with maximizing profits and the second, to do with minimizing variance in return: When the aim of diversification is the maximization of profits, the decision is made under the condition of full knowledge. In this case, the exercise involves equalizing the marginal rate of crop substitution to the ratio of crop prices allocated to the land (Mehta, 2009). The other aspect has to do with minimizing the variance of returns; that is, achieving a certain level of income that allows the producer and his family the occurrence of desirable results. Therefore, diversification can be a strategy to optimize income or an alternative to minimize the risks, or both.

In general, diversification has two properties: (i) it expands the set of options within the production possibility frontier or the area allocation frontier, and thereby increases opportunities for income generation and job creation; (ii) it reduces the risk of having all ones' eggs in a basket; with few crops, covariance risk potential is higher (Samuelson, 1967). The risk can be considered a large force affecting the allocation process of crops in space (Blank, 1990 Braun, 1995; Dercon, 1996).

Risks in agriculture are generally linked to erratic rainfall, pests and diseases, soil quality variability and other atmospheric phenomena. A vital perspective of risk regards how returns enable a farmer to obtain a certain level of income below which there is no sustainable produce from an economic point of view.

In classical economics, diversification is treated by traditional portfolio theory, which explains the behavior of agents in relation to their investments. Based on classical economic theory, choices are guided by the presumption of the "rationality" of the agents. However, the rural family tries to maximize profits under constraints imposed by exogenous factors: "There is a genuine interest in maximization of profits only once survival and social reproduction have been ensured" (Negrão, 2001). In remote areas where access to the markets incurs high transaction costs, diversified cropping is geared to meet the satisfaction of the consumers' needs (Omamo, 1998). Moreover, the limitation of resources can provide incentives for specialization (Prescott & Pope, 1980).

The decision of allocating labor to certain activities is conditioned by the context in which the family works. This context can include natural or environmental factors and government policies which influence access to assets and markets.

5. Results and Discussion - Land structure and horticultural diversification

In the *zonas verdes*, horticultural production is mainly done by small-scale family farmers. A very small number of farms belong to associations of producers, which raises the question of what the determinants of association-establishment are and by what process and to what extent associations are characterized by impaired abilities to solve the concerns of its members and consequently their ability (or inability) to boost agriculture. Employees of the agriculture sector at the local level reveal that farmers choose not to participate in associations given a level of financial autonomy. Although there is unanimity about the fact that family income is a decisive factor in the decision to participate in associations, there is no agreement on whether it is poor farmers who participate (Warning & Key, 2002) or relatively wealthy producers (Becchetti & Costantino, 2008). Gaiger (2006), for example, believes that the cooperation and economic entrepreneurship that characterizes the associations are justified by the fact that the activities in which its members are involved require little skill, generate little income and require little specialization.

In the survey area overall, half of respondent producers are male. However, in Mahotas, where the sample was relatively larger, the ratio of males to females is relatively larger (25:19). In this area the presence of men in farming is seen by the women as associated with lack of employment.

The main crops grown in the *zonas verdes* are: kale (99% of respondents stated its production), lettuce (94%), cabbage (44%), carrot (22%), beets and green beans (21%), and pumpkin (18%).

The average value of the Simpson diversity index (a measure of the horticultural diversification), ranges between 0.34 and 0.71 (Table 1). The most diversified producers (above the average SDI) counted on seemingly more profitable crops as cabbage, tomato, green pepper, carrot, beets, cucumber and spinach; while those below average SDI mostly planted kale and lettuce, which can be related to the fact that these crops are easier to manage and adapt better to the production conditions of the least technologically advanced producers with little resources.

Table 1. Distribution of crop diversity by quintile of SDI in the *zonas verdes*

Quintile	SDI Mean	Number of Producers
1	0.34	14
2	0.49	16
3	0.54	11
4	0.61	14
5	0.71	13

Source: Research data

The analysis of variance (ANOVA) between the mean SDI across quintiles shows an F test score of 189.34 at 99% significance level, indicating that there are significant differences between the mean values of SDI across quintiles (Table 2).

Table 2. Analysis of Variance (ANOVA) of the distribution of diversification by quintile of SDI in the *zonas verdes*

Source	Sum of squares	Degrees of Freedom	Squared Average	F	Prob > F
Between groups	1.06	4	0.275	189.34	0.0000
Within groups	0.09	63	0.001		
Total	1.15	67	0.017		

Source: Research data

An analysis to localize the differences indicates that the average diversity between different SDI quintiles is statistically significant, suggesting differences in productive capacities of producers in the *zonas verdes* (Table 3).

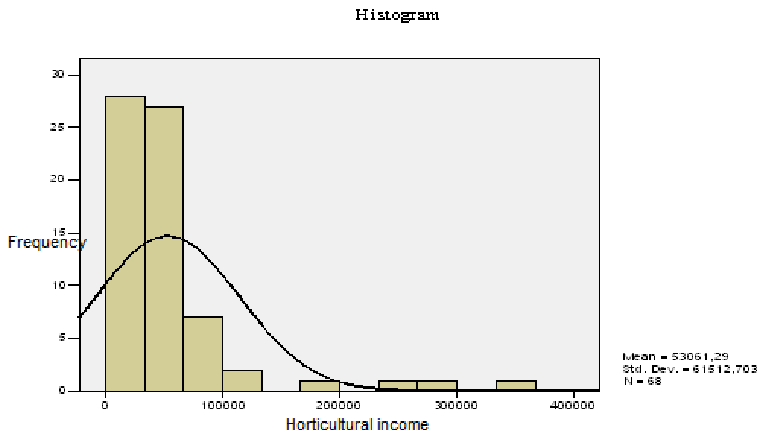
Table 3. Bonferroni test to compare SDI between quintiles in the *zonas verdes*

Average line – Average column	1	2	3	4
2	0.151 0.000			
3	0.201 0.000	0.051 0.010		
4	0.027 0.000	0.119 0.000	0.686 0.000	
5	0.375 0.000	0.237 0.000	0.173 0.000	0.105 0.000

Source: Research Data

The heterogeneity of producers in the *zonas verdes* is also confirmed by the frequency distribution of horticultural income shown in the following figure, where a high standard deviation value indicates an asymmetric distribution of horticultural income[4].

Figure 1. Frequency Distribution of horticultural income in the *zonas verdes*



The two sites (Mahotas and the Valley of Infulene) are very different in terms of horticultural diversification. The following table refers to a t test comparing the average SDI of Mahotas and Influene Valley. Pr (T> t) = 0.0001. On the basis of the significance level of this test, we can not reject the null hypothesis that the average SDI of Mahotas exceeds the average SDI of Infulene Valley (Table 4).

Table 4. T-test to compare the distribution of SDI diversity among the study locales in the *zonas verdes*

Groups	Obs	Average	Standard Deviation	Standard Error	95% Confidence Interval	
1-Mahotas	44	0.577	0.017	0.111	0.543	0.611
2-Infulene Valley	24	0.455	0.027	0.129	0.400	0.509
Combined	68	0.534	0.016	0.131	0.502	0.566
Difference (Diff) = average 1-average 2		0.122	0.030		0.062	0.182
Ho: Diff= 0		Ha: diff > 0			t= 4.0670	
Ha: Diff < 0 Pr(T<t)= 0,9999		Pr (T>t)=0,0001			Degrees of freedom= 66	

Source: Research Data

However, differences in the Simpson's Diversity Index score between producers are not significant enough to generate differences in income between horticultural producers in the *zonas verdes*, as indicated by analysis of variance of horticultural income in the different quintiles of SDI. The value of F is equal to 0.42 and the value of p is 079, indicating that the differences are not statistically significant (Table 5).

The interviewed producers have a positive perception of the importance of horticultural diversification. The importance of diversification is also noted in the answers of the producers to questions of what they

[4]An attempt to approximate the distribution to a "normal distribution" was made with the natural logarithm of the horticultural income variable; however, the standard deviation value still remained high.

planted in their fields. To this question they listed many crops, some of which being of the largest commercialized sale values and which they had not grown in the current season, which could be an indication that they saw the land as well suited for other crops than those being currently grown, but that their willingness to diversify production was conditional upon additional support, principally, that from the state.

Table 5. Analysis of Variance (ANOVA) between the horticultural income of the different quintiles of SDI in the *zonas verdes*

Source	Sum of	Degrees of	Average	F	Prob >F
Between groups	4.71	4	1.18	0.42	0.7924
Within groups	1.76	63	2.79		
Total	1.81	67	2.70		

Source: Research Data

6. Conclusions

The *zonas verdes* play a crucial role in the supply of vegetables to the cities of Maputo and Matola in the Maputo Province. Producers of the *zonas verdes* have different capacities to produce vegetables. Although horticultural production is being achieved mainly by a larger number of small producers, there is a chance that some of the producers of the *zonas verdes* can take advantage of horticultural market opportunities, but to take full advantage of these opportunities requires solving the structural problems affecting agricultural development. These problems include provision of credit, technical assistance, availability of quality seeds, managing pests, improved market conditions, etc. Part of these problems require state intervention, as producers have little ability to solve their problems by their own effort. The role of producer associations needs to be revisited so that they have a greater ability to help boost vegetable production as well.

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CHAPTER 2

Input Use, Input Purchase Channels, Sale Channels and other General Characteristics of the Horticultural Producers of Maputo

Expanded from the original *Flash* No. 68E

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Using data from the 2013 horticultural baseline study conducted as part of the trilateral partnership between Brazil, the United States, and the Mozambican Agricultural Research Institute (IIAM), this chapter offers a number of general characteristics of the horticultural farmers of Maputo and their crop sales, then goes on to explore these farmers' input purchase channels in terms of their formality, frequency, location and value, as well as methods of irrigation used. A summarized list of principal findings can be found in the final section of the chapter.

1. Introduction

High production value per unit land area makes horticulture particularly attractive as a source of income for land-constrained farmers. Yet major challenges of horticultural production marketing relate to the cost and knowledge needed to acquire quality inputs. How much, which, where and from whom a producer purchases the seed varieties, fertilizers, and pesticides used on her field(s), as well as what method of irrigation is used, all affect the productivity and prospects for a successful commercial harvest. Using data from the 2013 baseline survey of horticultural farmers in the *zonas verdes* and districts of Moamba and Boane in the province of Maputo, this chapter offers by means of introduction, a number of general characteristics of the horticultural farmers of Maputo and their crop sales, then goes on to explore in greater detail these farmers' input purchase channels in terms of their formality, frequency, location and value, as well as methods of irrigation used.

2. Production Areas and Sample

The horticultural production areas of the districts of Matola, Ka Mubucuana, and Ka Mavota are normally referred to as the the *zonas verdes* of Maputo. Production in this area often takes place within or near the administrative boundaries of the municipality and is dominated by very small farmers (typical land holding of 0.1 ha), producing primarily green leafy vegetables under individual irrigation. The districts of Moamba and Boane, in contrast, are primarily characterized by centralized irrigation areas (*blocos*) and farmers with larger land areas producing tomato, onion, cabbage, and other horticultural crops. A less numerous group of farmers in these districts operates with individual irrigation along the rivers, outside the *blocos*. We refer to these as the dispersed producers of those districts. Land holdings among both these types of farmers areas average 2.3 ha.

Because of the distinctly different production systems in each zone, the sample was stratified to individually represent all producers with less than 5 hectares of cultivated land with horticultural crops in each zone, with sample sizes of 344 for *zonas verdes* and 272 for Moamba and Boane. We report all results in this way. The dispersed producers of Moamba and Boane most commonly appear among the least technified farmers in those districts.

3. Crop Sales, Farmer Characteristics, and Common Sources of Agricultural Advice or Training

Crop Sale Frequency

Kale and lettuce are by far, the most common crops in the *zonas verdes* in both cool and hot seasons. 88% of producers sell kale and 86% of producers sell lettuce in the zonas verdes in the cool season (from March to August), and over half of producers sell each respectively in the hot season as well (from September through February), when plant pests and disease pressure are highest (see table 1). Pumpkin leaves are among the most common horticultural crop in both seasons within the *zonas verdes* as well. Thirty nine percent of households sell pumpkin leaves in the cool season, and 35% sell in the hot season among these producers. In the hot season, only 9% of producers in the *zonas verdes* produce cabbage, whereas twice this percentage of cabbage is produced in the cool season (18%).

Table 1. Horticultural sales participation and crop shares by zone and season among farmers selling any horticultural product (% selling)

Crop	Cool Season (March to August)		Hot Season (September to February)	
	ZV	M/B	ZV	M/B
Kale	87.8%	36.0%	56.1%	6.6%
Lettuce	85.8%	34.6%	58.7%	5.5%
Pumpkin Leaf	38.7%	4.4%	35.2%	3.3%
Beet	35.2%	4.4%	18.9%	1.5%
Onion	25.0%	22.8%	12.5%	5.5%
Cabbage	17.7%	17.6%	8.7%	9.2%
Tomato	6.1%	30.1%	4.7%	15.8%
Carrot	7.3%	3.3%	4.7%	1.1%
Pumpkin	5.5%	1.5%	3.8%	1.5%
Sweet Pepper	4.4%	10.3%	2.9%	6.6%
Parsley	3.5%	0.0%	2.9%	0.0%
Green bean	3.2%	32.0%	1.7%	21.7%
Garlic	2.0%	9.6%	0.6%	1.5%
Sweet Corn	2.3%	18.8%	4.1%	21.0%
Cucumber	2.0%	10.7%	2.3%	13.6%
Eggplant	1.5%	1.5%	1.5%	1.1%
Cilantro	1.7%	0.0%	1.7%	0.0%
Okra	1.5%	2.9%	2.0%	1.8%
Chili Pepper	1.2%	3.3%	1.2%	2.9%
Potato	0.9%	12.9%	0.0%	4.0%
Spinach	0.3%	0.0%	0.3%	0.0%

Note: No families in the survey recorded sales of traditional *inhame* yams, amaranthus, *cacana*, peas or watermelon. ZV – *Zonas Verdes*; M/B – Moamba/Boane

Kale and lettuce are also the most common crops in Moamba and Boane in the cool season, where 35-36% of producers in these two districts participate in each kale and/or lettuce sales. Green beans and sweet corn are the most popular horticultural crops among these producers in the hot season, 22% and 21% of interviewed families participate in sales of these two crops, respectively. And tomato is the third most popular crop sold in Moamba/Boane in the hot season, produced by 16% of farmers. Not surprisingly, smaller producers generally have the least diversified sold crops portfolio (see table 2).

Table 2. Production and Sales of Horticultural Crops

Quintiles of Cultivated Area	Mean number of crops produced		Mean number of crops sold		% Producers who sell tomato		% Producers who sell tomato in both seasons	
	ZV	M/B	ZV	M/B	ZV	M/B	ZV	M/B
Least Area 1	4	4	3	1	5%	11%	2%	3%
2	4	5	3	2	6%	14%	3%	2%
3	4	5	3	4	4%	48%	3%	8%
4	5	5	4	4	12%	50%	3%	22%
Most Area 5	5	5	4	5	10%	59%	5%	30%

ZV - *Zonas Verdes*; M/B - Moamba/Boane

Sale Locale

The majority of the time, green leafy vegetables are sold at farm gate in both the *zonas verdes* and in Moamba/Boane, usually to informal, and often female buyers, referred to locally as *maguevas*. Producers of Moamba/Boane sell their produce in more diversified channels than the producers of the *zonas verdes*, such as at the wholesale market of Maputo, Zimpeto, or other local retail venues. A summarized table of sale channel frequencies by crop can be found in table 3.

Table 3. Horticultural sale channel frequency shares among farmers selling any horticultural product

Crop	Moamba/Boane								Zonas Verdes					
	Frequency	In the Field	Zimpeto Wholesale Market	Maputo/ Matola Retail Markets	Moamba/ Boane Retail Markets	At home	Other (ag. fairs, at work, etc.)	**Row Total**	**Frequency**	In the Field	Zimpeto Wholesale Market	Maputo/ Matola Retail Markets	At home	**Row Total**
Kale	*107*	84	2	3	7	0	0	**100**	*319*	93	3	3	1	**100**
Lettuce	*101*	85	1	2	8	1	3	**100**	*314*	94	3	3	1	**100**
Pumpkin Leaf	*15*	73	0	13	13	0	0	**100**	*160*	93	3	3	1	**100**
Onion	*70*	67	10	7	9	6	1	**100**	*91*	87	7	5	1	**100**
Beet	*13*	46	15	15	15	0	8	**100**	*132*	89	4	6	2	**100**
Tomato	*108*	58	30	3	8	1	8	**100**	*31*	87	10	3	0	**100**
Cabbage	*63*	60	30	5	2	3	0	**100**	*63*	89	5	3	3	**100**
Green Bean	*106*	55	28	8	5	4	1	**100**	*15*	73	13	13	0	**100**
Sweet Corn	*75*	77	17	3	1	1	0	**100**	*15*	87	7	7	0	**100**
Cucumber	*58*	55	36	7	2	0	0	**100**	*9*	89	11	0	0	**100**
Green Pepper	*36*	47	39	8	6	0	0	**100**	*18*	89	6	0	6	**100**
Potato	*44*	55	27	2	5	9	2	**100**	*3*	100	0	0	0	**100**
Garlic	*29*	59	7	3	14	14	3	**100**	*7*	71	0	0	29	**100**
Carrot	*9*	56	0	22	11	11	0	**100**	*27*	93	7	0	0	**100**
Pumpkin	*6*	83	0	0	17	0	0	**100**	*22*	95	0	5	0	**100**
Okra	*11*	73	9	0	18	0	0	**100**	*9*	78	11	0	11	**100**
Hot Pepper	*10*	70	20	10	0	0	0	**100**	*6*	83	17	0	0	**100**
Parsley	*0*	0	0	0	0	0	0	**100**	*15*	67	7	27	0	**100**
Eggplant	*6*	50	17	17	17	0	0	**100**	*8*	75	13	13	0	**100**
Total/Average	*867*	61	15	7	8	3	1	**100**	*1264*	86	7	5	3	**100**

The reason for these differentiated marketing patterns can be explained by the fact that producers in the *zonas verdes* are in or on the boundaries of Maputo city where there are many retail markets available within a short proximity. In contrast, producers in Moamba and Boane are situated in primarily agriculture-based areas, where there is a lower density of consumers.

Dependency Ratio, Gender of Household Head and Percentage of Family Members in Full Time Horticultural Work

Table 4 shows that the ratio of household members under the age of 15 or over the age of 59 to household members age 15 to 59 (the dependency ratio) is consistently lower, by quintile of cultivated land area in the cool season, for producers in the *zonas verdes* compared to producers in Moamba or Boane. The number of family members in full time horticultural work is also consistently lower for producers in the *zonas verdes* by land size quintiles (table 5). This might suggest that concentrated field management by a few individuals in the family who are more free from the duties of child or senior care could be benefitting the sales potential of these producers, who generally cultivate smaller plots than their Moamba/Boane counterparts.

Across both the *zonas verdes* and Moamba and Boane, a consistent 2/3rds of household heads are female.

Table 4. Dependency Ratio by Quintile of Cultivated Area in the Cool season (ha)

Quintiles	*Zonas Verdes*	Moamba/ Boane
Least area - 1	0.50	0.56
2	0.46	0.50
3	0.36	0.43
4	0.40	0.44
Most area - 5	0.42	0.44

Table 5. Percentage of Family Members in Full Time Horticultural Work by Quintile of Area cultivated in the cool season

Quintiles	*Zonas Verdes*	Moamba/ Boane
Least area - 1	0.25	0.40
2	0.29	0.40
3	0.29	0.38
4	0.31	0.44
Most area - 5	0.38	0.38

Table 6. Sources of Extension Advice in Order of Importance

From whom did you receive advice concerning your horticultural production in order of importance?	1st	2nd	3rd
Casa(s) agrária(s)/the state	99%	10%	11%
Associations	21%	55%	56%
NGOs	9%	7%	11%
Neighbors	8%	16%	11%
TV/Radio	2%	.	.
Informal *Comerciante Ambulante*	1%	5%	.
University	1%	3%	.
Stores	2%	2%	11%
Seed, Fertilizer or Pesticide Companies	2%	2%	.
Total Responses:	100%	100%	100%

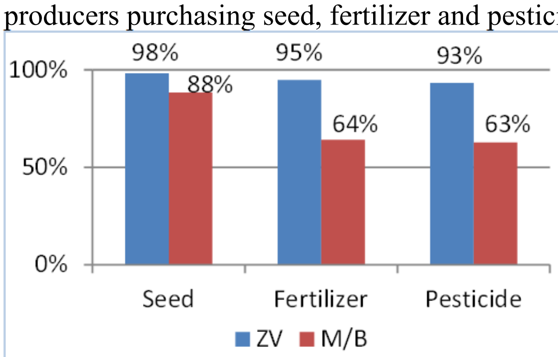
Exposure to Extension Advice and Agricultural Training

The most influential sources of agricultural advice, as ranked by the survey respondents, invariably take the form of government-employees, followed by members or leaders of the farmer associations of which households are a part (see table 6). Higher percentages of producers in the *zonas verdes* report having received advice from an extension agent (29%, compared to 25% of producers in Moamba/Boane). The typically larger producers in Moamba and Boane however, more frequently report having recently participated in an agricultural training of at least 3 months in duration compared to the typically smaller producers of the *zonas verdes* (11%, compared to 9% of producers in the *zonas verdes*).

4. Input Purchases

Seed is the most common and the most expensive input purchased in both the *zonas verdes* and Moamba/Boane (figure 1). This pattern holds across all quintiles of the area cultivated with horticulture in the cool season among these producers (table 7).

Figure 1. Percent of producers purchasing seed, fertilizer and pesticide by survey location



ZV - *Zonas Verdes*; M/B - Moamba/Boane

Table 7. Annual median value spent (MZN) on various inputs by cultivated land area quintiles

Quintiles of Area Cultivated with Horticultural Crops in the Cool Season	Median Amount Spent (MZN)					
	Horticulture Seed		Fertilizer for Hort Crops		Pesticide for Hort Crops	
	ZV	M/B	ZV	M/B	ZV	M/B
Least Area - 1	697	300	260	0	400	0
2	1,950	850	390	13	760	300
3	1,800	3,814	509	30	891	1,470
4	3,250	2,850	750	45	1,800	700
Greatest Area – 5	6,840	11,000	930	90	2,480	3,760

ZV - *Zonas Verdes*; M/B - Moamba/Boane

Despite seed being their greatest cost, farmers generally show low knowledge concerning what varieties of seed they use. Producers in the zonas verdes are able to give the common variety name for only 15% to 19% of the varieties they planted, and in Moamba and Boane, this percentage averages 11% to 22%. In both areas, knowledge shows no relationship to the farmer's total cultivated land size.

Second to seed, the costs of pesticides are consistently greater than the costs of fertilizer across cultivated land area quintiles. Costs for inputs across all three categories (seed, fertilizer and pesticide) generally rise with increasing cultivated area. Those in the lowest quintile of area cultivated with horticulture in the cool season in Moamba and Boane report a median value of 0 in purchases of fertilizer or pesticide in the past year (table 7). Compared to these low rates of pesticide or fertilizer purchases among the smallest and often dispersed farmers in Moamba and Boane, producers in the *zonas verdes* generally have a higher market orientation and cultivate their land more intensively.

Among producers in the top quintile of cultivated land area in Moamba and Boane, on the other hand, the median value of fertilizer and pesticide spent on horticultural crops over the last year is 90 MZN and 3,760 MZN, respectively, and a median 11,000 MZN is spent on horticulture seed by these producers. In the *zonas verdes*, a median 930 MZN is spent on fertilizer for horticultural crops in a year among those in the highest quintile of area cultivated, 2,480 MZN is spent on pesticides, and 6,840 MZN for seed. Compared to fertilizer or pesticides, seed tends to be bought from less formal vendors - *comerciantes ambulantes*, families, or neighbors, in contrast to state-run agri-input dealers called *casas agrárias*, privately-owned stores, or representatives sent by these stores.

The preference for formal vendors generally rises with farm size in all three input categories in the *zonas verdes* but this pattern is less clear in Moamba and Boane (see table 8[5]). Overall, producers in the *zonas verdes* are markedly much more likely to purchase their inputs from informal channels in comparison to Moamba and Boane.

Table 8. Index of input purchase source formality by cultivated land area quintiles

Quintiles of Area Cultivated with Horticultural Crops in the Cool Season	Mean ha cultivated in horticulture, cool season		Index of Input Purchase Source Formality					
			Horticulture Seed		Fertilizer for Hort Crops		Pesticide for Hort Crops	
	ZV	M/B	ZV	M/B	ZV	M/B	ZV	M/B
Least Area - 1	0.01	0.01	0.16	0.47	0.55	0.91	0.40	0.90
2	0.04	0.17	0.23	0.46	0.53	0.90	0.45	0.89
3	0.07	0.61	0.30	0.42	0.57	0.85	0.41	1.00
4	0.12	1.36	0.31	0.37	0.55	0.95	0.56	1.00
Greatest Area – 5	0.75	4.79	0.64	0.78	0.68	0.91	0.67	0.92

ZV - *Zonas Verdes*; M/B - Moamba/Boane

5. Pesticide Purchase Channels

Although only 63% of producers in Moamba/Boane purchase pesticides compared to 93% of those in the *zonas verdes*, a little over a third of producers in both of these zones purchase at least one of their pesticides from a store. Private stores have a market share of 80% of sales in Moamba and Boane and 41% in the *zonas verdes*. Correspondingly, the greatest annual median values for pesticides are also spent in stores. After stores, 10-14% of producers across the survey purchased at least one pesticide from a *casa agrária*, however the market share of these purchases is much lower, ranging from 8% to 11% between the two zones (table 9).

[5] The index of purchase location formality ranges from 0 to 1, with values closer to 0 representing purchase sources such as neighbors, friends, and informal *comerciantes ambulantes*, and values closer to 1 representing stores, *casas agrárias*, and formal *comerciante ambulantes* (store representatives operating outside the stores).

Table 9. Annual frequency and value of pesticide purchases for horticultural crops (MZN) by principal channels

	Pesticide Value used on Horticultural Crops							
	Zonas Verdes				Moamba/Boane			
	Market	% AFs	Among buyers		Market	% AFs	Among buyers	
Outlet Type	Share	Buying	Median	Mean	Share	Buying	Median	Mean
Private store	41.3%	33.5%	788	2,419	79.5%	39.9%	975	5,577
Casa agrária	8.0%	10.2%	613	1,805	10.9%	14.4%	900	2,679
Informal *comerciante ambulante*	48.8%	47.7%	450	2,458	3.2%	6.8%	500	1,951
Formal *comerciante ambulante*	0.2%	1.2%	370	335	5.9%	2.3%	700	11,488
Other Family	1.6%	4.3%	330	900	0.3%	1.1%	600	803

Informal *comerciantes ambulantes* differ from formal *ambulantes* in that they are not associated with a private store, but instead function as free agents who purchase and often repackage products for resale. Nearly half of producers in the *zonas verdes* purchase at least one pesticide from an informal *comerciante ambulante*. These sellers compose the largest pesticide purchase channel for this area, with a 47.7% share. The annual median amount spent for the pesticides in this channel, in contrast, is less than either in the stores or *casas agrárias*. When we look at purchases from informal *comerciantes ambulantes* in Moamba and Boane, we see these economic agents are used much less in comparison to in the *zonas verdes* (table 9).

Regardless of what channel the pesticide is bought from, producers in Moamba and Boane consistently spend more on pesticides than producers in the *zonas verdes* (table 9). Among stores, AgriFocus is the most popular for pesticide purchases among producers in Moamba and Boane, with a 30% share of pesticide purchases and median of 2,600 MZN spent annually. Agrifocus is followed by Hygrotech, with a 28% share and median 700 MZN spent annually, then by PANNAR, with a 19% share and median annual value of 600 MZN. Producers in the *zonas verdes* listed Tecap more than any other store (35% market share and 900 MZN median annual purchase value), followed by AgriFocus (33% share and 1,050 MZN median value spent).

In terms of purchase location, the *sede distrital* is the most popular location for pesticide purchases in Moamba and Boane; one-third of households in this area reported buying at least one pesticide at the *sede distrital*, followed by Maputo (23%). Purchases in the *machamba* (farmers' fields) were by far the most common location for those in the *zonas verdes* (47% of producers), consistent with the popularity of purchasing from informal *comerciante ambulantes* in this area.

6. Fertilizer Purchase Channels

Among inorganic fertilizer purchases, informal *comerciantes ambulantes* compose 90% of the market share in the *zonas verdes* (table 10). 52% of producers in this area purchase at least one inorganic fertilizer within this channel and the greatest median values spent by producers on fertilizer in this area were, correspondingly, those made in the field. The median annual value spent on inorganic fertilizer from a *comerciante ambulante* is 270 MZN. Following *comerciantes ambulantes* in popularity are purchases made at stores (15% of producers in the *zonas verdes,* with a 6% market share), where the median value spent is much lower, at 45 MZN/year.

Table 10. Annual frequency and value of inorganic fertilizer purchases for horticultural crops (MZN) by principal channels

	Inorganic Fertilizer Value used on Horticultural Crops							
	Zonas Verdes				Moamba/Boane			
	Market Share	% AFs Buying	Among buyers		Market Share	% AFs Buying	Among buyers	
Outlet type			Median	Mean			Median	Mean
Private store	5.9%	15.3%	45	268	77.9%	34.4%	48	360
Casa agrária	1.2%	7.9%	45	95	3.1%	10.8%	15	49
Informal *comerciante ambulante*	89.8%	51.8%	270	1173	11.0%	11.0%	30	179
Formal *comerciante ambulante*	0.9%	2.0%	60	171	0.5%	2.9%	15	32
Other Family	0.5%	2.0%	473	518	3.5%	2.5%	15	343

Producers in Moamba and Boane generally spend less money on inorganic fertilizers compared to producers in the *zonas verdes*, with the exception of purchases made in stores. 34% of producers in Moamba or Boane purchased from a store, and only 11% purchased from *comerciantes ambulantes* or a *casa agrária,* with shares of 78%, 12% and 3% respectively (table 10).

Organic fertilizer purchases are very common in *zonas verdes* but not at all common in Moamba and Boane (table 11). The greatest value of organic fertilizers purchased in both the *zonas verdes* and Moamba and Boane were through aviaries. Fifty-three percent of producers in the *zonas verdes* purchased fertilizer from an aviary (with a 62% share), and 4% of producers in Moamba and Boane did so (with a 91% share). Yet informal *comerciantes ambulantes* also figure prominently in this market within the *zonas verdes,* with 22% of producers purchasing organic fertilizer from a *comerciante ambulante* for a total market share of 21%.

Table 11. Annual frequency and value of organic fertilizer purchases used on horticultural crops (MZN) by principal channels

	Organic Fertilizer Value used on Horticultural Crops							
	Zonas Verdes				Moamba/Boane			
	Market Share	% AFs Buying	Among buyers		Market Share	% AFs Buying	Among buyers	
Outlet type			Median	Mean			Median	Mean
Private store	0.3%	1.7%	45	124	4.1%	1.7%	197	165
Aviary	61.0%	52.6%	300	855	91.5%	4.0%	53	1615
Casa agrária	0.7%	1.5%	300	373	0.9%	0.7%	1	90
Informal *comerciante ambulante*	21.0%	21.7%	270	616	0.4%	0.8%	90	49
Formal *comerciante ambulante*	1.0%	1.2%	75	617	0.0%	0.3%	1	1
Other Family	16.0%	8.2%	180	1292	2.9%	1.4%	39	148

7. Seed Purchase Channels

Ranked by median seed expenditures, the crops for which producers spent the most money on seed, in order, are potato, green beans, lettuce, cabbage, and cucumber. Channels of sale among crops and between zones vary greatly.

The greatest market shares of seed purchases in the *zonas verdes* were *casas agrárias* (47%), followed by informal *comerciantes ambulantes* (29%), then private stores (17%). Only 16% of producers purchased from a *casa agrária*, and 24% from a store, however, 65% of producers purchased from an informal *comerciante ambulante*. The greatest market shares of seed purchases in Moamba and Boane follow the same sequence: greatest in the *casas agrárias* (47%), followed by informal *comerciantes ambulantes* (37%), and then stores (15%). Twenty-three to 24% of producers purchased from a *casa agrária* or informal *comerciante ambulante*, and 51% purchased from stores. In both areas, the median value of sales spent on seed were lower for purchases made from *comerciantes ambulantes* than those made in the stores or *casas agrárias* (see table 12).

Table 12. Annual frequency and value of horticultural seed purchases (MZN) by principal channels

	Seed Value							
	Zonas Verdes				Moamba/Boane			
	Market Share	% AFs buying	Among buyers		Market Share	% AFs buying	Among buyers	
Outlet type			Median	Mean			Median	Mean
Private store	16.5%	24%	875	4,889	15.3%	51%	600	7,721
Casa agrária	46.8%	16%	400	23,191	47.2%	23%	600	59,19
Informal *comerciante ambulante*	28.5%	65%	350	3,095	36.7%	24%	200	61,93
Formal *comerciante ambulante*	0.4%	6%	200	725	0.3%	8%	250	1,411
Other Family	6.6%	32%	225	1,591	0.3%	14%	150	998
Market	0.1%	4%	100	545	0.0%	2%	100	172
Association	0.2%	2%	900	1,265	0.0%	0.5%	620	635
Agriculturalists	0.0%	0%	.	.	0.0%	1%	158	211
Feira	0.0%	0%	.	.	0.0%	2%	150	354
Other District	0.9%	0.3%	28,812	24,108	0.0%	0.4%	800	800
Other Channel	0.0%	0.6%	50	625	0.1%	0.0%	3,600	4,271

8. Irrigation Methods

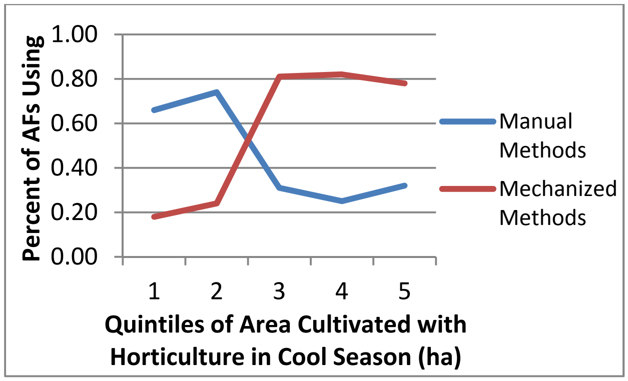
In addition to seed, fertilizer and pesticides, irrigation is essential for the successful harvest of most horticultural crops, and the method of its employment can make a big difference for farmers' productivity.

As has already been alluded to, 98% of producers in the *zonas verdes* of Maputo use purely manual mechanisms for irrigating their crops, that is, they water their crops by hand with a sprinkling can. Mechanized forms of irrigation (involving the use of a water pump) are practically nonexistent in these areas, reported to have been used for their horticultural plots by a total of only 0.7% of those in this group.

Whereas producers in Moamba and Boane also use manual irrigation, the use of mechanized irrigation is much more prevalent. Notably, the use of manual systems of irrigation by these producers decreases, and use of mechanical methods increases, with increasing average size of cultivated land dedicated to horticulture in the cool season (figure 2). Fifty-eight percent of farmers in Moamba and Boane use mechanized irrigation on at least one of their horticultural fields.

The most common method of mechanical irrigation is irrigation by gravity. Eighty-nine percent of those using mechanical irrigation listed this form, whereas only producers in Moamba and Boane's top quintile of cultivated land area used irrigation systems employing sprinkler (2%) or drip (4%) irrigation methods.

Figure 2. Irrigation systems used by quintile of cultivated land area with horticulture in the cool season (ha) in Moamba/Boane



9. Main Findings

In summary, the following can be said in terms of some of the general characteristics of the farmers in our study and their sales practices:

- Across both the *zonas verdes* and Moamba and Boane, a consistent 2/3rds of household heads are female
- The most influential sources of agricultural advice, as ranked by survey respondents, invariably take the form of government-employees, followed by members or leaders of the farmer associations of which households are a part
- Smaller producers generally have the least diversified sold-crops portfolio
- The majority of the time green leafy vegetables, which are very commonly grown in the areas of our study, are sold at farm gate in both the *zonas verdes* and in Moamba/Boane, usually to informal, and often female buyers, referred to locally as *maguevas*.
- Producers of Moamba/Boane sell their produce in more diversified channels than the producers of the *zonas verdes* such as at the wholesale market of Maputo, Zimpeto, or other local retail venues, rather than simply at farm-gate.

Furthermore, despite the large variety in input channels and expenditures by type and location, a number of conclusions can be drawn concerning irrigation use and input purchase channels among the farmers supplying Maputo:

- Farmers generally have low levels of knowledge about the varieties of seeds they use or the benefits of these compared to others, even though expenditures on seed are their largest input cost.
- Seeds are the most likely to be purchased from an informal channel as opposed to a formal channel.
- Informal input channels in general are more prevalent within the *zonas verdes* where informal *comerciantes ambulantes* are the most common source for purchases of seed, pesticide and inorganic fertilizer.
- Producers in Moamba and Boane spend more on pesticide than producers from the *zonas verdes*, but not always more than these producers for fertilizer or seeds, depending on the crop and the source where they purchased.

- Larger and more technologically advanced farmers spend more on inputs and are more likely to purchase them in a formal channel rather than an informal channel.
- Water pumps are nearly non-existent in the *zonas verdes*, leading to large labor demands for regular manual irrigation.
- Among the 58% of producers in Moamba and Boane who use mechanized irrigation, spray or drip irrigation is used by less than 4% of households, whereas irrigation with water pumps is nearly non-existent in the *zonas verdes* (0.7%). This leads to large labor demands in both of these areas for regular manual irrigation or trench-digging (in the case of gravity-fed irrigation methods).

10. References

Cairns, J., Tschirley, D., & Cachomba, I. (2013). Typology of the Horticultural Producers of Maputo. Flash 70E. Maputo: Ministry of Agriculture.

CHAPTER 3

Typology of Horticultural Producers Supplying Maputo

Also produced as *Flash* No. 70E

Jennifer Cairns Smart, Isabel Sitoe Cachomba & David Tschirley

Using data from the 2013 horticultural baseline study conducted as part of the trilateral partnership between Mozambique, Brazil, and the United States, this chapter characterizes the smallholder horticultural producers supplying the city of Maputo. Cluster analysis is used to partition households into four groups based on 32 dimensions of technology endowment, capacity, and behavior. Results of this study indicate that there is a great diversity of horticultural producers in Maputo, ranging from those generally characterized by low land endowment, access to extension or training advice, and diversity of horticultural sales (cluster one) to those with high levels of the same indicators (cluster four). Level of technological capacity among the producers does not correspond with specific geographic regions of our study, as the producers of Moamba and Boane most commonly appear among the least technologically advanced farmers (primarily the dispersed producers in these areas), but also frequently appear among the most technologically advanced producers (generally those with shared central irrigation systems). Producers in the *zonas verdes* tend to be more uniform in the level of technology they apply, making up most of the two middle clusters (two and three).

1. Introduction

Mozambique has a great diversity of horticultural producers in terms of knowledge and access to information, technology use and production and marketing behavior. For this reason, it is important to learn more about the different types of producers in order to design interventions specific to each group and by so doing, increase the probability that interventions will result in adoption of improved practices and higher profits for farmers.

The trilateral project (a partnership between Mozambique, Brazil and the United States) has been testing new technologies to be transferred to the horticultural project areas of Moamba, Boane and the *zonas verdes* of Maputo (Ka Mubuacuane, Ka Mavota and Matola). One of the planned activities of this project is defining a producer typology.

In this chapter, data from the baseline horticultural survey and the method of cluster analysis is used to generate a four-group typology of farmers in the study area, based on a range of indicators. These indicators cover knowledge and access to information, technology use, and production and marketing behavior. The trilateral project has been testing new technologies to be transferred to the horticultural production areas of Moamba, Boane and the *zonas verdes* of Maputo. This study allows recommendations to be formulated concerning which technologies and knowledge may offer the best prospects of adoption and improved performance.

2. Production Areas and Sample

The horticultural production areas of the districts of Matola, Ka Mubucuana, and Ka Mavota are normally referred to as the the *zonas verdes* of Maputo. Production in this area often takes place within or near the administrative boundaries of the municipality and is dominated by very small farmers (typical land holding of 0.1 ha), producing primarily green leafy vegetables under individual irrigation. The districts of Moamba and Boane, in contrast, are primarily characterized by centralized irrigation areas (*blocos*) in which farmers with larger land areas produce tomato, onion, cabbage, and other horticultural crops. A less numerous group of farmers in Moamba and Boane operates with individual irrigation along the rivers, outside the *blocos*. We refer to this latter group as the dispersed producers of those districts. Land holdings among both these types of farmers average 2.3 ha.

Because of the distinctly different production systems in each zone, the sample was stratified to represent all producers with less than five hectares of land cultivated with horticultural crops in each zone, with sample sizes of 344 for *zonas verdes* (ZV) and 272 for Moamba and Boane (M/B). We report all results in this way. The dispersed producers of Moamba and Boane most commonly appear among the least technified farmers in those districts.

3. Methodology

In this report, cluster analysis is used to group households on the basis of their technological endowment and productive capacity. Cluster analysis groups data into classes so that objects within a class are similar but are dissimilar to objects in other classes (Babu 2009). In this analysis we used cluster analysis to differentiate farmers in terms of their knowledge and access to information, technology use, and production and marketing behavior. Grouping farmers in this way should allow the development of technological packages and related extension material more suited to each group's needs and capacities.

Table 1 presents a complete list of the 32 indicators used to differentiate farmers, along with each indicator's mean value. The indicators are divided into five categories:

a. Experience, training and agricultural information
b. Diversification of production and sales
c. Input expenditures and farm management practices
d. Post-harvest activity and crop loss
e. Pesticide management and toxicity awareness

All 32 variables range in value from zero to one, giving each an equal weight in the clustering algorithm.

In this analysis, the k-means method of cluster analysis is used, where *k* clusters are specified. In the case of this study, four clusters are chosen after comparing the output of several different values of *k*. The algorithm begins by partitioning all 616 producers into four groups, each with its own initial set of means. In subsequent steps, the 616 cases are repartitioned to minimize the sum of the "distances" of each observation from the mean of the cluster to which it was assigned. For every subsequent partition, the sum of distances within each cluster becomes progressively smaller, meaning that the similarity of farmers within a given cluster becomes greater while the differences across clusters increase. The algorithm stops when it has minimized within-cluster distances.

4. Findings

After weights are applied to account for relative representation across the sample areas, producers in

Moamba and Boane with less than 5 hectares of horticultural crop land account for 11% of all the horticultural producers in the area. The mostly small producers in the *zonas verdes* account for the remaining 89% (43% from Ka Mavota, 28% from Matola, and 19% from Ka Mubucuana). In terms of area cultivated in horticulture, however, the two zones are nearly equal: Moamba and Boane show approximately 990 hectares during the cool season while *zonas verdes* show approximately 1,100 hectares.

Among the four clusters of farmers, clusters one and four hold the smallest percentages of producers in the study, 10% and 19%, respectively. These clusters form two extremes across the sample in terms of representation of technological capacity, low to high, and together account for 76% of the Moamba and Boane sub-sample (Figure 1); farmers in Moamba and Boane dominantly reside in one of these clusters, while those in *zonas verdes* reside primarily in the middle two clusters.

Table 1. Indicators Included in the Typology Creation

		Together		*Zonas Verdes*		Moamba/ Boane	
	Indicators of Experience, Training and Agricultural Information	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
1	A family member received information from an extension agent concerning horticulture	28%	0.55	29%	0.46	25%	0.42
2	A family member received information about horticultural prices	20%	0.49	20%	0.41	21%	0.41
3	A family member received credit for horticulture in the last 12 months. Top sources: Bank (33%), Relatives (17%), Government (14%), Association (14%)	7%	0.31	7%	0.26	11%	0.31
4	A family member participated in a training of at least three months in duration	9%	0.35	9%	0.29	11%	0.31
5	Percent of literate adults in the family	70%	0.27	71%	0.22	57%	0.29
6	Years of experience cultivating horticulture of the family member with the most experience in horticulture > 23 (median)	48%	0.62	50%	0.51	37%	0.49
7	The number of years of education of the most educated adult in the family > 9 (median)	48%	0.61	49%	0.51	32%	0.46
	Diversification of Production and Sales						
8	Total number of horticultural crops produced > 3	67%	0.57	68%	0.48	63%	0.49
9	Total number of horticultural crops produced > 5	28%	0.55	28%	0.45	33%	0.48
10	The family sold tomato	11%	0.33	7%	0.26	37%	0.47
11	The family sold tomato in both seasons of the year	4%	0.21	3%	0.17	13%	0.34
12	Total number of horticultural crops sold > 2	72%	0.54	73%	0.45	56%	0.49
13	Total number of horticultural crops sold > 4	28%	0.55	28%	0.45	29%	0.45

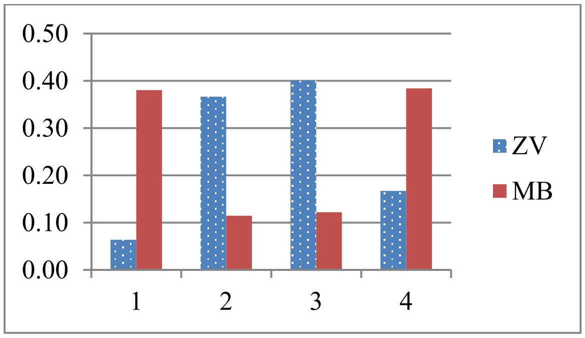
Note: Total Number of Observations = 616 (total); 344 in the *zonas verdes* and 272 in Moamba/Boane

Table 1. Indicators Included in the Typology Creation (cont.)

		Together		*Zonas Verdes*		Moamba/ Boane	
	Input Expenditures and Farm Management Practices	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
14	Index of seed purchase source formality (0 informal, 1 formal)	0.35	0.49	0.31	0.40	0.65	0.42
15	Percent of seed varieties used for which the producer could give the name	18%	0.17	18%	0.14	16%	0.17
16	Pump irrigation was used in at least one horticultural field	7%	0.16	1%	0.09	58%	0.42
17	Value of fertilizer used > 500 MZN (median)	50%	0.61	55%	0.51	10%	0.29
18	Valor of pesticide used > 1,000 MZN (median)	52%	0.61	53%	0.51	45%	0.47
19	Valor of seed used > 2,500 MZN (median)	49%	0.07	49%	0.51	45%	0.47
20	Employed part-time hired labor	90%	0.38	90%	0.32	95%	0.22
21	Employed full-time hired labor	20%	0.49	20%	0.41	24%	0.43
	Post-harvest activities and Crop Loss						
22	Selected the product before sale	7%	0.31	6%	0.25	12%	0.33
23	Washed the product before sale	9%	0.34	9%	0.29	7%	0.25
24	Used a personal car to transport produce to sell in a market	1%	0.11	1%	0.09	4%	0.19
25	Sold all the produce that was brought to the market (applicable in the case of tomato, cabbage, lettuce or kale)	15%	0.43	14%	0.36	21%	0.41
	Pesticide Management and Toxicity Awareness						
26	Percent of total pesticides for which respondent gave a verified correct assessment of true EPA **human** toxicity level	44%	0.40	46%	0.33	28%	0.32
27	Percent of total pesticides for which respondent gave a verified correct assessment of true EPA **bird** toxicity level	38%	0.43	40%	0.36	25%	0.30
28	Percent of total pesticides for which respondent gave a verified correct assessment of true EPA **fish** toxicity level	21%	0.35	21%	0.29	23%	0.31
29	Percent of total pesticides for which respondent gave a verified correct assessment of true EPA **bee** toxicity level	12%	0.29	12%	0.24	13%	0.23
30	The person who applied the pesticide(s) could read the label	53%	0.61	54%	0.51	46%	0.49
31	The person who applied the pesticide(s) used protective clothing beyond just boots (plastic overalls, mask/glasses, gloves, other)	48%	0.62	50%	0.51	36%	0.48
32	Pesticides were applied in the early morning or after sunset	56%	0.61	58%	0.50	39%	0.48

Note: Total Number of Observations = 616 (total); 344 in the *zonas verdes* and 272 in Moamba/Boane

Figure 1. Percent of producers in each typology group by survey location



ZV - *Zonas verdes*; M/B - Moamba/Boane

The rest of this chapter is organized as follows: First we broadly characterize each of the four groups. Then we focus on clusters two and three and the factors that distinguish them from clusters one and four. Note that clusters two and three hold 77% of all producers in *zonas verdes* (Figure 1) and 71% of all producers across the entire survey area.

A summary characterization of the four groups in Table 2 is as follows:

Cluster One - Low levels of land endowment, access to extension or training advice, and horticultural crop sales diversity

Cluster Two - Moderate levels of land endowment, access to extension or training advice, and horticultural crop sales diversity

Cluster Three - High levels of land endowment, high education/literacy, and moderate horticultural crop sales diversity

Cluster Four - High levels of land endowment, access to extension or training advice, horticultural crop sales diversity and mechanized irrigation use

In the first six categories in table 2, mean values progress steadily from low to high across the clusters, beginning with cluster one. The only exception is use of mechanized irrigation, which is practiced by a greater percentage of farmers in Moamba and Boane in cluster one than in cluster two.
In all clusters, kale and lettuce are the most frequently grown crops, but their dominance falls steadily across the clusters; these two crops account for 64% of all crops grown during the cool season in cluster one, but only 28% in cluster four. Several other crops are commonly produced by farmers in cluster four, including tomatoes (11%), beets (9%) and onion (9%) (Table 2).

Though not shown in the table, patterns of diversification into non-horticultural crops are opposite in the two regions. Generally, farmers in Moamba and Boane grow fewer non-horticultural crops as one moves across the clusters (i.e., cluster four is more specialized in horticulture than is cluster one), whereas producers in the *zonas verdes* tend to diversify more into non-horticultural crops as one moves across the technology capacity groupings.

The last five categories in table 2 (#7 to #11) do not show a steady progression in values across clusters, but do highlight differences between clusters two and three, and how these differ from clusters one and four, in the following ways:

Table 2. Typology

	Cluster One: Low levels of land endowment, access to extension or training advice, and horticultural crop sales diversity	**Cluster Two:** Moderate levels of land endowment, access to extension or training advice, and horticultural crop sales diversity	**Cluster Three:** High levels of land endowment, high education/literacy, and moderate horticultural crop sales diversity	**Cluster Four:** High levels of land endowment, access to extension or training advice, horticultural crop sales diversity and mechanized irrigation use
	10% of producers total: - 6% of all the ZV producers - 38% of all the M/B producers	34% of producers total: - 37% of all the ZV producers - 11% of all the M/B producers	37% of producers total: - 40% of all the ZV producers - 12% of all the M/B producers	19% of producers total: - 17% of all the ZV producers - 38% of all the M/B producers
	These farmers are characterized by:			
1	**Least area cultivated with horticulture in the cool season** - Median of 0.04 ha in ZV - Median of 0.17 ha in M/B	**Moderate area cultivated with horticulture in cool season** - Median of 0.05 ha in the ZV - Median of 0.50 ha in M/B	**Most area cultivated with horticulture in cool season** - Median of 0.11 ha in ZV - Median of 1.00 ha in M/B	**Most area cultivated with horticulture in cool season** - Median of 0.12 ha in ZV - Median of 1.00 ha in M/B
2	**Least counsel and training received** - 12% of households have at least one member who received horticultural extension advice in ZV, 6% in M/B. - 0% receive a training of over 3 months in agriculture in ZV, 3% in M/B	**Moderate counsel and training received** - 29% of households have at least one member who received horticultural extension advice in ZV, 13% in M/B. - 8% receive a training of over 3 months in agriculture in ZV, 3% in M/B	**Moderate counsel and training received** - 30% of households have at least one member who received horticultural extension advice in ZV, 32% in M/B. - 12% receive a training of over 3 months in agriculture in ZV, 10% in M/B	**Most counsel and training received** - 58% of households have at least one member who received horticultural extension advice in ZV, 45% in M/B - 15% receive a training of over 3 months in agriculture in ZV, 21% in M/B
3	**Least informed concerning hort prices** - 14% have received hort price information in the last 12 months in ZV, 13% in M/B	**Moderately informed concerning hort prices** - 18% have received hort price information in the last 12 months in ZV, 13% in M/B	**Moderately informed concerning hort prices** - 19% have received hort price information in the last 12 months in ZV, 17% in M/B	**Most informed concerning hort prices** - 46% have received hort price information in the last 12 months in ZV, 34% in M/B
4	**Least diversity of hort crop production** - Frequency share of all crops produced in the cluster: Kale (33%), Lettuce (31%), Pumpkin Leaves (7%) in cool season.*	**Moderate diversity of hort crop production** - Frequency share of all crops produced in the cluster: Kale (24%), Lettuce (22%), Onion (12%), Pumpkin Leaves (11%), Beets (10%) in cool season	**Moderate diversity of hort crop production** - Frequency share of all crops produced in the cluster: Kale (25%), Lettuce (23%), Pumpkin Leaves (10%), Beets (10%), Onion (7%), Cabbage (7%) in cool season	**Greatest diversity of hort crop production** - Frequency share of all crops produced in the cluster: Kale (14%), Lettuce (14%), Tomato (11%), Beets (9%), Onion (9%), Cabbage (7%) in cool season

ZV - *Zonas Verdes*; M/B - Moamba/Boane

Table 2. Typology

	Cluster One: Low levels of land endowment, access to extension or training advice, and horticultural crop sales diversity	**Cluster Two:** Moderate levels of land endowment, access to extension or training advice, and horticultural crop sales diversity	**Cluster Three:** High levels of land endowment, high education/literacy, and moderate horticultural crop sales diversity	**Cluster Four:** High levels of land endowment, access to extension or training advice, horticultural crop sales diversity and mechanized irrigation use
5	**Least number of crops sold** - Range of 0-3, mean 2 and median 2 in ZV. - Range of 0-3, mean 1 and median 0 in M/B	**Moderate numbers of crops sold** - Range of 0-10, mean 4 and median 4 in ZV **-** Range of 0-9, means and medians of 4 in M/B	**Moderate numbers of crops sold** - Range of 0-10, mean 4 and median 4 in ZV **-** Range of 0-6, means and medians of 3 in M/B	**Greatest number of crops sold** - Range of 5-10, mean 7 and median 6 in ZV - Range of 2-13, mean 6 and median 5 in M/B
6	**Moderately likely to use pump irrigation among producers of M/B** - 33% of the producers in M/B use pump irrigation, 0% in ZV	**Moderately likely to use pump irrigation among producers of M/B** - 12% of the producers in M/B use pump irrigation, 1% in ZV	**Moderately likely to use pump irrigation among producers of M/B** - 70% of the producers in M/B use pump irrigation, 0% in ZV	**Most likely to use pump irrigation** - 93% of the producers in M/B use pump irrigation, 7% in ZV
	Characteristics that differentiate farmers in clusters two and three among the four clusters:			
7	**Greatest dependency ratio** - 50% in ZV and 53% in M/B	**Moderate Dependency Ratio** - 46% in ZV and 55% in M/B	**Lowest Dependency Ratio** -38% in ZV and 36% in M/B	**Moderate Dependency Ratio** - 43% in ZV and 44% in M/B
8	**Lowest Adult Literacy Levels** - 60% literate adults in the AF within ZV, and 47% in M/B	**Moderate Adult Literacy** - 67% literate adults in the AF within ZV, and 60% in M/B	**Highest Adult Literacy Levels** - 80% literate adults in the AF within ZV, and 71% in M/B	**High Adult Literacy** - 71% literate adults in the AF within ZV, and 69% in M/B
9	**Poorest pesticide management** **-** 27% of those applying the pesticides can read the label in ZV, 12% in M/B - 29% of those applying the pesticides use protective clothing other than boots in ZV, 12% in M/B ** - 49% apply at the right time of the day in ZV, only 15% in M/B	**Average pesticide management** **-** 44% of those applying the pesticides can read the label in ZV, 51% in M/B - 49% of those applying the pesticides use protective clothing other than boots in ZV, 38% in M/B - 57% apply at the right time of the day in ZV, 51% in M/B	**Outstanding pesticide management** **-** 78% of those applying the pesticides can read the label in ZV, 81% in M/B - 62% of those applying the pesticides use protective clothing other than boots in ZV, 67% in M/B - 62% apply at the right time of the day in ZV, 38% in M/B	**Average to High pesticide management** **-** 49% of those applying the pesticides can read the label in ZV, 69% in M/B - 45% of those applying the pesticides use protective clothing other than boots in ZV, 49% in M/B - 67% apply at the right time of the day in ZV, 62% in M/B
10	**Moderate formality of input purchase channels used** (See table 3)	**Least formal input purchase channels used** (See table 3)	**Most formal pesticide purchase channels used** (See table 3)	**Most formal seed and fertilizer purchase channels used** (See table 3)
11	**Least likely to purchase, and spend the least on inputs** (See tables 4 and 5)	**Moderately likely to purchase, and spend moderate amounts on inputs** (See tables 4 and 5)	**Most likely to purchase, and spend the most on inputs, generally** (See tables 4 and 5)	**Moderately likely to purchase, and spend moderate amounts on inputs** (See tables 4 and 5)

*Frequencies varied little between cool and hot seasons; ** Other items of clothing include plastic overalls, mask or glasses, gloves and other.

a. Producers in group three have the lowest dependency ratios (38% in ZV and 36% in Moamba and Boane) and highest levels of adult literacy (80% in ZV and 71% in Moamba and Boane) across all four groups.

b. Producers in group three perform the best in the pesticide management categories of (a) use of protective clothing when applying pesticide and (b) ability to read pesticide labels across all four groups; and well in (c) the time of day pesticide is applied (Table 2). Higher literacy undoubtedly plays a role in families' perceptions and behavior regarding pesticide application. More information about this trend and farmers' attitudes and management practices concerning pesticides among those in the baseline survey can be found in chapter 4.

c. Producers in group two generally use the least formal input purchase channels across all four groups (Table 3).

Table 3. Index of Input Channel Formality by Cluster

	Index of Input Channel Formality					
	Pesticide		Seed		Fertilizer	
	Zonas Verdes	Moamba/Boane	*Zonas Verdes*	Moamba/Boane	*Zonas Verdes*	Moamba/Boane
Cluster One	0.40	0.94	0.27	*0.46*	0.62	**0.92**
Cluster Two	*0.35*	*0.86*	*0.15*	0.53	*0.53*	*0.87*
Cluster Three	**0.64**	**0.99**	0.46	0.84	0.58	0.89
Cluster Four	0.61	0.90	**0.50**	**0.86**	**0.64**	**0.92**

Note: Values in italics and a yellow cell color highlight the lowest values in each column, values in bold and pink cell color highlight the highest values in each column.

d. Producers in group three are generally the most likely to purchase inputs and spend the greatest amounts on these across all four groups (Tables 4 and 5). Only 73% of producers of Moamba and Boane in cluster one purchased seed for their harvest. Generally, the producers who did not purchase their seed indicated that they used saved seed from their last or other previous seasons (37%). Others use seeds that were offered to them by another family (12%), relatives (7%) or even by their association (12%).

These last two characteristics concerning input channels are driven by the dominance of producers from the *zonas verdes* in clusters two and three. More information concerning the differences between farmers in these two zones in regards to their respective input purchase channel formality, frequency, location and value can be found in chapter 2.

Table 4. Percent of Farmers Purchasing Inputs by Cluster

	Percent of Farmers Purchasing Inputs					
	Pesticides		Seed		Fertilizer	
	Zonas Verdes	Moamba/Boane	*Zonas Verdes*	Moamba/Boane	*Zonas Verdes*	Moamba/Boane
Cluster One	*88%*	*29%*	*91%*	*73%*	*89%*	*36%*
Cluster Two	90%	45%	**100%**	90%	94%	41%
Cluster Three	**100%**	**100%**	99%	**100%**	**99%**	**94%**
Cluster Four	96%	95%	**100%**	**100%**	91%	92%

Table 5. Median Input Purchase Value Spent (MZN) by Cluster

	Median Input Purchase Value Spent (MZN)					
	Pesticide		Seed		Fertilizer	
	Zonas Verdes	Moamba/Boane	*Zonas Verdes*	Moamba/Boan	*Zonas Verdes*	Moamba/Boan
Cluster One	*500*	*0*	*670*	*225*	*270*	*0*
Cluster Two	540	*0*	1,060	550	400	*0*
Cluster Three	**2,860**	**4,050**	7,670	**11,100**	**1,410**	**105**
Cluster Four	1,351	3,500	**9,485**	8,800	330	90

Finally, it can be observed from table 2 that producers in Moamba and Boane consistently have more average area cultivated with horticulture in the cool season, are more likely to receive agricultural training of at least three months in duration, are more likely to use mechanized irrigation and are more likely to purchase their inputs from a formal channel than producers in the *zonas verdes*, across all four groups.

Producers in the *zonas verdes*, on the other hand, consistently are more likely to receive advice from an extension agent, to receive horticultural price information in the last year, to apply pesticide at the proper time of day, to sell a greater number of horticultural crops, and to have a greater percentage of literate adults in the family than producers in Moamba and Boane, regardless of the cluster ranking into which these producers were grouped.

5. Conclusions

In this study, we use cluster analysis with data on farmer training or counsel received, number of crops sold and practices concerning pesticide use, to classify farmers into four groups. Findings are as follows. First, land endowment, access to extension or training advice, and crop sales diversification progress from low to high levels across the clusters, from one to four. Producers with the least crop diversity, least technified production practices, and lowest knowledge capacity are found in cluster one while those with the highest levels of each of these indicators tend to be found in cluster four.

Second, level of technological capacity does not correspond with specific geographic regions of this study, as the producers of Moamba and Boane most commonly appear among the least technified farmers (primarily the dispersed producers in these areas), but also represent a large share of the most technified producers (generally those with shared central irrigation systems). Producers in the *zonas verdes* tend to be more uniform in the level of technology they apply, making up most of the two middle clusters (two and three).

Third, the sharpest distinctions across all factors are between clusters one and two, on the one hand, and clusters three and four, on the other. Because very few farmers in Moamba/Boane lie in clusters two and three, while very few households in *zonas verdes* lie in clusters one and four, the most pragmatic approach to designing an extension outreach program may be the following.

- In Moamba/Boane, distinguish between households in cluster one and those in cluster four; group the limited number of cluster two households of this zone with cluster one, and group cluster three households with cluster four.

- In the *zonas verdes*, distinguish between cluster two households and cluster three households (most differences between these groups are sharp in this region), again including the small number of cluster one households with cluster two, and cluster four households with cluster three. Methods for making these distinctions in the field (properly assigning all households to clusters, not just those that were surveyed in the baseline) can be developed in consultation with IIAM, MSU and EMBRAPA technical personnel, likely based on a simple questionnaire that would take little time to administer.

6. References

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CHAPTER 4

Risk Perception and Behavior in Pesticide Use by the Horticultural Producers of Maputo

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This chapter examines the perceptions of horticultural farmers in the province of Maputo with regard to pesticides, as well as the behavior that these producers exhibit concerning use of these chemicals. The analyses are based on data from a baseline survey conducted within the trilateral project (Mozambique, Brazil and the United States) also known as the horticultural food security project (PSAL). The survey took place from May to June of 2013 in the green belt of Maputo, and in the nearby districts of Boane and Moamba. The results of this study indicate that the most-used pesticide among farmers in these areas - Methamidophos - is classified as highly toxic by both the Environmental Protection Agency of the United States (EPA) and the World Health Organization (WHO). Producers in these areas generally hold the perception that almost all pesticides are highly toxic (even those that are less toxic according to the EPA and WHO), yet do not take proper precautions of pesticide handling or use.

1. Introduction

The use of pesticides is quite high among the horticultural farmers in Mozambique producing for market, however generally speaking pesticide use across Mozambique as a whole is very low. Results from the TIA agricultural survey show that only about 6% of producers used pesticides in the 2011/2012 season and these were primarily producers of tobacco and cotton, where contract farming is prevalent. Although the TIA is nationally representative, it does not capture well information concerning crops that are locally produced, such as vegetables, which are largely produced along river banks or in centralized irrigation units and with extensive use of pesticides.

Using data from the horticultural survey performed under the trilateral project, which covers the green belt of Maputo city (Ka Mubucuana, Ka Mavota, and Matola) and the districts of Moamba and Boane, this study analyzes risk perception and behavior in pesticide use by the horticultural producers of Maputo. Another study by Cairns et al, (2013) explores channels of input purchases from horticultural producers in terms of their formality, frequency, location and value, and provides a lot of information on pesticides which can additionally serve as a reference for those interested to know more about the pesticide value chain or of that of other inputs.

2. Production Areas and Sample

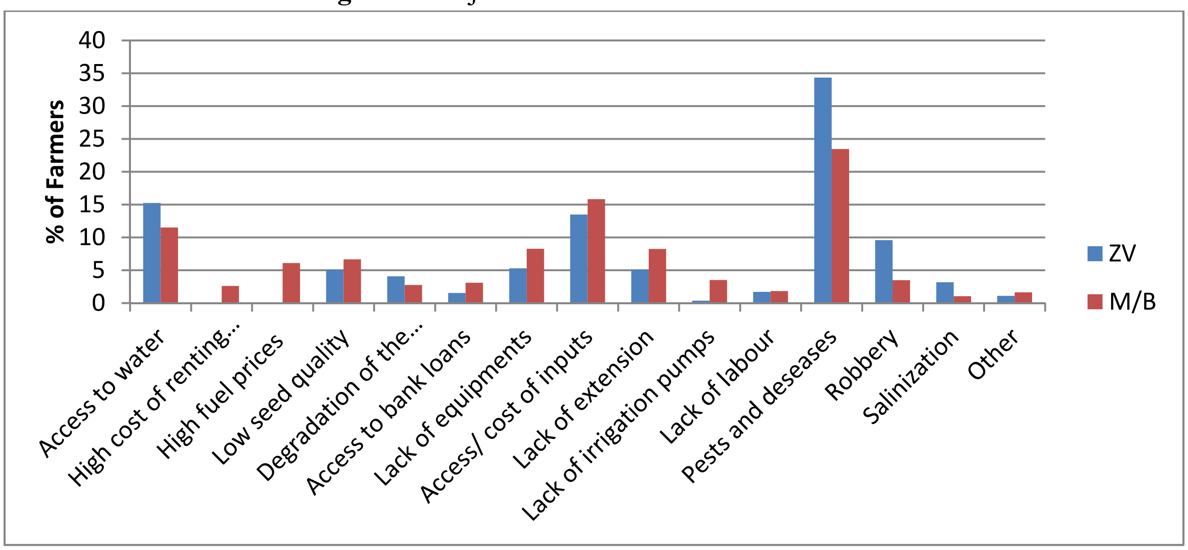
The horticultural production areas of the districts of Matola, Ka Mubucuana, and Ka Mavota are normally referred to as the the *zonas verdes* of Maputo. Production in this area often takes place within or near the administrative boundaries of the municipality and is dominated by very small farmers (typical land holding of 0.1 ha), producing primarily green leafy vegetables under individual irrigation. The districts of Moamba and Boane, in contrast, are primarily characterized by centralized irrigation areas (*blocos*) and farmers with larger land areas producing tomato, onion, cabbage, and other horticultural crops. A less numerous group of farmers in these districts operates with individual irrigation along the rivers, outside the *blocos*. We refer to these as the dispersed producers of those districts. Land holdings among both these types of farmers average 2.3 ha.

Because of the distinctly different production systems in each zone, the sample was stratified to individually represent all producers with less than 5 hectares of cultivated land with horticultural crops in each zone, with sample sizes of 344 for *zonas verdes* (ZV) and 272 for Moamba and Boane (M/B). We report all results in this way. The dispersed producers of Moamba and Boane most commonly appear among the least technified farmers in those districts.

3. Key Issues and Methods of Pest and Disease Control

Across all the locations of the study, pests and disease are cited as the most serious problem for horticultural production compared to other problems such as high costs of inputs, lack of water or theft (Figure 1).

Figure 1. Major Problems in Horticultural Production



ZV - Zonas Verdes; M/B - Moamba/Boane

Table 1. Use of different pest control methods

Method	% of producers who used	
	Zonas Verdes	Moamba/Boane
Physical Control	3%	1%
Cultural Control	6%	4%
Tree Leaf Extract	2%	0%
Chili Extract	3%	1%
Garlic Extract	3%	1%
Other	1%	0%
Chemical Pesticides	98%	77%
Tolerant Varieties	4%	2%

Physical control, cultural control, plant or tree leaf extract and use of pest and disease- tolerant varieties are alternative methods of controlling pests and diseases which have reduced adverse environmental effects and are being explored by the producers in the *zonas verdes* and Moamba/Boane. However, the use of chemical pesticides is the most common method used by farmers in these areas, most likely due to its speed and efficacy in controlling pests and disease (Table 1).

4. Pesticide Toxicity According to the Envionmental Protection Agency and the World Health Organization

In the *zonas verdes* as well as in Moamba and Boane, the five chemicals that were most widely used by producers in the past 12 months, in order, were Methamidophos, Mancozeb, Cypermethrin, Abamectin and Acetamiprid (Table 2). According to the classification of the Environmental Protection Agency of the USA (EPA), these range from highly toxic (Methamidophos) to slightly toxic (Mancozeb, Abamectin and Acetamiprid). Of the names of pesticides collected in the survey, it was possible to assign a toxicity rating to 95.1% and 95.2% of the given chemicals listed, using the classification systems of the EPA and the World Health Organization of the United Nations (WHO), respectively. Results reveal that most of the pesticides used in these areas are highly toxic (47% of the pesticides used, according to the EPA and 56%, according to the WHO). However, these results also show that a good portion of pesticides are considered to have low toxicity (31% according to the EPA and 20% according to the WHO) (Tables 3 and 4).

Table 2. Most-used pesticides among producers of Moamba, Boane and the *zonas verdes* of Maputo

Pesticide	% of producers that used		Corresponding pesticide toxicity class	
	ZV	M/B	EPA	WHO
Methamidophos	87.0%	56.5%	1 – Highly toxic	Ib – Highly hazardous
Mancozeb	38.8%	49.6%	4 -- Slightly toxic	U – Unlikely to present hazard
Cypermethrin	33.5%	42.9%	3 – Somewhat toxic	II – Moderately hazardous
Abamectin	19.8%	12.5%	4 – Low toxicity	Ib – Highly hazardous
Acetamiprid	7.9%	0.3%	4 – Low toxicity	Not clearly defined

ZV - Zonas Verdes; M/B - Moamba/Boane

Table 3. Pesticides classified by the Environmental Protection Agency classification

Item	
Class 1-- Highly toxic	47.2%
Class 2-- Moderately toxic	1.8%
Class 3 – Slightly toxic	18.2%
Class 4 – Practically nontoxic	31.0%
Total	100%

Table 4. Pesticides classified by the World Health Organization classification

Item	
Ia – Extremely hazardous	0.1%
Ib – Highly hazardous	55.5%
II – Moderately hazardous	24.2%
III – Slightly hazardous	0.3%
U – Unlikely to present hazard	19.9%
Total	100%

5. Producer Perceptions Regarding the Use of Pesticides

Producers of horticultural crops commonly have the perception that all pesticides are highly toxic to humans. Eighty-seven percent of the pesticides ranked as highly toxic by the EPA were correctly classified as highly toxic. However, 84% of pesticides classified as moderately toxic, 85% of the pesticides ranked as slightly toxic and 76% of those ranked as having low levels of toxicity by EPA, were incorrectly classified by producers as being highly toxic (Table 5).

Table 5. Producers' perception concerning pesticide toxicity to humans vs. true pesticide toxicity according to the EPA

Producer perceptions concerning pesticide toxicity for humans	EPA Pesticide Toxicity Classification				
	Class 1 (highly toxic)	Class 2 (moderately toxic)	Class 3 (slightly toxic)	Class 4 (low toxicity)	Total
	-------------------- Percent of Producers --------------------				
Yes, highly toxic	87%	84%	85%	76%	83%
Yes, moderately toxic	10%	8%	12%	13%	11%
Not toxic	1%	0%	2%	1%	93%
Do not know	3%	8%	2%	10%	5%

Despite the fact that producers consider most of the pesticides they use as highly toxic, a large percentage of them wash their pesticide spraying equipment in the water channels of the farm (27% in the *zonas verdes* and 16% in Moamba and Boane), and/or throw away their used pesticide bottles on the ground in the farming areas (60% in the *zonas verdes* and 35% in Moamba and Boane) (Tables 6 and 7). Such practices are inadvisable as they can contribute to the contamination of irrigation water and cause harm to the other living creatures in the ecosystem.

Table 6. Location where producers wash pesticide application equipment after use

Washing Location	*Zonas Verdes*	Moamba/Boane
In the river	2%	8%
In the water channel of the farm	27%	16%
In the farm	67%	69%
At home	1%	1%
Another place	1%	4%
Do not wash	3%	2%
Do not know	1%	1%
Total	100%	100%

Table 7. What producers do with used pesticide packaging

What Producers Do	*Zonas Verdes*	Moamba/Boane
Leave on the ground in the farming areas	60%	35%
Throw out in the backyard	1%	0%
Throw out in another place	2%	3%
Burn	18%	26%
Bury	19%	14%
Reuse for another purpose	2%	0%

6. Precautions Taken by Producers in Pesticide Storage, Preparation and Application

Seventy-nine percent of producers of the *zonas verdes* and 54% of producers in Moamba/Boane reported that they store their pesticides in the field. Some of the producers, however, keep pesticides in a room of their home (3% of producers of the *zonas verdes*) or in a pantry (1% in the *zonas verdes*, and 3% in Moamba/Boane). A low percentage of producers store their pesticides in a special warehouse (4% in the *zonas verdes* and 9% in Moamba/Boane) (Table 8).

Table 8. Location of pesticide storage

Item	*Zonas Verdes*	Moamba/Boane
In the field	79%	54%
In their room	3%	0%
In a pantry	1%	3%
In the garage	1%	0%
In another part of the house	6%	7%
In a special warehouse	4%	9%
In the yard of the house	4%	1%
In another place outside of the house	2%	1%
Not applicable	2%	2%

Table 9. Relationship to AF of persons who prepare and apply the pesticides used

Item	Who prepares the pesticides?		Who applies the pesticides?	
	Zonas Verdes	Moamba/Boane	*Zonas Verdes*	Moamba/Boane
Someone from the family	89%	78%	88%	71%
Permanent labor	6%	11%	7%	17%
Temporary labor	2%	4%	2%	6%
Contracted labor	2%	2%	2%	2%
Other	1%	4%	1%	3%
Total	100%	100%	100%	100%

Both pesticide preparation and application is primarily performed by family members (> 70% of the interviewed families in the two zones) (Table 9), often being the head of household (60% of green areas and 77% in Moamba and Boane) or his spouse (31% in the *zonas verdes* and 17% in Moamba and Boane) (Table 10). Among the children involved, there is often a greater involvement in the process of pesticide application than pesticide preparation. In the *zonas verdes,* 1.5% of the family members preparing pesticides are between the ages of 13 and 16, while 1.8% and 1.4% of family members applying pesticides within the *zonas verdes* and Moamba/Boane, respectively, are between the ages of 12 and 16.

Both in the *zonas verdes* and in Moamba and Boane, there is generally low use of protective clothing during application of pesticides: all producers reported having used less than two items of protective clothing, consisting of boots, gloves, overalls or a mask. Specifically, those who wear protective clothing primarily wear boots (53% of those in the *zonas verdes* and 73% in Moamba and Boane) and/or masks (36% of those in the *zonas verdes* and 33% of those in Moamba and Boane) (Table 11). Surprisingly, boots are used more often than masks. Whereas masks can protect against the inhalation of pesticides, the most common form of ill-exposure, boots provide skin protection, and only work most effectively when additionally accompanied by the use of appropriate pants.

Table 10. Family members who prepare and apply the pesticides used

Relationship to the Household Head	Who prepares the pesticides?		Who applies the pesticides?	
	Zonas Verdes	Moamba/Boane	*Zonas Verdes*	Moamba/Boane
Himself	59.6%	78.8%	59.8%	76.6%
Wife	31.8%	17.7%	31.2%	16.8%
Child	4.7%	3.4%	4.3%	4.4%
Sibling	0.4%	0.0%	0.8%	0.7%
Parent	0.4%	0.0%	0.8%	0.0%
Nephew/Niece	0.3%	0.7%	0.3%	0.7%
Grandchild	1.1%	0.0%	1.1%	0.7%
Another relative	1.5%	0.0%	1.5%	0.0%
Not related	0.3%	0.0%	0.0%	0.0%

Table 11. Use of protective clothing

Protective Clothing	Percent of producers	
	Zonas Verdes	Moamba/Boane
Overalls	7%	16%
Mask	36%	33%
Boots	53%	73%
Gloves	18%	25%
Other protective clothing	19%	11%

There are differences between producers in terms of pesticide handling care. Producers located in the highest quintiles of cultivated horticultural area[6] among all the producers in the study take greater precautions when handling pesticides. The number of protective items of clothing worn by the person applying pesticide, the percentage of producers who can read the package labels and the percentage of farmers applying pesticides at the right time of day increase from the producers located in the lower quintiles of horticultural cultivated area to the third quintile of horticultural cultivated area. Surprisingly, this percentage lowers in the fourth quintile and increases again in the quintile of largest area (Table 12).

Table 12. Producer behavior with regard to pesticides by quintile of land area

Quintiles of area cultivated with horticulture in the cool season		Average area cultivated with horticulture in the cool season		Average number of protective clothing items used during pesticide application		Percent of persons that prepare pesticides who can read the label or ask for help to do so		Percent of AFs that applied pesticides at the correct hour of the day	
		ZV	M/B	ZV	M/B	ZV	M/B	ZV	M/B
Least Area	1	0.01	0.01	0.92	0.60	59%	32%	54%	17%
	2	0.04	0.17	1.04	0.85	69%	36%	59%	29%
	3	0.07	0.61	1.27	1.01	74%	65%	62%	51%
	4	0.12	1.36	1.13	1.49	79%	77%	57%	46%
Most Area	5	0.75	4.79	1.33	1.64	86%	84%	59%	52%

ZV - Zonas Verdes; M/B - Moamba/Boane

[6] Area measurement is calculated for the cool season

Compared to Moamba and Boane, the *zonas verdes* have the highest percentage of producers who can read the pesticide labels or ask for help from someone who can. This zone also has the highest percentage of producers who apply pesticides at the most optimal time of day – at sunrise or sunset, when the sun is not so strong (Table 13). The fact that the producers in the *zonas verdes* generally have a higher educational level and apply pesticides more intensively throughout the year could be contributing factors to their better understanding of pesticide management norms.

Table 13. Producer behavior with regard to pesticides by typology classes of technological capacity[7]

	Average number of protective clothing items used during pesticide application		Percent of persons that prepare pesticides who can read the label or ask for help to do so		Percent of AFs that applied pesticides at the correct hour of the day	
	ZV	M/B	ZV	M/B	ZV	M/B
Cluster One	.29	.12	.27	.12	.49	.15
Cluster Two	.49	.38	.44	.51	.57	.51
Cluster Three	.62	.67	.78	.81	.62	.38
Cluster Four	.45	.49	.49	.69	.67	.62

ZV - Zonas Verdes; M/B - Moamba/Boane

7. Pesticides and Their Relationship to the Crops on which they are used

On average, each producer uses 2.2 pesticides in the *zonas verdes* and 2.8 pesticides in Moamba and Boane. With increasing quintiles of horticultural cultivated area, an increasing number of pesticides are used (Table 14). And the same occurs across the typology cluster: generally, the producers in cluster four use the greatest number of different pesticides (Table 15).

Table 14. Number of pesticides used by quintile of area cultivated in the cool season

Quintiles of area cultivated with horticulture in the cool season	*Zonas Verdes*	Moamba /Boane
Least area - 1	1.9	1.6
2	2.0	1.3
3	2.1	1.2
4	2.5	1.8
Most area - 5	3.0	2.8

Table 15. Number of pesticides used by typology classes of technological capacity

Typology Cluster	*Zonas Verdes*	Moamba/ Boane
Cluster One	1.7	1.3
Cluster Two	1.8	1.5
Cluster Three	2.9	3.4
Cluster Four	2.7	3.5

Methamidophos, Mancozeb, Cypermethrin, Acetamiprid and Abamectin are the five most commonly used pesticides during production on the crops of cabbage, lettuce, pumpkin leaves, onions, beets, cabbage and tomato, both in the *zonas verdes* as in Moamba and Boane (Tables 16a, 16b, and 16c). Methamidophos is classified as highly toxic by the EPA, and holds the largest share of pesticides used for each of the aforementioned crops in both zones of the study. This means that Methamidophos is the most commonly used chemical of all the pesticides used among these crops. In the *zonas verdes*, its share ranges between 44% and 56% of the total pesticide varieties used, with onion and beets being the crops

[7] This typology classification groups producers into four categories, or clusters, by their technological capacities. The generation of the typology indicator is discussed in further detail in chapter 3 of this report, or *Flash* 70E.

on which the most Metheamidophos was, comparatively, applied. In Moamba and Boane, Methamidophos accounted for between 22% to 36% of all pesticides used, with lettuce, cabbage and tomato being the crops with the highest shares.

Table 16a. Shares of pesticides used for selected crops by producers in Moamba, Boane and the *zonas verdes* of Maputo

Chemical Name	Kale	Lettuce	Pumpkin Leaves	Onion	Beets	Cabbage	Tomato
	Share of each pesticide used by crop						
Methamidophos	47.9%	46.4%	47.5%	49.7%	51.9%	41.8%	38.1%
Mancozeb	14.5%	19.4%	19.2%	13.6%	17.3%	12.5%	22.5%
Cypermethrin	14.4%	14.5%	17.1%	15.9%	7.7%	15.2%	14.8%
Acetamiprid	-	-	-	6.9%	8.4%	3.3%	6.4%
Abamectin	9.1%	9.1%	5.6%	3.9%	6.8%	13.6%	5.7%

Table 16b. Shares of pesticides used for selected crops by producers in the *zonas verdes* of Maputo

Chemical Name	Kale	Lettuce	Pumpkin Leaves	Onion	Beets	Cabbage	Tomato
	Share of each pesticide used by crop						
Methamidophos	48.6%	46.8%	47.7%	53.1%	52.4%	44.2%	44.3%
Mancozeb	14.1%	19.3%	19.2%	12.0%	17.2%	10.7%	23.1%
Cypermethrin	14.2%	13.9%	17.2%	14.5%	7.4%	13.7%	10.9%
Acetamiprid	-	-	-	7.9%	8.5%	3.7%	10.5%
Abamectin	9.4%	8.5%	5.6%	3.9%	7.0%	14.5%	5.6%

Table 16c. Shares of pesticides used for selected crops by producers in Moamba and Boane

Chemical Name	Kale	Lettuce	Pumpkin Leaves	Onion	Beets	Cabbage	Tomato
	Share of each pesticide used by crop						
Methamidophos	35.2%	36.2%	-	26.6%	22.9%	29.3%	30.6%
Mancozeb	22.9%	21.4%	-	24.7%	23.0%	22.2%	21.8%
Cypermethrin	20.4%	22.4%	-	25.5%	22.6%	23.2%	19.4%
Acetamiprid	2.8%	-	-	4.2%	-	-	-
Abamectin	-	3.0%	-	-	-	8.9%	5.7%

Cypermethrin is used more commonly than Mancozeb on onion and cabbage crops, in contrast to cabbage, lettuce, pumpkin leaves, beets and tomato, where Mancozeb is applied more frequently than Cypermethrin. Acetamiprid is among the five most used pesticides for onion, beets and tomato, but not for kale, lettuce, pumpkin leaves and cabbage. Among the former, Acetamiprid is listed as used by producers more than Abamectin. Of the selected crops, Abamectin played the largest role in the production of cabbage.

8. Technical Assistance by Extension Agents in Pesticide Storage, Management and Application Practices

More producers in the *zonas verdes* received extension advice regarding pesticide storage, management or application, generally, compared to producers in Moamba or Boane. There is no direct relationship between extension assistance and increased horticultural cultivated area (Table 17). But when we analyze the relationship between technical assistance and level of technological capacity, we verify that the least technologically advanced producers (those in cluster one) receive less technological assistance compared to the more technologically advanced producers (Table 18).

Table 17. Percent of producers that received extension advice* concerning storage, management and application of pesticides, by quintile of cultivated horticultural area in the cool season

Area Quintiles	Storage		Management		Application	
	ZV	M/B	ZV	M/B	ZV	M/B
Least area - 1	12%	6%	13%	6%	15%	8%
2	18%	10%	19%	10%	23%	10%
3	28%	0%	29%	0%	32%	0%
4	21%	9%	20%	9%	22%	9%
Most area - 5	23%	20%	23%	21%	32%	23%

ZV - Zonas Verdes; M/B - Moamba/Boane. *Note that extension advice here refers to advice not just from extension workers, but from anyone the producer said they received any advice from, neighbors, informal sales-persons of inputs, etc.

Table 18. Percent of producers that received extension advice concerning storage, management and application of pesticides, by typology classes of technological capacity

Typology Cluster	Storage		Management		Application	
	ZV	M/B	ZV	M/B	ZV	M/B
Cluster One	5%	3%	5%	3%	7%	3%
Cluster Two	17%	7%	20%	7%	24%	7%
Cluster Three	27%	26%	26%	26%	28%	32%
Cluster Four	43%	30%	39%	32%	49%	34%

ZV - Zonas verdes; M/B - Moamba/Boane

The percentage of producers in the *zonas verdes* that received technological assistance in pesticide application is also slightly and consistently higher than the percentage that received technical assistance on pesticide storage or management (Table 18).

9. Conclusions

This chapter uses data from the Trilateral horticultural survey which took place from May to June of 2013 in the greenbelt of Maputo (Ka Mubucuana, Ka Mavota and Matola) and the districts of Moamba and Boane in Maputo province, to analyze the perceptions of producers in relation to pesticides, as well as the behavior that these producers have in relation to these chemicals.

Results of this study indicate that although there are other circulated methods for pest and disease control which are less harmful to the environment and human health, chemical pesticides are the most common method used, likely due to its rapid action and efficacy.

In the *zonas verdes*, as in Moamba and Boane, the most used pesticides are Methamidophos, Mancozeb, Cypermethrin, Acethameprid and Abamectin. These have toxicity levels, according to the EPA, which vary between highly toxic (Methamidophos) and low toxicity (Mancozeb, Acetamiprid, and Abamectin)

Although producers have the perception that almost all pesticides are highly toxic, most of them wash their equipment in the farm irrigation canals, leave the used pesticide receptacles splayed on the ground in the farm areas, and often use boots as their only protective clothing while spraying.

Results of this study also reveal that most of the producers in both the *zonas verdes* as well as Moamba and Boane store their pesticides in hidden places on the farm. A low percentage of producers keep pesticides in a room or in a pantry where food is stored.

Despite there being (a) low use of protective clothing, (b) a considerable percentage of producers who cannot read package labeling nor ask for help to do so, and (c) a considerable percentage of farmers who apply pesticides at inappropriate times, there are differences between producers by quintiles of horticultural cultivated area. The larger the area, (1) the greater the number of protective clothing items that are used while spraying, (2) the greater the percentage of producers who know how to read the labels, and (3) the greater the percentage of farmers applying pesticides at the correct time of day.

When comparing the *zonas verdes* with Moamba and Boane, it appears that in the *zonas verdes* there is a higher percentage of farmers applying pesticides at the correct times of day and a higher percentage of producers who can read the package labels or ask for help to do so.

Generally, the least technologically advanced producers (those belonging to cluster one) received less extension assistance in aspects related to storage, handling and application of pesticides than the more technologically advanced producers.

It would have been interesting to include questions concerning a) producer perceptions concerning the proper pre-harvest waiting interval after pesticide application and b) the use of pesticides which have not been registered in Mozambique. However, this was not possible to include these analyses in this volume.

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CHAPTER 5

Pesticide use in Sub-Saharan Africa: A Case Study of Horticultural Farmers in Zambia and Mozambique

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The purpose of this chapter is to present new evidence, including pesticide purchase rates and respective toxicity levels from horticultural farmers in Zambia and Mozambique, and frame this evidence in the context of urbanization, income growth, food system change and pesticide use in developing Sub-Saharan Africa (d-SSA) more broadly. We find that farmers in Mozambique and Zambia are purchasing pesticides at much higher rates than predicted for farmers in d-SSA as a whole, and are highly exposed to health hazards due to high chemical toxicity and low levels of safety precaution. We discuss the challenge of inducing behavioral change in what, despite the rapid influx of supermarkets and modern procurement practices, is still largely a traditional and informal food system. This chapter highlights key material from the more comprehensive research report No.8E found in the *IIAM Research Report Series*, where a more complete account of the prediction model of pesticide use for d-SSA can be referenced.

1. Introduction

Sub-Saharan Africa (SSA) has urbanized rapidly over the past six decades. According to official UN estimates, only 11% of the population lived in urban areas in 1950. Today this share is closer to 38% and is expected to reach 50% by 2040. Moreover, it has been broadly recognized that over the last 15 years, SSA has greatly improved its growth trajectory, averaging a robust 2.8% per capita real GDP annual growth from 2000 to 2013 (or 3.4% excluding South Africa). If this continues, it will spell fundamental changes at all levels of the food system.

A simulation exercise by Tschirley et al. (2013) finds that overall demand for food in East and Southern Africa (ESA) is likely to increase by a factor of 3.3 to 9 times in the next 30 years, depending on economic conditions. The composition of demand is also likely to change dramatically. With increasing incomes, consumers are shifting away from purchasing primarily maize-based products or other cereal staples and towards purchasing processed and fresh perishable foods, including meats and horticultural products. Horticultural farmers, in order to meet the growing demand for consistent quantity and quality both locally and for export, have great incentives to increase yields and minimize crop damage due to insects, weeds, and fungi, all while dealing with rising labor costs.

Responding to these incentives in tropical/sub-tropical climates with high pest pressure involves substantial use of pesticides, including insecticides, herbicides, and fungicides. This pesticide use occurs in a lax regulatory environment (Karungi et al., 2011; Oluwole and Cheke, 2009), where many farmers do not possess adequate knowledge of optimal spray regimens (Abang et al., 2013; Karungi et al., 2011; Obopile et al., 2008), training in safety behavior (Mekonnen and Agonafir, 2002; Sosan and Akingbohungbe, 2009), or awareness of the environmental impact of indiscriminate use (Nonga et al., 2011).

Indeed, there is evidence at the local level that small scale farmers in SSA have become greatly reliant on synthetic pesticides, replacing more traditional methods of pest control (Cachomba et al., 2013; Nyirenda et al., 2011). However, most studies focus only on the proportion of farmers within a community using particular chemicals and the general circumstance and pattern of use (Ngowi et al., 2001; Ngowi et al., 2007; Nyirenda et al., 2011; Obopile et al., 2008; Oluwole and Cheke, 2009; Williamson et al., 2008). There are relatively few studies that report pesticide purchase or application rates in SSA.

To summarize, we perceive a key gap in the literature regarding pesticide use in SSA: There is limited evidence collected from household-level datasets on pesticide purchase or application rates. The focus of this report is to present new evidence, including pesticide purchase rates and respective toxicity levels from Zambia and Mozambique.

2. Data and Methods

In this report, we present and analyze evidence from Zambia and Mozambique collected from recent agricultural household surveys, 2012 and 2013, respectively, conducted among producers supplying the capital city market.

In Zambia, we sampled farming households growing horticultural products in areas supplying the capital city of Lusaka. Lists of such farmers were developed in three steps. First, we identified farmers visiting the Soweto wholesale market in Lusaka and obtained their contact information. Second, we interviewed traders working at the wholesale market to generate names of additional farmers with whom they dealt. Following consolidation of these lists, we visited known production areas, met with farmers who had been identified in the previous steps, and used their knowledge to add additional names of farmers selling into Lusaka. This procedure produced a total list of over 400 farmers, from which 263 were selected using systematic random sampling.

In Mozambique, we sampled farming households from the horticultural production areas primarily supplying the capital city of Maputo, composed of both the peri-urban areas normally referred to as the *zonas verdes* (ZV) or "green zones" and the nearby districts of Moamba and Boane (M/B). The sample frame for the *zonas verdes* was developed using lists of farmers' associations operating in the zones, followed by visits to each association to develop a more complete list. In M/B, two processes were followed. First, farmers in the irrigation areas were identified through lists residing in the district agricultural offices. Second, production zones along the rivers were identified on maps followed by visits to those areas to complete the lists. In each case, farmers were selected using systematic random sampling. Due to the distinctly different production systems in each of these two areas, the sample was stratified to individually represent all small producers (those with less than 5 hectares of cultivated land with horticultural crops) in each area, with sample sizes of 344 for the ZV and 272 for M/B.

Clearly, smallholder farmers are not a homogenous group in either of these countries. Our data show considerable variation across households in most of our variables including production activities, market access, asset ownership, education, and household demographics. In order to further disaggregate the data, we employ a cluster analysis to create groups of farmers within each country that are statistically similar across several indicator variables. This method is described in chapter 3 and applied to create similarly defined clusters the case of Zambia.

3. Results

Smallholder horticulturalists face myriad challenges and risks in every stage of production, from input procurement to crop growth and harvesting. Consistent with what has been found among the horticultural producers supplying Maputo city in Mozambique (see chapter 4) our data from Zambia show that an inability to control pests is the primary reason for crop loss among Zambian farmers (46%). Farmers also cite lack of inputs and irrigation water as reasons for loss, but the gap between pests and the next major problem is even more exaggerated for crop failure in Zambia than in Mozambique, a spread of 32 percentage points compared to 18 (table 1).

Table 1. Reasons for crop loss among farmers in Zambia

Reason For Loss	Share of farmers
Inability to control pests	46%
Lack of fertilizer	14%
Poor quality seed	13%
Other reasons	10%
Lack of irrigation water	9%
Insufficient rainfall	9%

Pesticide use can be a very effective short-term pest control strategy, and may often be the difference between profits and losses. But pesticides also pose several risks to the health of applicators, consumers and the environment. Alarmingly, table 2 shows that large shares of farmers in each country use highly hazardous WHO Class Ib chemicals (76% and 87% in Zambia and Mozambique respectively) and moderately hazardous WHO Class II chemicals (77% and 48%, respectively). However, we observe a marked difference in the share of farmers using highly toxic chemicals across zones and countries: 76% of farmers in Zambia apply class Ib pesticides compared to 59% of farmers in the rural M/B and 90% of farmers in the peri-urban ZV. The latter may be partly attributable to the relatively higher intensity use of the land in the ZV, coupled with lower crop diversity, and hence, the greater potential for evolving pest resistance and the felt need to apply a more toxic pesticide.

Table 2. Share of producers using chemicals from each toxicity class

WHO Toxicity Class	Mozambique			Zambia
	ZV	M/B	Total	
Ib - Highly hazardous	90%	59%	87%	76%
II - Moderately hazardous	48%	53%	48%	77%
III - Slightly hazardous	0%	3%	1%	16%
U - Not Hazardous	52%	56%	53%	75%

Interestingly, classes Ib, II and U pesticides are used by very similar shares of farmers within Zambia, approximately 75% of each, and within the M/B area in Mozambique, approximately 55% of each. Overall pesticide prevalence is lowest in the M/B area, which is characterized by dispersed plots where many producers grow their vegetables alongside the riverbanks and often without the aid of productive inputs (e.g. chemical fertilizer).

Analysis of specific chemicals used in each country refines these results. Table 3 shows that in Zambia there are five chemicals that are in use by at least 30% of farmers, but only three in each Mozambique region. The most commonly applied active ingredient, methamidophos (we group methamidophos and monocrotophos in Zambia) is the only class Ib chemical used in each country, but it is used by a clear majority of farmers. Producers using pesticides in the M/B have the lowest relative share of farmers using methamidophos, but the highest shares using mancozeb and cypermethrin as well as several less commonly used pesticides.

Table 3. Most-used pesticide active ingredients

Active ingredient	Mozambique			Zambia	WHO Toxicity Class (toxicity to humans)
	ZV	M/B	Total		
	---- percent of producers that used ---				
Methamidophos or Monocrotophos*	90.0%	58.2%	86.6%	74.5%	Ib - Highly hazardous
Cypermethrin	34.8%	43.9%	35.8%	7.3%	II - Moderately hazardous
Acetamiprid	6.3%	1.8%	5.9%	-	
Acephate	2.2%	4.5%	2.5%	13.4%	
Endosulphan	2.0%	2.4%	2.1%	5.4%	
Copper Oxycloride	0.6%	3.9%	1.0%	16.5%	
Imidacloprid	0.0%	4.2%	0.5%	36.0%	
Lambda-cyhalothrin	-	-	-	31.4%	
Mancozeb	40.3%	50.9%	41.4%	47.5%	U - Not Hazardous
Abemectin	20.6%	12.8%	19.7%	38.3%	

ZV - Zonas Verdes; M/B - Moamba/Boane **.** *Mozambique data show use of methamidophos exclusively and Zambia data show use of methamidophos as well as moncrotophos. Both pesticides are highly toxic, so we combined them to compare highly hazardous chemical usage across countries.

Table 4 shows the differences in toxicities used on major crops: tomatoes, kale, cabbage, and onions. In this analysis, chemical shares are not weighted by the volume of active ingredient used; we implicitly gave an equal weight to each chemical that a farmer applied. Furthermore, there is not much difference in the toxicity composition across crops. For example, in the ZV, which has the most toxic composition of chemicals, WHO class Ib chemicals are used 44% of the time on tomatoes (low) and 55% of the time on onions (high). In M/B and in Zambia, WHO class Ib chemicals are used most often on kale (38% and 39%, respectively), but not by a large margin. Class Ib chemicals are used on tomatoes 26% of the time in Zambia and used on onions 29% of the time in the M/B region of Mozambique.

In table 5 we estimate the annual median purchase rate of pesticide per household. The most striking result is that the purchase rate of active ingredient is approximately 16 times higher in ZV compared to M/B in both the share of pesticides purchased for horticultural crops and for all crops more generally. The pesticide purchase intensity represented by the producers in ZV confirms the observation by Williamson et al. (2008) that horticultural production is the most pesticide intensive activity of all crops. It is also important to note that the farmers selected for this study were chosen specifically because they farm in the areas within Mozambique that primarily supply the vegetable markets of Maputo city, and as such, we could expect these producers to use more pesticides than the average farmer in Mozambique or the broader region.

Table 4. Toxicity shares of chemicals applied to each crop

Country	Crop	WHO Pesticide Toxicity Classification			
		Ib	II	III	U
Zambia	Tomato	26%	35%	4%	34%
	Kale	39%	39%	4%	18%
	Cabbage	30%	36%	5%	28%
	Onion	32%	36%	0%	32%
Mozambique (M/B)	Tomato	33%	35%	1%	31%
	Kale	38%	32%	1%	29%
	Cabbage	31%	34%	2%	33%
	Onion	29%	41%	0%	30%
Mozambique (ZV)	Tomato	44%	26%	0%	30%
	Kale	51%	24%	0%	25%
	Cabbage	46%	27%	1%	26%
	Onion	55%	28%	0%	17%

Table 5. Median annual PURCHASE amount of product and active ingredient per household, among those using

	Estimated pesticides applied to horticultural crops		Estimated pesticides applied to all crops	
	Median Product/ Avg ha cultivated with horticulture	Median a.i./ Avg ha cultivated with horticulture	Median Product/ Total ha	Median a.i./ Total ha
Moamba/Boane	2.00	0.32	0.89	0.15
Zonas Verdes	47.00	5.08	25.35	2.44
Both	40.73	4.23	20.57	1.92

Units are in either liters or kgs, these are used interchangeably. Land cultivated with horticultural crop is the average between cool and hot seasons of the year.

All of this points to the fact that, while pesticide use in d-SSA might be lower than in other parts of the world, there is significant regional and crop variation. In addition, the composition and toxicity of pesticide use matters. Table 6 displays the median quantities of specific chemical purchases per hectare on horticultural crops among those using each chemical in Mozambique. The small relative volume of active ingredient per hectare used for methamidophos stands out immediately. Farmers purchase methamidophos almost twice as often as any other chemical, but the median application rate is only 1.1 units/ha. Three chemicals show much higher median volumes than the rest; endosulphan, profenofos and mancozeb. Endosulphan and profenofos have the two of the highest median purchase amounts per hectare and are both WHO class II, moderately hazardous, chemicals.

When we disaggregate our pesticide purchase data for Mozambique by clusters (shown in table 7, with 1 indicating "low technological capacity" and 4 indicating "high technological capacity") we see a general, though not consistent, trend of decreasing pesticide application rate from low to high clusters. In particular, cluster 4 farmers purchased less active ingredient than the farmers in all other clusters for each pesticide. Clusters 2 and 3 are primarily composed of producers in the ZV where smaller plots are farmed very intensively, explaining the sometimes higher averages in these two clusters (notably of mancozeb and cypermethrin) compared to cluster 1, which is primarily composed of producers in M/B.

Table 6. Median annual PURCHASE among those using pesticides for horticultural crops of chemical products and active ingredients per hectare

Chemical	Observations	Median Annual Product*/ha	Median Annual a.i./ha	Estimated Mean Annual Application Range (a.i.) in Ghana (Ntow 2008)
Methamidophos	526	22.2	1.1	
Cypermethrin	234	16.0	2.4	0.1-0.7
Mancozeb	268	14.5	11.6	0.2-1.1
Abamectin	106	23.6	1.9	
Acetamiprid	29	29.6	6.5	
Profenofos	18	24.0	12.0	
Fipronil	14	6.2	1.2	
Imidacloprid	11	3.1	2.2	
Acephate	19	5.2	3.9	
Endosulphan	14	22.9	8.0	0.1-12.0

*Units are in either liters or kgs, these are used interchangeably. Hectares represent the average land cultivated with horticultural crop between cool and hot seasons of the year.

Table 7. Median annual purchase of active ingredients per hectare among farmers in Mozambique using each pesticide for horticultural crops*

	Clusters			
	1	2	3	4
	A.I. purchased per hectare			
Methamidophos (L)	1.6	1.2	1.1	0.6
Cypermethrin (L)	2.0	2.6	2.6	1.1
Mancozeb (kg)	10.4	22.4	10.9	4.4
Abamectin (L)	7.2**	1.8	1.9	0.9

*Units are in either liters or kgs, these are used interchangeably. Hectares represent the average land cultivated with horticultural crop between cool and hot seasons of the year. **This median represents only 9 cases, and hence should be interpreted cautiously. Note: Only four pesticides are shown due to very low numbers of observations per cluster for the other pesticides. For a more detailed description of how cluster analysis was performed in the case of Zambia please refer to the full version of Research Report 8E.

The general downward trend of pesticide purchases across increasing technological capacity clusters is related to the shift of higher capacity farmers towards a more diversified portfolio of chemicals, with the exception of those producing kale in both countries (see table 8). More advanced farmers are likely to be more discriminating in their pesticide purchases and apply a more diversified pesticide regimen, relying less on any single product. We also observe a large difference across countries in the number of chemicals used – in Zambia they use, on average, 5.1 different chemicals, while in Mozambique the average is 2.2 different chemicals. Interestingly, the analysis shows a large difference in pesticide use across crops in Zambia, but not in Mozambique. In particular, Zambian producers used nearly two more pesticides on tomatoes than kale, while Mozambican producers use, on average, 0.7 more pesticides on kale than tomatoes.

Table 8. Average number of pesticides used on specific crops among those growing

Crop	Mozambique					Zambia			
	Clusters					Clusters			
	1	2	3	4	All	1	2	3	All
	Mean number of pesticides used among those growing each crop								
Tomato	0.7	0.7	1.3	1.8	1.2	3.6	4.0	5.7	3.8
Kale	1.4	1.6	2.4	1.9	1.9	1.9	1.9	1.7	1.9
Cabbage	1.3	1.0	2.2	2.1	1.8	0.1	0.6	0.8	0.4
Total pesticides*	1.4	1.7	2.9	3.0	2.2	4.8	4.9	5.7	5.1

*Total pesticide numbers are averages across ALL households producing horticultural crops, not limited to those using pesticides.

4. Discussion

Household level evidence from Mozambique and Zambia indicates that farmers surveyed in both these countries use highly toxic chemicals (WHO class Ib) with astonishing regularity: 87% and 76% of farmers in Mozambique and Zambia, respectively. Second, there are considerable differences across farmer types. In both Zambia and Mozambique, we observe that more technologically advanced farmers generally purchase a more diverse set of pesticides, and in Mozambique, we can see that these producers use smaller per-hectare quantities of any given one. In addition, they use roughly half the rate of methamidophos - a “highly toxic” pesticide - than the least technologically advanced farmers. Over all, these results are worrisome given that pesticide use in d-SSA is expected to double from 2015 to 2040, and the regulatory environment in these areas is weaker (see research report 8E, the full version of this report, for more context regarding this prediction). Furthermore, this study finds that farmers in Mozambique and Zambia are purchasing pesticides at much higher rates than predicted for farmers in d-SSA as a whole (Snyder et al, 2015). Smallholder farmers often do not take adequate safety precautions when preparing and applying pesticide, making them vulnerable to associated short and long term illnesses.

Clearly pesticide exposure, especially among horticultural farmers, is a growing concern in SSA. Addressing this concern will require better coordination in the horticultural supply chain and the food marketing system, which despite rapid modernization overall, still largely takes place within the traditional sector. There are a number of challenges making behavioral change difficult in the informal market, including the difficulty of verifying the safety of food sold at informal markets through simple visual inspection, and the difficulty of monitoring the behavior of the numerous actors involved in the food supply chain.

Achieving behavioral change is much more straightforward in modern supermarket chains, which emerged in South Africa and have started to spread throughout ESA. These large retailers depend on consistent quantity and quality of supply, which they tend to procure through imports and the use of long-term contracts with large and well-capitalized farms. In such cases it is much easier to monitor farmer activity, streamline production processes, and control some of the inputs of production. Supermarket chains have also been known to complement this "preferred supplier" system by buying products from local wholesale markets (for an example in Kenya, see Neven and Reardon, 2004), but this is generally seen as a backup strategy, one that is not highly publicized due to safety concerns. Despite their rapid emergence in the last three decades, supermarket chains currently control a relatively small market share throughout ESA (Tschirley et al., 2013).

Consumer demand can also drive behavioral change in the food system, but evidence suggests that urban consumers in SSA are largely unaware of the dangers of pesticide residue (Probst et al., 2010), making it unlikely that they would be willing to pay a premium in the short run for certification schemes promising the absence or negligibility of harmful chemical residues. As evidence from developed countries suggests, this is likely to slowly change in the future as rising educational levels and incomes lead urban consumers to become more aware of food safety and more willing and able to pay for it. For example, Batte et al. (2007) find that consumers in Ohio are willing to pay an average premium of $0.33/box at traditional grocery stores and $0.50/box at specialty stores for pesticide-free breakfast cereals. Additional studies have shown that anywhere from 21-66% of consumers are willing to pay at least a 6% premium for pesticide-free produce (see table 9). Fu et al. (1999) find that, if consumers in Taiwan are explicitly informed that the risk of developing cancer over a lifetime from eating bok choy with pesticide residues is 0.01%, consumers are willing to pay a 46% premium to reduce the risk by 25%, a 56% premium for a 50% reduction, and a 75% premium for a 90% reduction.

Table 9. Willingness to pay (WTP) a price premium for pesticide-free produce in other countries

Study	Location	Product	Not WTP or not sure	WTP ≤ 5%	WTP 6-10%	WTP 11-20%	WTP > 20%
(Boccaletti and Nardella 2000)	Italy	Fresh fruit and vegetables	11%	23%	34%	21%	11%
(Cranfield and Magnusson 2003)	Canada	Food products	18%	38%	29%	10%	5%
(Misra, Huang, and Ott 1991)	USA	Fresh produce	55%	25%	15%	6%	0%

In the short run, immediate action can be taken by governments to ban the use of highly toxic pesticides. Some progress has been made on this front; Mozambique, for example, has recently officially banned the use of methamidophos, although it is taking some time for this ban to be fully enforced. Restricting access to dangerous pesticides, however, must be coupled with the provision of access to less harmful but equally effective pesticides and/or training in integrated pest management (IPM) strategies to reduce the pesticide application volumes overall.

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CHAPTER 6

Information, Pesticide Safety Behaviors, and Perceived Pesticide Health Risks in Maputo

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1. Introduction

Increased pesticide use in Sub-Saharan Africa (SSA) brings new health and safety risks to smallholder farmers. A large and growing body of research shows that farmers in developing countries seldom use complete personal protective equipment (PPE) when handling and applying pesticides, which often leaves them highly exposed to toxic chemicals (Blanco et al, 2005; Aragon et al, 2005; Machera et al, 2003; Abdel Rasoul et al, 2008; Oluwole and Cheke, 2009; Sosan and Akingbohungbe, 2009). The high potential for exposure leads to large acute illness risks from pesticide use.

Researchers agree that pesticide exposure in SSA is a problem and they even agree, at least generally, on a solution: that improved and targeted extension and training efforts are needed to ensure that farmers use pesticides safely (Ngowi et al, 2007; Ntow et al, 2006; Hashemi et al, 2012; Macheria et al, 2013; Madisa et al, 2012; Matthews et al, 2003; Mekonnen et al, 2002; Nonga et al, 2011; Obopile et al, 2008; Okello and Swinton, 2009; Oluwole and Cheke, 2009; Tijani, 2006). Despite this consensus, literature exploring the relationships between agriculture information channels, and perceived pesticide health risks and safety behaviors is scarce.

Of the voluminous literature that touches on smallholder farmer pesticide use in SSA only Karungi et al (2011), Ntow et al (2006), Nonga et al (2011), and Tijani (2006) discuss heterogeneity in farmer pesticide information sources. To our knowledge, no study actively seeks to identify relationships between information sources and pesticide behaviors or perceived health risks in SSA. We consider this to be a major gap in the literature especially in view of evidence outside of SSA that various information sources can have differing impacts on perceived chemical risks (Tucker and Napier; 1998).

This paper explores this research gap by analyzing data from horticulture producers in Maputo. First, we describe farmers' pesticide behaviors including what types of pesticides they use and whether or not they are safely handled and applied. Second, we outline farmers' perceived health risks from the pesticides they purchase. Third, we detail farmers' pest management advice sources and explore how technological capacity might relate to farmers' access to information sources. Fourth, we use mean comparisons and regression analysis to identify the correlations between pest management advice sources and farmers' accuracies in their pesticide health risk perceptions. Lastly, we use regression analysis to explore the relationships between pest management advice sources and pesticide safety behaviors using two unique behavior metrics.

2. Data and Methods

We employ data from a baseline survey conducted in 2013 consisting of a random and stratified sample of 616 horticulture producers out of a population of 6,458 small horticultural producers in the major rural districts and peri-urban areas supplying Mozambique's capital city of Maputo. This is the same data used in the rest of this report, so little additional detail is added here.

i. Health risk perceptions

Our data contain a perceived risk assessment for each pesticide a farmer used. While these perceptions are interesting in their own right, it is more meaningful to compare these perceptions to each pesticide's actual health risk. To learn about the accuracy of each farmer's perceptions and to identify the factors leading to more or less accurate perceptions of health risks, we create a mean perceived health risk accuracy score for each household. We construct this variable by first assigning a value to each possible pesticide risk perception (1 is "highly toxic", 2 is "moderately toxic" and 3 is "not toxic") and to each possible World Health Organization (WHO) classified chemical toxicity by combining WHO classes II and III to match our perception information (1 is class 1b "highly toxic", 2 is class II "moderately toxic" *or* class III "slightly toxic", and 3 is class U "unlikely to be harmful"). We then subtract each pesticide's true WHO toxicity value from each farmer's perceived human health risk value and square the difference. To obtain a farmer level value and to reduce possible bias from farmers using many pesticides, we sum these differences and divide by the number of pesticides used. The resulting value is a measure of average accuracy in perceived pesticide human health risks that has a maximum (and least accurate) possible value of four and a minimum (and most accurate) possible value of zero.

We analyze differences in this mean perceived health risk accuracy score across various sources of pest management advice and estimate several regressions using it as the dependent variable to identify what household characteristics and information sources are correlated with more or less accurate health risk perceptions.

ii. Safety behavior metrics

While risk perceptions are likely important factors in each farmer's calculus of what safety behaviors to employ, access to PPE items, incomes, experience and educational levels also likely play a role in farmer safety decisions. We create two unique metrics of safety behaviors to analyze the relationships between each of these variables and farmers' pesticide safety practices.

a. Dermal exposure score

The first unique safety behavior metric is a dermal "exposure score" based on reported use of PPE items and observed farmer exposures from Aragón et al (2005). Exposure through direct contact with a farmer's skin is the most important avenue for farmers applying pesticides with a knapsack sprayer, so we focus on dermal exposure in our analysis. Aragon et al (2005) provide detailed dermal exposure data from 32 pesticide applications by smallholder farmers in Nicaragua that we use as a baseline for possible exposure in our study. The application environment and methods used by the farmers in their study are similar to those for the farmers in our study.

To create our baseline dermal exposure score we use observed exposures from Aragon et al that incorporate the surface area of each exposed region of the body and the intensity of the observed exposure. We multiply these exposure values by the probability of exposure defined as the share of farmers that Aragón et al observed to have contamination in each region. We then use information from the EPA's Occupational Pesticide Handler Unit Exposure Surrogate Reference Table which provides estimated dermal exposures for several chemical mixing and application scenarios to impute possible exposures for mixing liquid chemicals.

Using the same source together with exposure estimates from Machera et al (2002) and Matthews (2003), we create dermal exposure reductions for each type of PPE listed. We apply these reductions to our baseline exposure to estimate the share of possible exposure protection provided by each PPE item.

To corroborate our exposure scores we compare our calculations with the observed exposures from Machera et al (2002) who provide an even more rigorous dermal exposure assessment on two pesticide applications in a greenhouse using a low volume knapsack sprayer. Table 1 reports their mean exposures as shares of total body exposure in each body region alongside the corresponding body shares for our exposure score calculations.

Table 1. Exposure share comparisons

Body segments	Machera et al (2002)[a]	Exposure scores[b]
	Shares of body exposure	
Head	0.09	0.02
Left arm	0.37	0.08
Right arm	0.06	0.05
Chest	0.14	0.08
Back	0.03	0.37
Upper body	*0.69*	*0.61*
Thighs (front)	0.10	0.10
Thighs (back)	0.04	0.05
Left leg	0.07	0.13
Right leg	0.10	0.11
Lower body	*0.31*	*0.38*

[a] Mean of low pressure exposures
[b] Calculated from Aragón et al (2005)

This comparison largely confirms our exposure calculations as the upper body and lower body shares differ by only 0.08 and 0.07 respectively across assessments. While the individual body segment shares are generally similar – 7 of the 9 segment shares are within 0.1 of each other – there are two large differences as the left arm share is 0.29 higher in the study by Machera et al while the back share is 0.34 higher for our exposure score. These differences are explained by the state of equipment used in the two studies. Machera et al noted a leak in the handle of the sprayer while Aragón et al observed the knapsack tanks – which farmers carry on their backs while spraying – leaking in several applications.

Table 2 summarizes the additive exposure reductions provided by each PPE item listed in our data as shares of total possible exposure. These shares can be interpreted as percentages of possible exposure that are eliminated by using each PPE item.

Table 2. Additive exposure reduction shares of possible exposure for each PPE item

Protection Item		Total Exposure Reduction Score
Protective clothing that covers the whole body		63
Partial protective clothing		35
Mask		1
Boots	(alone)	29
	+ Full protective clothing	14
	+ Partial clothing	21
Gloves		13
No PPE		0

Protective clothing covering the whole body (arms, legs and torso) offers the most protection (63% of total exposure reduced) because it covers the largest surface area. Gloves and boots also provide a lot of protection despite being small body surface areas. Greater than 90% of farmers had contaminated hands and greater than 70% of farmers had contaminated feet in Aragón et al. Protective pants overlap with boots, so boots provide a smaller protection increase when worn together with partial and full protective clothing.

To put these exposures in a form that is more easily interpreted, we converted them into relative exposure scores – $Exposure\ score = 100 - \sum Total\ exposure\ reduction\ scores$. Thus we can provide a relative exposure score for each farmer based on their reported use of PPE items. Farmers that used no PPE had an exposure score of 100 while farmers that used maximum PPE (protective clothing covering the whole body, a mask, gloves and boots) had an exposure score of 9 – not zero because even full PPE does not completely eliminate exposure. For example, the exposure score for a farmer that used full PPE was calculated as 100 minus the sum of total exposure reduction shares for full protective clothing, mask, boots and gloves (100 – (63 + 1 + 14 + 13) = 9).

b. Safety behavior index score

Our second unique safety behavior metric is a "safety index score" that scores nine safety behaviors. Table 3 lists the behaviors and the practices defined in each category. We use a method similar to Macharia et al's (2013) and assign two points for each best behavior, one point for each second best behavior, and zero points for each not recommended behavior. We sum points across behaviors for each individual to arrive at a single safety index score for each farmer. This metric has the advantage of including a broader range of behaviors than the PPE use that defines our exposure score.

3. Pesticide practices and perceptions

An alarming share of horticultural farmers in Maputo use hazardous pesticides - 87% of farmers in Maputo used pesticides that are classified by the World Health Organization (WHO) as Ib, "highly hazardous to humans." (see Cachomba et al.) This makes PPE use all the more important. Farmers face potentially very high risks of acute illness if they do not adequately protect themselves.

Similar to Cachomba et al, we unfortunately find that there is considerable room for improvement in pesticide safety practices in Maputo (Table 4). Farmers in the *zonas verdes* show low PPE use rates, only 7% of farmers wore overalls, only 18% wore gloves, and 53% wore boots while mixing their chemicals prior to application – a time of particularly high exposure risk (Matthews; 2008). This result is generally consistent with the literature on pesticide safety and handling. Matthews et al (2003) showed low use of PPE in Cameroon as only 24% of their sample wore boots. Mekonnen et al (2002) found better PPE use in Ethiopia as about 60% of farmers wore gloves when handling pesticides. Ntow et al (2006) observed only 24% of Ghanaian farmers to fully protect themselves when applying chemicals. Sosan and Akingbohungbe (2009) found that only 29% of Nigerian farmers wore boots and 41% wore overalls when using pesticides. In another study we are currently conducting (*forthcoming)* only 34% of farmers wore overalls and 54% wore gloves among horticulture producers supplying Lusaka, Zambia.

Table 3. Best, second best and not recommended safety practices used to create safety index scores

	Practices		
Safety behavior	Best	Second best	Not recommended
Pesticide application time	Morning, following weather	Evening	Anytime, afternoon
Equipment washing location	At the farm		In the river, at home, another place, do not wash
Pesticide package disposal method	Bury	Burn	Throw out in the backyard, throw out another place, reuse, leave on the ground
Pesticide storage location	In a garage, in a special warehouse	In their room, in another part of the house	In the field, in the pantry/kitchen, in the yard, in another place outside of the house
Personal Protective Equipment			
Overalls	Used		Did not use
Mask/goggles	Used		Did not use
Boots	Used		Did not use
Gloves	Used		Did not use
Other protective clothing	Used		Did not use

Source: Guidelines on good practice for ground application of pesticides, FAO (2001)

PPE use practices are summarized in our exposure score which shows that farmers averaged 0.1% of their possible exposure. They showed particularly poor pesticide storage practices as 88% stored chemicals in "not recommended" locations including kitchens and unprotected in their fields where they could be easily accessed by other family members or farmers. Likewise, 66% of farmers disposed of their pesticide containers in manner that is "not recommended" and that puts other people and the environment at risk. Our safety index score summarizes these nine pesticide safety behaviors. With a maximum (and best) possible score of 18, the mean safety index score was only 6 for Maputo.

Most farmers also demonstrate a limited ability to vary their perceptions based on actual toxicities – an average 1.1 of 2.5 agrochemicals used were assigned the correct human toxicity ranking out of 4 ranking categories. WHO class U pesticides (those unlikely to present acute hazard) are less likely to be perceived as highly toxic although the difference is only 12%.

Table 4. Share of farmers practicing best and second best safety practices by country

Pesticide application time	
Best	65%
Second best	9%
Not recommended	26%
Washing location for equipment	
Best	67%
Second best	-
Not recommended	33%
Pesticide package disposal method	
Best	15%
Second best	18%
Not recommended	66%
Pesticide storage Location	
Best	5%
Second best	7%
Not recommended	88%
Personal protective equipment used	
Overalls	7%
Mask/goggles	36%
Boots	54%
Gloves	19%
Other protective clothing	18%
Other	
Mean safety index score (out of 18)	6.2
Mean exposure score	70.1
Mean perceived human toxicity accuracy score	1.1
Mean number of pesticides applied	2.5

Having briefly discussed farmer safety practices and health risk perceptions among the horticultural farmers of Maputo, we move forward by categorizing pest management information sources for these farmers. Table 5 shows the share of farmers receiving general advice and pest management advice from several possible sources by technological capacity clusters in each country.

Extension access is generally low, only 28% of farmers receive any pest management advice during the year (table 5), however it is worth noting that respondents in the survey may not have immediately considered another farmer, for instance, as a source of pest management advice worth citing in the method the questionnaire was administered.

Table 5. Share of farmers receiving advice from various sources by cluster

	Cluster				All
	1	2	3	4	
Formal agriculture training of 3+ months	0%	4%	10%	17%	6%
Any extension advice *without family*	12%	32%	27%	49%	28%
Any pest management advice *without family*	8%	27%	25%	45%	25%
Pest management advice by source					
Any *formal* source	3%	21%	20%	40%	19%
Any *informal* source	5%	15%	12%	21%	13%
Government extension agents	3%	20%	15%	36%	17%
NGO	0%	2%	0%	6%	2%
Agro-dealer	0%	1%	8%	2%	2%
Radio	0%	0%	0%	0%	0%
Another farmer	5%	15%	12%	21%	13%
Mean number of sources *without family* among those receiving pest management advice	1.0	1.4	1.5	1.5	1.4

*Clusters are defined in chapter 3 of this collection.

Table 5 also shows that there is a large gap across technological capacity in access to pest management advice from government extension agents: 36% of farmers in the highest capacity group receive pest management advice from a government agent compared to only 3% of farmers in the lowest capacity group. The share of famers that receive formal agricultural training also varies substantially across clusters, increasing from 0 to 17%, and farmers with greater technological capacity are the most likely to have received pest advice from both formal and informal sources.

Overall, government extension is the most prevalent source of pest management advice even though it only reaches 19% of farmers. In comparison, Nonga et al (2011) present that 75% of Tanzanian farmers receive pesticide advice from agrochemical shops, yet we observe that the share of farmers receiving advice from agrochemical dealers is only 2% in Maputo.

4. Information sources, perceived health risks and pesticide safety behaviors

We now explore the relationships between these information sources and farmers' perceived human health risks and safety behaviors. Table 6 examines differences in mean perceived health risk accuracy scores for farmers that did and did not receive advice from several sources – note that a lower perceived health risk accuracy score indicates higher perception accuracy. Eight of the ten differences are negative suggesting a general improvement in perceived health risk accuracy for farmers that received extension advice. All differences are insignificant.

Table 6. Differences in mean perceived health risk accuracy scores by information sources

Advice	Share of farmers receiving advice	**Difference in mean pesticide perceived health risk accuracy score**
Formal agriculture training of 3+ months	6%	**-0.14**
Any extension advice	28%	**-0.06**
Any pest management advice	25%	**-0.02**
Pest management advice by source		
Any *formal* source	19%	**-0.02**
Any *informal* source	13%	**-0.03**
Government extension agents	17%	**-0.07**
NGO	2%	**-0.12**
Agro-dealer	2%	**0.30**
Radio/TV	1%	**1.85**
Another farmer	13%	**-0.03**

Regression analysis adds depth by controlling for household characteristics and isolating the correlations between pest management advice sources and farmers' accuracy in perceived health risks from chemicals. We regress mean accuracy scores of perceived health risks on information sources, household demographics, and the number of pesticides used within each WHO toxicity classification.

Our count variables for the number of class Ib, class II and III, and class U pesticides applied by each farmer confirm our observation that farmers do a poor job of varying their perceived risks based on actual toxicities. The number of class Ib chemicals used is strongly significant and negative, implying that farmers that use a greater number of class Ib pesticides are more likely to have more accurate perceptions. Similarly, using a greater number of class U chemicals is strongly correlated with less accurate health risk perceptions. Thus farmers generally perceive pesticides to be highly toxic, and a farmer's perceived accuracy score is largely determined by whether or not he or she actually used highly toxic pesticides, i.e., WHO class Ib.

After controlling for these persistence effects we again find no significant relationships between any pest management advice source or household characteristic and a farmer's mean perceived health risk accuracy score; a result that is consistent with the difference in means analysis for table 6 above. The lack of a family advice variable in our Maputo regressions may help explain the lack of significant relationships.

We also explore the relationships between farmer information sources and whether or not a farmer showed any ability to adjust their perceived toxicities across pesticides they used. Our mean accuracy scores reveal that a farmer's accuracy was strongly related with the actual toxicities of pesticides they used. This is because farmers generally perceived all pesticides to be highly toxic -- 410 farmers perceived all of their pesticides to be highly toxic while only 98 were able to correctly adjust their perceptions. Relative differences in perceived health risks across pesticides are likely to be important drivers of farmer demand for toxicity. Farmers that perceive a decreased health risk from using lower toxicity pesticides may have higher demands for less toxic chemicals compared to those farmers that view all pesticides as highly toxic. To estimate the determinants of a farmer's ability to adjust their health risk perceptions, we create a dummy variable for whether or not farmers changed at least one of their stated toxicity perceptions and limit the sample to those farmers that used at least one pesticide that was not WHO class Ib..

We find that formal pest management advice has a positive and significant effect on the ability to vary pesticide perceptions, while informal advice (received from another farmer) has a negative and significant impact. Specifically, advice from a government agent is associated with a 21% increase in the probability that a farmer could vary pesticide perceptions. Similarly, experience in horticultural cultivation of greater than 5 years has close to the same effect (19% increase and significant).

While it is important to understand what information sources are related to pesticide perceived health risks, Macharia et al (2013) found that pesticide risk perceptions have no association with pesticide safety behaviors. In light of their results, we extend our analysis to better understand the relationships between pesticide safety behaviors and health risk perceptions, and pest management advice sources.

Table 7 begins this analysis by showing the share of farmers practicing best, second best and not recommended safety practices by farmers receiving and not receiving pest management advice. Worse pesticide application timing is actually evidenced by farmers that receive any kind of advice. However farmers that receive advice do report better practices in washing their equipment. In package disposal techniques, we also see large improvements, however for pesticide storage practices, there are no noticeable differences between farmers who receive advice and those that do not.

Across each pest management advice source, there are higher shares of farmers using overalls, masks, goggles and boots. These and other PPE-use behaviors are summarized in our exposure score which applies various protection factors to each item, the lowest scores representing the least exposure. We observe small decreases in exposure scores for farmers receiving advice, with the largest mean improvement coming from farmers receiving informal pest management advice (from a score of 72 to 67).

All of the safety behaviors listed in table 7 are summarized in our safety index. Again, we observe small improvements for farmers that receive advice over those that do not receive advice, and again, we see the largest improvements in the category of informal pest management advice.

These results suggest that pest management advice and, especially informal pest management advice, are correlated with improved pesticide safety behaviors. To better understand the complete relationship, we estimate several regressions controlling for household asset ownership – as a proxy for income – and other characteristics that might also be related to these behaviors. First, we identify relationships between extension sources and perceptions and farmers' possible exposure level measured by our exposure score metric.

Table 7. Share of farmers practicing best and second best safety practices by pest advice types

Safety behaviors	Pest advice		Formal pest advice		Informal pest advice	
	No	Yes	No	Yes	No	Yes
Application time						
Best	65%	64%	65%	63%	65%	63%
Second best	16%	10%	17%	7%	15%	11%
Not recommended	18%	26%	18%	30%	20%	25%
Place equipment is washed						
Best	65%	71%	66%	70%	66%	71%
Second best						
Not recommended	35%	29%	34%	30%	34%	29%
Package disposal method						
Best	15%	16%	15%	19%	15%	15%
Second best	17%	20%	16%	24%	17%	25%
Not recommended	68%	63%	69%	58%	68%	60%
Storage Location						
Best	5%	5%	5%	5%	5%	5%
Second best	8%	7%	7%	8%	8%	6%
Not recommended	88%	88%	88%	88%	88%	88%
PPE use						
Overalls	6%	12%	6%	14%	7%	13%
Mask/goggles	34%	41%	35%	41%	35%	43%
Boots	52%	60%	52%	62%	53%	60%
Gloves	17%	24%	17%	25%	18%	21%
Other protective clothing	19%	16%	19%	16%	18%	17%
Other						
Mean safety index score	5.9	6.6	6.0	6.6	5.9	6.7
Mean exposure score	72.4	68.9	71.9	68.8	72.7	67.0
Mean perceived human toxicity accuracy score	1.1	1.0	1.1	1.0	1.1	1.0
Mean # of pesticides used	2.3	2.6	2.3	2.4	2.3	2.6

Years of education and female-headed households show significant relationships to exposure scores. An additional year of education is related to a 2.0% lower predicted exposure. A similar result was found by Okello and Swinton (2009) in Kenya as education reduced acute pesticide poisonings incurred by farmers. Female-headed households are significantly associated with about 9% higher possible exposures.

We do not reveal many significant positive relationships between pest management advice sources and exposure scores save for Radio/TV (which only one farmer reported), agrodealers and formal agricultural training. Our previous analyses do not highlight formal trainings as significantly meaningful advice sources, but these do have a highly significant and meaningful relationship in this regression. Farmers that attend a formal agricultural training in the past three years have a lower predicted exposure by 22%.

Moreover, we find that farmers that protect themselves effectively against pesticide exposure are more likely to perceive pesticides as not toxic – possibly because they are less likely to incur acute poisonings as a result of their improved PPE use. Also, the ability to read pesticide labels is weakly correlated with a higher predicted exposure, suggesting that reading labels alone does not result in more effective PPE use.

To extend our scope of behaviors beyond PPE use, we estimated the same set of regressions on our safety index score. The regression results largely confirm the results from our exposure score regressions. Agricultural training is again statistically and practically significant -- farmers receiving agricultural training show improved behaviors on average. Education is also significantly related to improved practices. Female-headed households have lower safety index scores on average (consistent with the previous regression results), and the inverse relationship of number of pesticides perceived to be not toxic and safety score is again significant. Regression results are not shared here due to length limitations.

5. Discussion and Policy Implications

Smallholder horticulture producers in Maputo generally believe pesticides to be highly toxic to humans and demonstrate little ability to adjust these perceptions based on the chemical's actual toxicity. Farmers with different technological capacities seem to obtain pest management advice from different sources, but overall farmers appear to have good access to government extension advice and this advice has the strongest impact on their ability to adjust their pesticide toxicity perceptions.

The results of this study show a number of relationships, summarized here:

- Farmers perceive most pesticides to be highly toxic regardless of their true toxicity class; 410 farmers perceived all of their pesticides to be highly toxic while only 98 were able to correctly decrease their perceived risks for lower toxicity pesticides.
- Farmers that protect themselves effectively against pesticide exposure are more likely to perceive pesticides as not toxic – this result may be because these farmers are less likely to incur acute poisonings as a result of their improved PPE use.
- The number of years of education has a robust relationship with safety behaviors - an additional year of education is related to a 2.5% lower predicted exposure score.
- Female-headed households are also significantly associated with about 11% higher possible exposures, and should be targeted in intervention approaches.
- Pest management advice is significantly related to a greater accuracy in toxicity perceptions in both countries, while the largest mean improvements in exposure score and farmer safety index come from farmers receiving informal pest management advice.
- Slightly worse pesticide application timing is actually evidenced by farmers that receive advice (formal or informal). However farmers that receive advice do report better practices in washing their pesticide application equipment and disposing of packaging.

- Significant positive relationships exist between improved pesticide safety and agricultural training programs. Although no evidence exists that pest advice from government extension agents – excluding formal agricultural training – is related to improved safety behaviors.

The common literature recommendation that extension is the key to improving pesticide safety practices may have some merit, but it is far too general. There is a need for more research to identify which extension methods are most effective. Our analysis suggests formal trainings and informal sources as the most promising, but it is evident that not all extension efforts have meaningful relationships to pesticide safety behaviors.

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CHAPTER 7

Value Chain Model of Products in the Agricultural Sector: Conceptual and Methodological Procedure Considerations

André Yves Cribb

1. Introduction

Both in developed countries and the least developed, the agricultural sector is often interpreted as a system with a very specific dynamic, or more precisely, as a sector very different from other economic sectors. Such an interpretation indicates that this system functions as a set of elements that interact with one another according to certain principles or rules.

According Sppeding (1975) a system is a set of interactive components. Stair (1996) defined system as a set of interdependent parts which form a whole with a specific goal. Rechtin & Maier (1997) state that a system is a set of different elements connected or related to perform a single function unrealizable by the elements alone. For Karapetrovič (2002), a system is a composition of processes linked to each other that work harmoniously, they share the same features and are all targeted to achieve a set of goals or objectives. In a process view, Campos & Medeiros (2009: 75) add that "the whole system is composed of elements or parts that interact through their inputs and outputs (the process approach) with a view toward a common goal". Maciel (1974) notes that a system is defined by three disjoint sets: the set of the elements, the set of the activities and the set of the interactions.

A system is characterized: a) by the nature of its components; b) by the interactions between these; c) by its limits, ie, the extent of its ability to include elements; and, d) by its interactions with its external environment. It may consist of various structures respectively derived from specific arrangements of its elements to fulfill certain functions. It can be opened, closed or isolated according to the degree of interaction with other systems or the external environment.

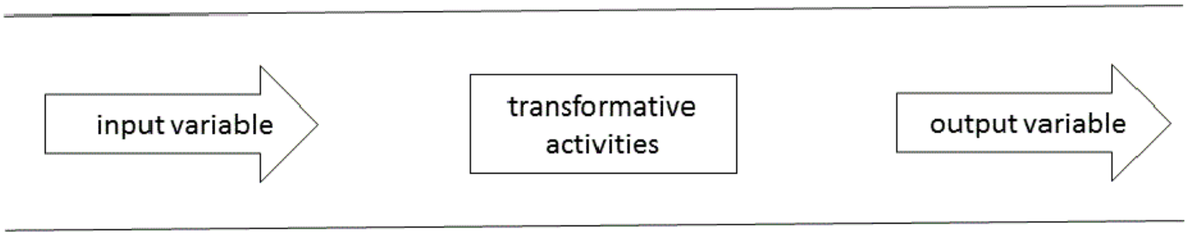
The reality of the agricultural sector is reflected in a system that is fundamentally its real match. It may be the irrigation of land in a region, the functioning of agricultural credit in a country, the poverty level of a population, the behavior of credit unions in the promotion of family farming or the food chain situation in a given area. In any of these cases, the concept of a system has enough potential to contribute to the study of its respective reality.

In an attempt to understand and manage a real system - ie a reality - the fundamental task is to delineate it. Castro (2001: 3) adds that "the characterization of a system (or its analysis) starts with establishing its goals, followed by defining its boundaries, subsystems, component entities and external environment." According to Gauthier (2003: 470),

> "[...] the simplest way to conceptualize a real system is to assimilate it to a box in which energy and information enter to be processed, and then leave in a different state. The inputs correspond to input variables, outputs the output variables and the box the transformative activities of the input variables to output variables" (Fig. 1).

Such a comparison shows that reality, interpreted as a real system, is dynamic. Its elements are in constant motion.

Figure 1. Key elements of a real system



Source: Adapted from Gauthier (2003)

The agricultural system is composed of multiple subsystems, usually called value chains, each of which is constituted by dynamically interacting elements. The purpose of this chapter is to provide clarification of concepts related to the notion of value chain and indicate methodological procedures concerned with its graphical representation.

2. Theoretical and Conceptual Clarification

Generally, the study of a value chain requires the involvement of a team of different academic professionals. A key step is the conceptual leveling between team members. For example, there needs to be consensus about different types of agriculture (family versus commercial and subsistence versus market). Also, the same observation applies to basic concepts used in the process of developing the study to be performed, such as agricultural system, production system, organizational environment, institutional environment and value chain.

- **Family Agriculture**: In the section of its website dedicated to the International Year of Family Farming 2014, the Food and Agriculture Organization (FAO) defines it thus:

> "Family farming is a means of organizing agricultural, forestry, fisheries, pastoral and aquaculture production which is managed and operated by a family and predominantly reliant on family labour, including both women's and men's" (FAO, 2014).

In the same vision, the Brazilian Ministry of Social Development and Hunger Alleviation (MDS) provides the following definition:

> "Family farming is a form of production where the interaction between management and labor predominates; the production process is led by the family farmer, with emphasis on diversification and using family labor, possibly supplemented by wage labor" (Brasil, 2014).

In a study under a technical cooperation agreement between the United Nations Food and Agriculture Organization (FAO) and the National (Brazilian) Institute of Colonization and Agrarian Reform (INCRA), family farming is defined:

> "[...] from three central features: a) the management of the agricultural operation and the investments made in it are realized by individuals who maintain ties of blood or marriage between them; b) most of the work is equally provided by the family members; c) the ownership of the means of production (although not always land) belongs to the family and it is inside that framework that those means are transmitted in the event of the death

> or retirement of those responsible for them" (INCRA / FAO 1996: 4, Quoted by Altafin, 2007).

In Brazil, for example, the aspects that characterize family agriculture include:

> "property management by their owners, kinship links between the manager and workers, primarily family labor, capital belonging to the family and residence of family members on the agricultural land" (Abramovay, 1997).

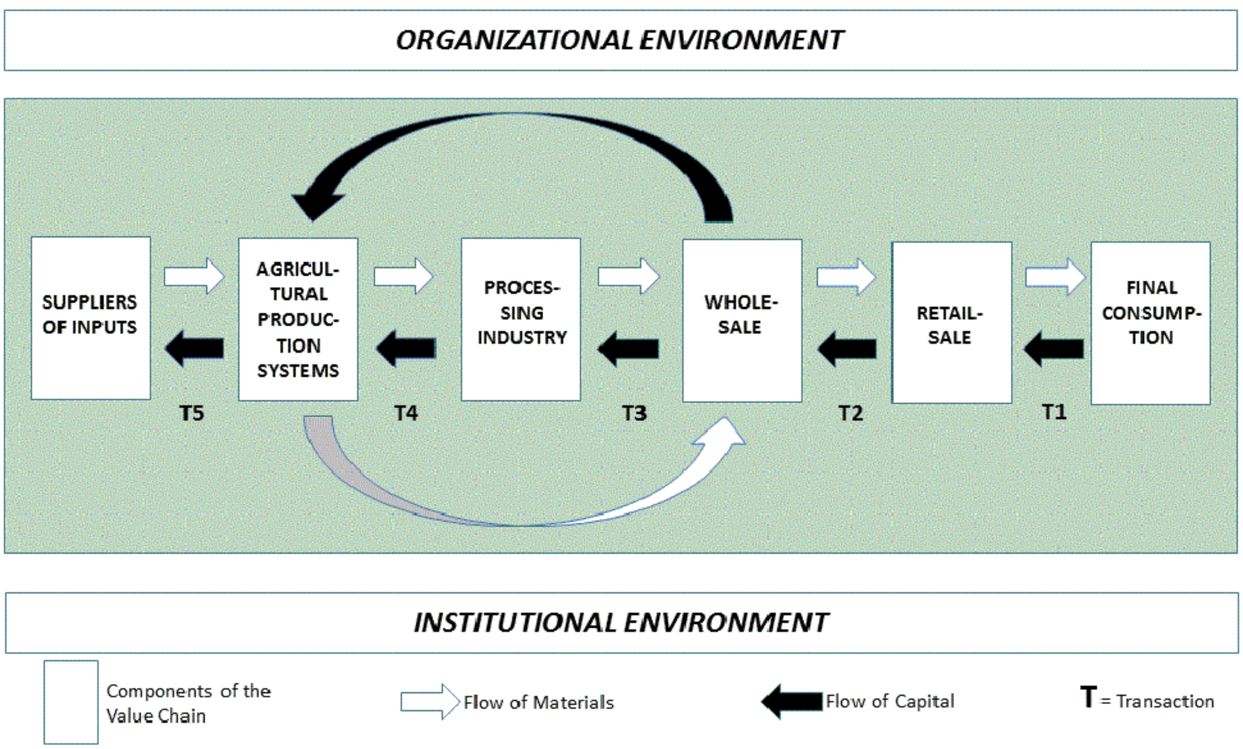
- **Commercial Agriculture**: The expression "commercial farming" is used as an opposite to family farming. The polarization has as its focal point the type of labor and management employed. If, in family mode, agriculture is predominantly dependent on family labor, in commercial mode, the farm depends essentially on permanent and / or temporary employees. The work of the establishment is directed to be exercised by professional contractees.
- **Subsistence Agriculture**: Subsistence agriculture is a mode that has as main objective the production of food to ensure the survival of the farmer, his family and the community in which he lives. In other words, it aims to meet the food needs of rural families. It is necessary to avoid confusion between subsistence farming and family farming, the latter of which in many cases is largely linked to the market.
- **Market Agriculture**: As opposed to subsistence farming, market agriculture is the form of agriculture in which production is destined to be sold and self-consumption is a secondary consideration. It can be intensive or extensive.
- **Agricultural System:** This is a set of production operations, processing, storage, distribution and commercialization of inputs and agricultural and agroforestry products. It includes support services and aims to meet the needs of the final consumer in terms of goods, services and product derivatives linked to agricultural and forestry activities.
- **Production System**: This is a structured set of the means of production (labor, land, equipment, etc.) combined to ensure production of crops and / or animals in order to meet the goals of the owner of the productive unit" (Jouve, 1999: 37).
- **Organizational Environment**: This is one of two components of the external environment of the value chain. It refers to all the various organizations that act directly or indirectly upon the value chain. These include educational organizations, research, extension, information, technical assistance, finance, marketing, cooperatives, companies (firms), and agencies of development, credit and supervision.
- **Institutional environment:** This is the second of the two components of the external environment of the value chain. It represents the set of institutions that influence the value chain directly or indirectly. Among these are laws, regulations, standards, culture, traditions, customs, habits, and macroeconomic and sectoral policy.
- **Value chain**: This is the set of interactive components, including production systems, suppliers of inputs and services, processing and transformation industries, distribution and commercialization agents, as well as the final consumers. It aims to meet the needs of the final consumer in terms of certain products or by-products (Castro et al., 1994; Castro et al., 1996a).

In Figure 2, we can observe the main components of a typical agricultural value chain. Highlighted are its most common components, ie, the consumer market, composed of individuals consuming the final product (and who pay for it), the network of wholesalers and retailers, the processing and / or transformation industry of the product, agricultural operations, with their various agricultural or agroforestry production systems and suppliers of inputs (fertilizers, pesticides, machinery, tools and other services) (Castro, 2001).

Between these components, there are multiple transactions evidenced by two types of flows. On the one hand, there is the flow of materials that will link the inputs from suppliers in the direction towards the end consumers. On the other hand, there is the flow of capital that runs the opposite direction, ie, the link starts with the end consumers and flows toward the input suppliers.

The existence of the external environment should be noted. Formed by their organizational and institutional aspects, this environment influences the components of the chain and affects their performance as a whole.

Figure 2. Main components of a typical agricultural value chain



Source: Adapted from Castro, 2001

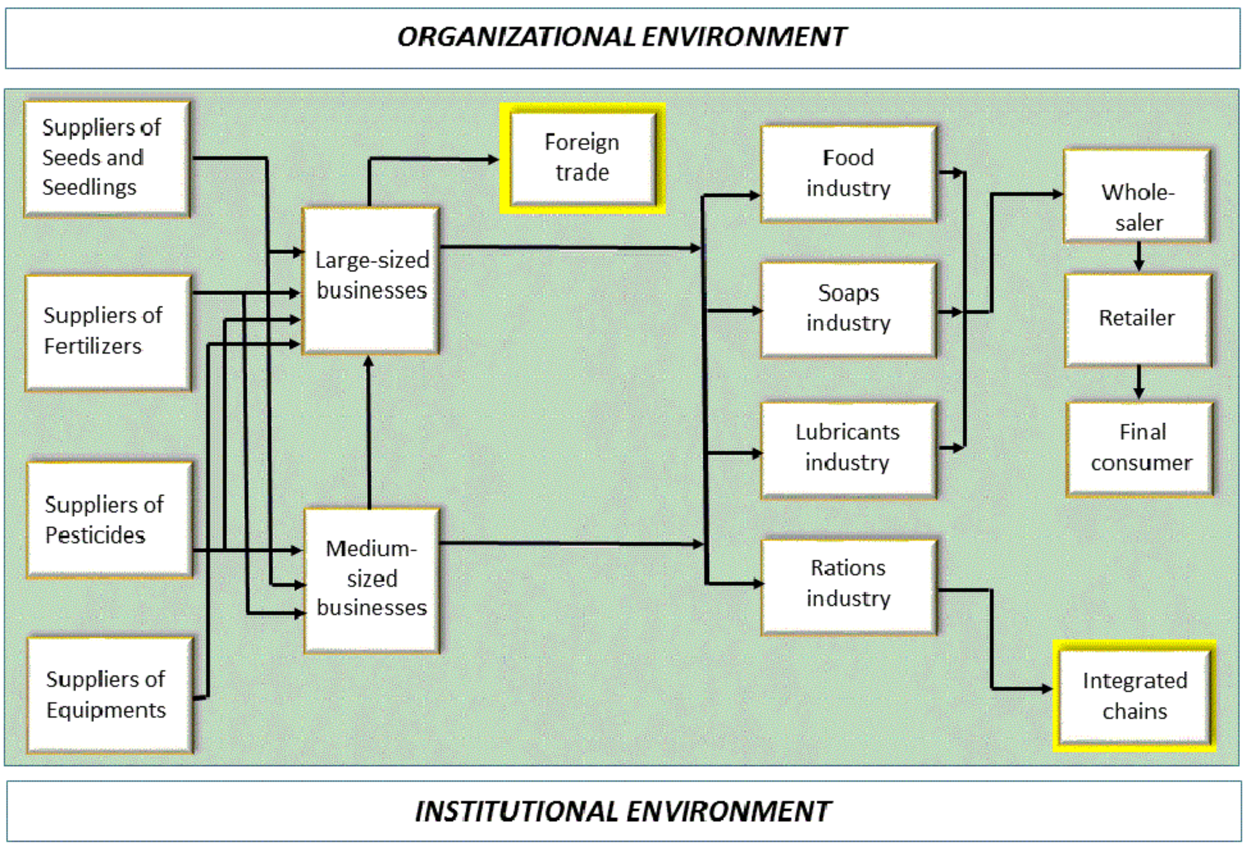
3. Graphical Representation of the Value Chain

Figure 3 is an example of graphical representation of a value chain. Observing its contents and structure, it is possible to understand how the chain works in the real world.

The value chain has five components: input supply, primary production, agribusiness, trade and consumption. The first four are segmented. The input supply component consists of four sub-components: seed / seedlings, fertilizers, pesticides and equipment. The primary production component contains two sub-components: large and medium-sized businesses. The agribusiness component is divided into four sub-components: food, soaps, lubricants and rations. The trade component comprises three sub-components: foreign, wholesaler and retailer. The last component (the consumer), not being segmented, is considered homogeneous.

The interpretation of the figure shows that in this value chain, small and micro-sized producers do not exist. Primary production is destined not only to internal use but also to foreign trade. Another important aspect to highlight is the integration of the chain with others through the sub-component of the rations industry. It should also be noted that the figure mentions the organizational and institutional dimensions of the external environment of the value chain.

Figure 3. Example of a segmented flow diagram of the agricultural value chain



Source: Adapted from Lima et al, 2000, cited by Castro, 2001

As shown in the figure, the flow of capital is not included. This is a delicate operation that requires a difficult task of getting very specific data. For example, in some regions, localities or communities, it is not easy to ask the informant directly about the use of their financial resources. Still, it is not possible to forget that the use of indirect questions has the potential to help estimate the capital flow.

The construction of such a figure, or the simplified representation of reality of a value chain, requires implementing a suitable methodology. In this sense, here follow proven methodological procedures.

- **Literature review**: When one starts the graphing of a value chain, it is necessary to make a brief review of the literature on the functioning of agricultural production systems in the region. Such a revision is intended primarily to collect available data and information and to identify social actors (individuals and organizations) involved. Thanks to data and information, the types of agriculture (family versus commercial, subsistence versus market) practiced in the region can be characterized.

- **Preliminary contacts with surveyed actors**: Actors identified in the literature review have the potential to facilitate the identification of other actors currently involved in the value chain. Thus, it becomes possible to estimate the size of the universe of those involved in the region and list the different components and sub-components of the chain as well as its main activities.

- **Fast agro-ecological zoning of the area under study**: This consists in defining homogeneous agricultural areas based on climate and soil factors (Mettrick, 1994). The first step to do this is to analyze the geographical maps of the area. Second, is to undertake visits to the production areas to achieve a greater technical understanding of them. Third, information is collected together with professionals (researchers, analysts, extension, etc.) operating in the agricultural sector.

  Such zoning allows the division of the area of production into blocks according to characteristics such as soil type, rainfall, etc. It is not an exhaustive approach but helps the project team to identify agro-business opportunities for different sub-regions of that area.

- **Collection and analysis of data and information on agricultural production systems:** For this, a questionnaire needs to be drawn up to collect information and data on the various activities performed in production systems such as agriculture, livestock, trade and/or extraction of natural resources. Interviews are conducted with informants based on a sample defined not in terms of quantitative representation but on the basis of qualitative representation. In other words, the sampling is based on the diversity among production systems. The information and data are collected on the spot, ie at the production units. The analysis and interpretation of that data and information takes place through descriptive methods using various tools such as literary exposition, tables, matrices of priority and frequency or distribution graphics.

- **Functional typology of production systems**: The generation of a typology is meant to group production systems which have a similar function, ie a similarity in terms of objective, strategy and limiting factors (Mettrick, 1994). It then facilitates the formulation of recommendations for the production systems studied.

- **Interviews with actors in other components of the value chain**: These include interviews with experts, input suppliers, processors, distributors and consumers involved in the value chain. For each of these components, a specific questionnaire is to be drawn. Before applying these questionnaires, a list is to be drawn up of informants from indications given by local organizations with different social purposes, working in the value chain. These organizations can be chosen during the technical visits undertaken to better understand the region.

Ideally, the list of informants will include representatives of each component. The experts are ideally professionals with a global vision of the value chain, such as teachers, rural extension workers, civil servants, etc. Input suppliers are producers and sellers of resources needed to produce the main product of the chain and its derivatives. The processors are employees and / or owners of businesses such as restaurants and food processing industries. Distributors are employees and / or owners of supermarkets, grocery stores, and other points of sale in street markets. Consumers are potential or actual buyers of the main product and its derivatives for consumption.

From this list, a statistically valid sample is defined through a mediation technique and the saturation point criteria: Data collection is carried out based on specific questions raised about the very role of each actor in the value chain. Treatment and analysis of data and information collected are performed in order to detect contradictions, conflicts and similarities between the results of the interviews.

- **Study of the organizational environment**: To study such an environment, various activities are carried out. First, organizations that have been active in the region are listed. Then interviews are conducted with representatives of these organizations. The essence of such interviews is concerning services currently provided in the region. Also, information is to be gathered on prospects for new services. All this information is likely to contribute to characterize the potential generation, transmission, adoption, application and accumulation of technologies in the value chain.

- **Study of the institutional environment**: The study of this environment involves various activities. First, bibliographic and internet searches are performed. Then interviews are carried out with representatives of public authorities such as ministries, municipal departments and regulatory agencies. The information that needs to be collected is that which is related to topics such as tax laws, legislation concerning economic incentives, labor laws, land reform, environmental legislation and quality standards and food safety. These types of information have the potential to facilitate the characterization of the performance of the actors involved in the value chain at a macro-environment level.

4. Conclusions

Understanding the nature and functioning of the reality of the agricultural sector is made possible when performed in systemic perspective. The components of this sector are interconnected. It would be hard to imagine the development and strengthening of an isolated component or sub-component. Therefore, transactions between the components or sub-components of a value chain are necessary.

A chain can not have all the above mentioned components. A product may have a short flow when, for example, it exits the production establishment to arrive directly at the consumer's table. In such a situation, ie when there is a lack of one or more of the components of the value chain, the chain is considered incomplete.

Chain integration is another situation often observed. An agricultural chain is built when his product becomes an input for another chain. For example, one can cite the example of the integrated chains of poultry and corn, or swine and corn.

Thanks to the graphical representation, it is possible to see the internal dynamics of the value chain, expressed by physical flows of goods and services needed to obtain the final products sold. Also, the representation reveals relationships of dependence and dominance between the different actors in the chain. Another important aspect of the graphical representation of the value chain is the interpretation of the occurrence of value-additions to the products of the chain in order to observe, for example, the adequacy of prices paid to small producers. Based on these considerations, the study of agricultural value chains is a real source for guiding entrepreneurs' strategies, smallholders' organizational mechanisms, and sectoral and macroeconomic policies.

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CHAPTER 8

The Tomato Value Chain in Moamba District: A Graphical Representation and Structural Analysis

Armindo António Quilambo, Hélder Zavale, André Yves Cribb & Isabel Sitoe Cachomba

1. Introduction

Small and medium producers of food crops, including vegetables, contribute more than 90% of the total area planted to food crops in Mozambique. In the 2011/2012 agricultural year about 1.4 million small and medium-sized farms, around 37% of all farms, produced vegetables, and about 21% of vegetable producers marketed their production. The majority of small and medium-sized farms produce tomatoes, kale and/or onion (IAI, 2012).

Data from the baseline study conducted in 2013 as part of the Trilateral project to support food security in Mozambique (a partnership between Mozambique, Brazil and the United States also known as PSAL) which covered five districts of Maputo province (Moamba, Boane, Matola, Ka Mavota and Ka Mubucuana), revealed that, of the 616 households surveyed, 212 produced tomato in the 2012/2013 agricultural year. It was also observed that the district of Moamba had the greatest number of tomato producers (84 in total).

Horticultural crops have an important place among food products consumed in Mozambique. According to the Household Budget Survey (IOF), conducted in 2008, this is most evident in the provinces of Inhambane, Gaza and Maputo with respective consumption shares of 40%, 38% and 21%. Yet analyzing the monetary value spent on vegetables and fruits, Maputo province (at 2.3 million MZN) stands out as the most important, followed by the provinces of Inhambane (1.4 million MZN) and Gaza (around 1.0 million MZN) (IOF, 2008). Therefore, it is important to better understand the value chain of this crop group.

This study aims to analyze the value chain of tomato in the district of Moamba. To do this, various links and segments that make up its structure are identified. Then a graphical representation shows how all these actions contribute to reveal the functional characteristics of the value chain as well as the main constraints and opportunities related to the supply of tomatoes in the local markets and in the city of Maputo.

2. Study Data and Methodology

This study uses the exploratory Rapid Rural appraisal research method based on the trilateral project baseline survey data conducted in 2013. The survey covered five districts of the city and province of Maputo, namely: Ka Mubukwane, Ka Mavota, Matola, Moamba and Boane, and collected extensive information at the household level. This information includes a) demographic information; b) the frequency, location and formality of input acquisition channels; c) methods used for vegetable irrigation, and d) points of sale of the final product. Due to different production systems in the *zonas verdes* (Ka Mubucuana, Ka Mavota and Matola), compared to Moamba and Boane, the sample was stratified to represent each system individually, with sample sizes of 344 for the *zonas verdes*, and 272 for the districts of Moamba and Boane. This study was restricted only to the Moamba district where 164 households were interviewed.

In addition to the secondary data used from the baseline study of the trilateral project, primary information was collected on the marketing and agro-processing of tomato in Moamba district, where in addition to the observations made on these visits, four tomato producers and two technicians of the district services of economic activities (SDAE) in this area were interviewed.

3. Tomato Value Chain in Moamba

3.1 Graphical Representation of the Chain

Figure 1 shows the components of the value chain and the relationships between them. It is important to observe that the figure clearly distinguishes the product flows and money generated within the chain.

3.2 Description of Components and Chain Flows

The value chain of tomato in Moamba has four links: supply of inputs, production, marketing and consumption of tomato. Relationships develop among these links evidencing two types of flows, each of which is oriented in the opposite direction in relation to the other.

Supply of inputs

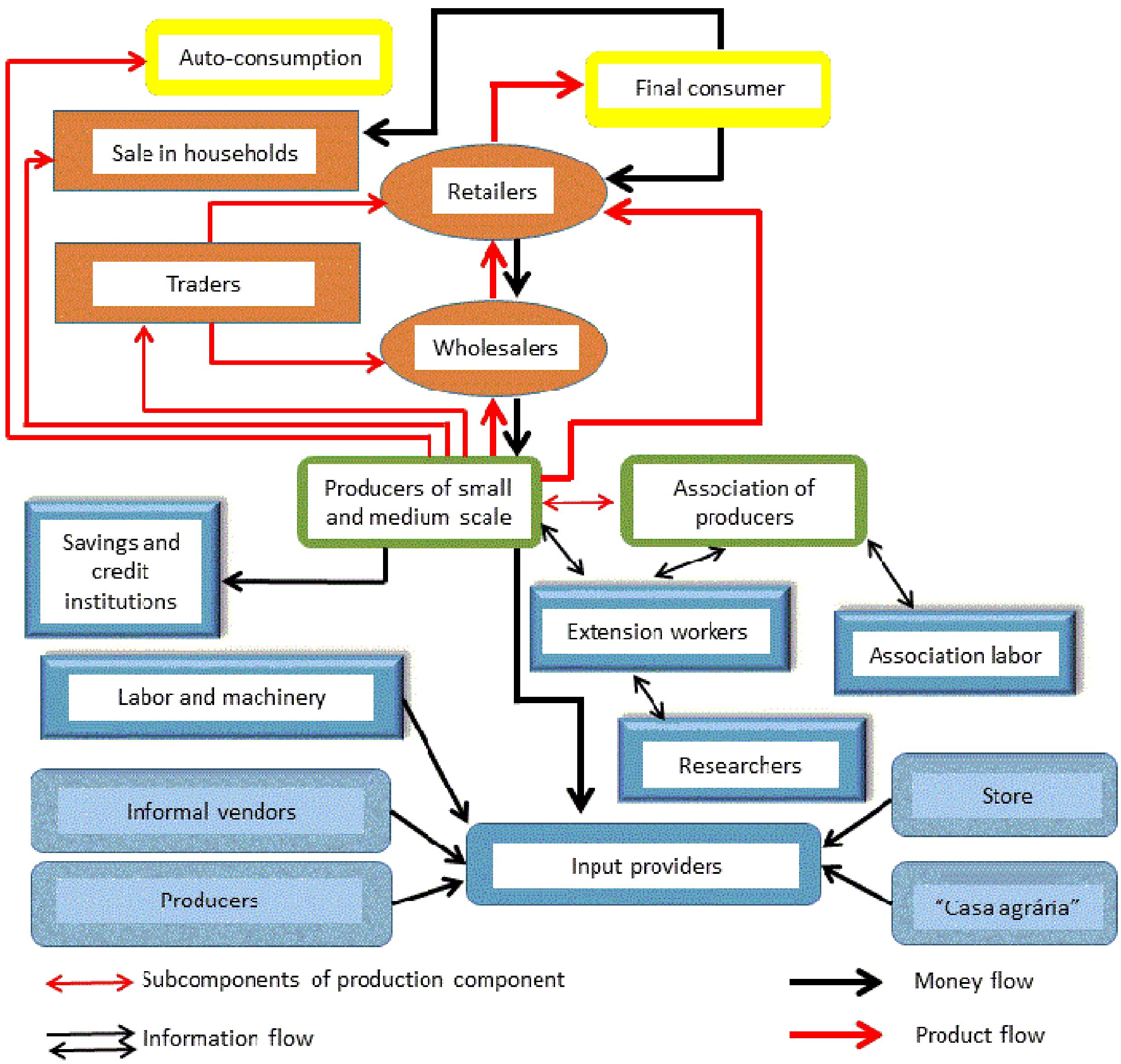
The link represented in blue in figure 1 comprises the provision of inputs and support services. Input providers include formal and informal vendors of inputs including the Provincial Directorate of Agriculture (DPA), the District Services of Economic Activities (SDAE), those families and other laborers that form the organzation of agricultural associations, and agricultural equipment providers. Highlighted among support services provided are input financiers, the Agrarian Research Institute of Mozambique (IIAM), and extension-workers.

Data from the 2013 baseline survey show that primary purchase locales for seed in Moamba district are: stores (52%), street merchants (21%) and state-owned *casa agrária(s)* (16%). The Hygrotech store was most popular in terms of seed purchases in Moamba district among tomato producers. 52% of farmers who bought seed at stores, made their purchases at Hygrotech, followed by PANNAR at about 19%, and Agrifocus - in third place, with 15% of the producers of Moamba purchasing there.

Support services such as the Agricultural Research Institute of Mozambique (IIAM) and public extension services have played a key role in the dissemination of varieties and production techniques. The other key players are the providers of land preparation equipment who are completely funded by private producers at a rental cost of 750 MZN per hour of machine use, a cost that producers consider high.

Interviews carried out with extension workers in the district of Moamba revealed that every year, at the beginning of each agricultural season, the DPA and SDAEs have organize agricultural fairs, selling agricultural inputs at subsidized prices, including a variety of vegetable seeds and equipment, such as hoes, machetes, rakes, axes, sprinklers and sprayers. However, the 2013 baseline survey data indicate that only one respondent obtained seed at one of these fairs. According to the producers interviewed in the tomato value chain study, this may be due to the fact that the fairs often sell low quality seeds.

Figure 1. Description of the tomato value chain in Moamba district



Tomato Production

The production of tomato is performed by producers of small and medium scale and their respective associations of producers. This link is represented in Figure 1 in the color green. Tomato production in Moamba district is characterized mainly by cultivation in the cool season which begins in late March. This is because during the cool and dry season, crops suffer less from pests and diseases given the favorable climatic conditions.

Inputs commonly used in the production of tomatoes in Moamba district are seed, labor, pesticide, organic and inorganic fertilizer. The tomato varieties used in Moamba are mostly hybrid varieties (22% HTX14, TX 8%, and 4% F14), with higher requirements of inputs. Under optimal growing conditions, these varieties have the potential to produce 90-120 metric tons per hectare.

Some small capacity farmers operating with individual irrigation along the rivers grow certain varieties such as Big River (11%), Rio Fuego (6%) and Cal J (4%). Open-pollination varieties are less demanding in terms of inputs and have a potential of up to 60 metric tons/ha under optimal growing conditions. However based on the baseline survey data, of the majority of farmers who buy seed in stores, about 37% show having little knowledge about the varieties they used.

Producers have different forms of access to land in the district of Moamba, to mention specifically those that were assigned land by the association (27%), assigned land by relatives (18%) and those who occupied the land in good faith (13%). One tomato producer of the 84 respondents in the district claimed to have purchased her land, however according to the land law in Mozambique, this is not a legal practice given land is considered state property and hence cannot be sold.

Among the households interviewed in Moamba, only 10% had access to credit (corresponding to 16 households). Access to credit in Moamba district is weak due to various constraints (lack of credit facilities with net interest rates lower than the market as a way to encourage and guide investment for the tomato production sector). Sixty-three percent of households interviewed in the district of Moamba used savings from their production as their source of financing for the purchase of seed, seedling, pesticide and fertilizer. In terms of the percentage of households, the other two most important sources of financing for the purchase of inputs were off-farm work at 20% and donations at 9%.

Processing and Marketing

The actors involved in the marketing of tomato are comprised of wholesalers, retailers, traders and producers who sell part of their production in their homes. This link is illustrated in Figure 1 in the color orange. According to the 2013 trilateral baseline survey data, the marketing of tomatoes produced in Moamba district takes place in a dispersed way. There are no accumulation centers or processing and storage facilities where value is added, and thus little opportunity for these producers to exploit the most demanding consumers of their fresh produce in terms of its quality-requirements -- consumers such as supermarkets and hotels.

According to the 2013 trilateral baseline survey data, over 70% of tomato growers in Moamba district sold their production. The tomatoes produced in Moamba are marketed soon after harvest. This can be explained by the lack of an agro-processing industry and tomato storage infrastructure in the district.

After harvest, the tomato crop passes through a selection process in the field where it is divided into quality categories (first, second or third). First and second grade tomatoes are allocated into boxes of 20 kilograms with target markets of Maputo and other local district markets, while third grade tomato is for immediate consumption. At a district level, the point of sale for the tomato sold by Moamba producers spans from at farm-gate (54.1%), the railway station (5.0%), the markets in Moamba (5.0%) and the residences of local producers (3.3%). In Maputo city, the point of sale included Fajardo market with 3.3%, and Zimpeto,wholesale market with 64%. The latter boasts the greatest market share of sold product.

The wholesale segment of Maputo city is basically defined by the markets of Zimpeto and Fajardo. The retail segment, on the other hand, is diversified , therefore has not yet managed to achieve greater centralization. This is seen in the great number of formal and informal traders in the markets and surrounding areas of Maputo where tomatoes are sold wholesale, together with retail traders who purchase tomatoes from them to supply the various formal and informal markets in Maputo city and province

.

The wholesale market of Zimpeto is the largest trading center of the tomatoes produced in Moamba district, however the pricing of products is based on a scheme known as the "vote", which prevents domestic producers, including Moamba producers, from fixing the prices of their products according to their field production costs. Because this is the largest sales center of agricultural products in the province and city of Maputo, domestic producers that sell here are forced to compete for space and with the prices of import product agents, especially those importing from South Africa.

The importers of tomato from South Africa often pay intermediaries to fix the prices to be charged by domestic producers. This act takes place through the "vote," a domestic production marketing price adjustment process (often this adjustment is initiated by the importers) to equalize the domestic prices with the prices applied by the importers. In Moamba, retail sale occurs in local markets, in the homes of producers and the railway stations.

Consumption

According to 2013 Trilateral baseline survey, about 30% of households interviewed did not market their production. This unsold portion inludes post-harvest loss and tomato intended for household consumption. According to Ribeiro & Rulkens (1996), there is a preference for tomato varieties with lower water content in Mozambique (the preferred variety of the industry), because these have a longer storage life. Tomato producers in Moamba have a preference for these varieties due to their lack of appropriate infrastructure for storage after harvesting.

4. Conclusion

The results of this study allow us to conclude the following:

- The tomato value chain in Moamba district comprises only one sub-sector, namely the subsector of fresh tomato, and this subsector is characterized by poor co-ordination between the different links of which it is comprised.
- There are four main links, or intervention points, in the tomato value chain in Moamba district: producers of small and medium scale; input providers and support services to production; marketing; and consumption.
- The main tomato trading markets of production in the district are:

- In Moamba: at farm-gate, in local markets, in producers' residences and at the railway station of Moamba
- In Maputo city: at the wholesale market of Zimpeto and the market of Fajardo

4.1 Constraints in the Tomato Value Chain of Moamba

Land preparation:

- Lack of producers having mechanized equipment;
- Lack of a rental park for land preparation services and machines
- High cost of rental machines and services funded entirely by few private producers

Inputs:

- High cost of quality seed acquisition
- The low quality of seed sold at subsidized prices in the fairs organized by the DPA and SDAE in the district of Moamba at the beginning of each agricultural season negatively affects the income of producers by contributing to low productivity of their product.
- Informal sale of toxic inputs which are banned in the country and may be associated with future public health and the environmental concerns.

Support services:

- Difficulty accessing credit;
- Scarcity of financial services for farming, and among those that do exist, high interest rates which do not facilitate access;
- Poor coverage of extension services and market information provided by the district services of economic activity in Moamba;

Production losses in field:

- Pest attacks and crop diseases
- Theft

Processing:

- Lack of the agro-industry link for proper tomato processing
- Lack of adequate cold storage facilities for the accumulation and consequent increase in product shelf-life, and improper handling during transport causing high post-harvest losses of product
- Weak product-processing, also at the artisanal level

Markets:

- Uncertainty of the selling price at harvest time
- Proximity to South Africa as a major producer can discourage local production due to imported products and lower prices that these vendors set in relation to national tomato sales.
- Seasonal availability and low priceswhich are more evident in the cool and dry season when production is subject to lower incidence of pests and diseases;

4.2 Opportunities in the Tomato Value Chain of Moamba

- Soil and climate conditions favorable to tomato production particularly in the cool season with lower incidence of pests and diseases;
- Disclosure of the nutritional importance that tomato has in preventing various types of cancer (prostate cancer, breast cancer, etc.) can incentivize the government to design policies oriented to the construction of storage and processing facilities for tomato;
- The expansion of the banking system combined with the production of risk-sharing formal and informal contracts is an opportunity for more farmers to have access to credit;
- The proximity to South Africa may allow producers to acquire high quality agricultural inputs, not available in the local market, at affordable prices.
- Selected, cleaned and packaged tomato has increased demand in relation to the tomato currently provided, which can be sold at relatively higher prices and meet greater demand from higher quality consumer channels.

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CHAPTER 9

Costs of Production in the Agricultural Sector: Characterization and Calculation

André Yves Cribb

1. Introduction

All productive initiative must have survival and/or competitiveness-oriented behavior to ensure its sustainability, or better stated, to ensure the continued existence of its activities. Such behavior can be individual or collective. In the capitalist environment, individualism and collectivism are not incompatible strategies. Both can coexist in an enterprise. For this reason, so-called "co-opetition” is gaining popularity in recent years, a concept formed by the junction of the words "co-operation" and "competition".

Co-opetition refers to the work of production establishments together with competitors in such a way that these establishments are able to benefit from their competitors' skills and distinctive features (Cabrera, 2014). This definition makes abundantly clear the importance of the cooperatives and the associations which serve as approximate mechanisms in ensuring the sustainability of production establishments in their respective product markets. As a productive behavior strategy, co-opetition has advantages and disadvantages. At the top of the list of advantages comprise increased production capacity, a reduction in investment effort, greater flexibility, greater speed in accessing technologies and easier access to new markets. Disadvantages include the difficulties of clearly defining rights and obligations, the lack of cooperation “spirit”, and the risk of know-how exposure.

From the perspective of sustainability, all productive establishment, existing individually or collectively in a competitive environment, must adopt strategies aligned to market behavior which, by definition, symbolize the encounter between supply and demand for their products. Because of this need, market relations are usually analyzed and interpreted by the laws of supply and demand. According to this law, the price to be paid for a particular product is basically defined as the result of the confrontation of consumer interests with those of the producer and determined by the balance between the quantity demanded and offered of the given product. This equilibrium is affected by many variables such as the price elasticity of the product, the structure of the market, producer expectations and consumer preferences.

Prices are usually fixed within a given range, defined on the one hand by consumer income, and on the other, by the cost of producing the product. Indeed, if the consumer is not willing to pay a price compatible with her income, the producer seeks to recover at least the product's most basic production cost[8].

[8] Remember that, especially in the international market, there may be “dumping”. This is a commercial practice consisting of offering products for sale at a price lower than the domestic market. Such practice occurs for a limited time in order, for example, to dispose of a surplus or beat competition. The better-known cases of dumping are repressed by national governments and have been resolved within the World Trade Organization (WTO), which severely condemns the practice (Wolffenbuttel, 2006).

Within this logic, the production cost is a fundamental factor in the formation of the selling price. The comparison of the "price obtained on the basis of production cost" with the "market price" determines the degree of convenience in investing in the production and marketing of a product. The first must be at or below the second. If it is higher than the second, productive strategies should be reconsidered.

The cost of a product can be calculated for a production establishment or a geographic area, which may be a locality, region, country, etc. When it is just a productive establishment, it suffices to thoroughly list all its manufacturing operations and allocate their prices. But when it is a geographical area, one must remember the existence and interaction of various production operations and adopt methodological procedures that allow the calculation of a cost of production representative of the market's production factors as a whole.

In this study, the main features of production costs are highlighted and procedures for its caluculation according to the geographic area approach are explained. In this sense, the distinction between production costs and other expenses is discussed. Components of the production cost are also identified. After this, the proper procedures for calculating the costs of production are described. And finally, recommendations deemed necessary for the successful determination of the cost of production are given within the geographic area approach.

2. Differentiation of production costs from other expenses

The literature on financial management of business establishes differences between expense, loss, waste and production costs[9]. The consideration of this distinction helps to avoid errors at the time of characterizing and calculating the cost of production.

- **Expenses:** These are recognized as the expenses occurred in the process of income generation and maintenance of the business (eg, taxes, freight and commissions).
- **Loss:** These are understood as abnormal or involuntary expenses that do not generate a new good or service, nor revenue and are included directly in the results of the period in which it occurs (eg, material with its period of validity expired; expenses incurred in the period of halting production due to a shortage in input supply, problems with equipment, floods, accidents, etc.).
- **Waste:** This is defined as expenses incurred in the production process which can be eliminated without jeopardizing the quality or quantity of goods or services (eg. repairing due to manufacturing defects, unnecessary movement of materials).
- **Production cost:** This is understood as the expense for the production of goods and services (eg. raw materials, auxiliary materials, production labor, maintenance, depreciation, etc.).

Despite these theoretical differences, the single term "cost" is used in practice or in the day-to-day, to designate all of these types of expenses. Cost is indispensable for the existence of any business. All activities related to the implementation, renewal, and conduct of an enterprise in the market require the purchase of resourceswhose use is carried out in return for payment. In this regard, costs are fair or normal. But costs begin to become problems when they are fattened by loss and waste. In this event, they come to be called unjust or abnormal costs because they exceed the standard set by the state of the art in

[9] Each of these four concepts (expenses, loss, waste and production costs) can also be called "expenditures" defined as general consumption of goods and services. In other words, the expenditure may be classified as expense, loss, waste and cost of production (Perez et al., 2001).

the production area. The excess in the production cost hinders the efficiency of productive and commercial factors; and, over time, destroys the economic and financial viability of the business.

The cost of production can be seen not only as the result of producer spending, but also as a valuable indicator of opportunities for improving the management of productive establishments, risk prevention initiatives, public policies and government programs. In any economic sector of a given geographic area, the characterization and calculation of production costs are essential for targeting private and public performance strategies.

In fact, the calculation of the cost of production in productive establishments is mainly a mechanism to allow for the entity to meet the accounting and tax requirements imposed upon it, eliminate losses and waste, adjust the process of managerial decision making and optimize results (Perez et al., 2001). With regard to risk prevention initiatives, crop insurance companies are interested in following the evolution of production costs, seeking to characterize the losses to properly set, for example, coverage levels for natural disasters. With respect to public policy, a very clear example in some countries is the establishment of guaranteeing minimum prices for certain products, stimulating the need to determine the average cost per sales unit of certain crops. About government programs, it is common, for example, to estimate costs before the start of the operations of soil preparation to support decisions in the process of determining the amount of resources needed to finance the crop in terms of agricultural credit (Conab, 2010).

3. Components of Production Costs

Both in agriculture and in other economic branches, the realization of any business requires the application of financial resources. Such applications are carried out with a view to obtaining benefit streams throughout the business lifetime. The necessary resources are used for investment and operational expenses purposes[10].

In the case of investment resources, it is any expense or economic sacrifice whose effects relate to the life of the business project.. In other words, these effects not only correspond to a cycle of production or trade.

An investment can occur at the start of a business or at some point in its life. In the first case it is called a deployment investment. In the second case, it is renewal investment. In general, investment resources are related to the acquisition of durable factors, such as machinery, equipment, buildings, land, vehicles, furniture and utensils. These resources determine the installed capacity of the project.

About operational expenses, these are costs that can be allocated to a specific period of business life, for example those that help improve the capacity utilization level of the business. They are also called costs and are generally classified under two criteria[11]: a) their characterization in the product; and b) their

[10] See Cribb (2006)

[11] Other classification criteria of costs exist, but are relatively little used. For example, the classification of costs can be performed with respect to the payment flow during the period, generating: a) costs with monetary disbursements as in the cases of rents, wages and taxes; and, b) costs without monetary disbursements as in the case of depreciation

variation with production and sale volumes.

1) **Due to their characterization in the product:** The way in which available resources are allocated for the production of a product gives rise to a highly suggestive classification of its costs. As such, costs can be direct or indirect.

   a) Direct costs are costs that can be qualified and identified directly in the product or service and valued relatively easily, via their physical composition or their production and commercialization process. Thus, these do not need criteria for the identification of the resources allocated to the product or service, as they are easily identified. Generally, direct costs include:

      i. **Direct materials**: raw materials, packaging materials, components and other materials needed for production, finishing, presentation and commercialization of the final product.

      ii. **Direct labor**: wages, social charges and provisions for vacation and 13th month salary (applied directly in the production of the product or provision of services).

   b) Indirect costs are costs that, because they are not clearly identified in the product or service may not be attributed directly to the product or service performed. Therefore, the use of an apportionment criteria for their allocation is needed. These are as follows:

      i. **Indirect materials:** materials used in auxiliary production activities, or whose relationship with the product is irrelevant. Examples: greases and lubricants used in the maintenance and cleaning of machines; materials used for cleaning production sites.

      ii. **Indirect labor:** work performed but not measurable in any product or service performed. Examples: spending on personnel responsible for the safety or the maintenance of equipment, for planning and control, for supervision, etc.).

2) **Due to the variation with production and sale volumes**: This criterion creates what is called "proportional classification". Fixed costs and variable costs are generally distinguished on this basis. In some cases, certain expenses are commonly said to be semi-fixed and semi-variable costs when there are difficulties in their classification.

   Fixed costs are costs that remain constant within a given capacity and depend on production volume. A change in the volume of production more or less does not alter the total amount of these costs. Examples: salaries and social charges of indirect labor, board fees, rents, insurance, depreciation, amortization deployment costs, maintenance costs, interest on long-term loans, interest on capital, etc.

   Variable costs are expenses that maintain a direct relationship with the volume of production or

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and portions of social charges constituted by expenditure forecasts that may or may not occur (Cribb, 2006).

service. Thus, the absolute value of the variable cost increases as the volume of business activity increases. In most cases, this growth in the total variable costs evolves in proportion to the increase in the quantity produced. Examples of variable costs include wages and social costs of labor, direct labor, raw materials, secondary materials, packaging materials, taxes, banking, interest on short-term loans, advertising, electricity, fuels and lubricants.

4. Production cost calculation procedures

In calculating the cost of production, it is necessary to establish a formula to be adopted, the different phases of the work and the methods of data and information collection. These three actions are interconnected.

- **Formula usually employed**:

Cost of Production = PVPF X MTC

Where: the PVPF is the price vector of production factors, generally expressed in monetary value; and the MTC is the matrix of technical coefficients, expressed in quantities (CONAB, 2010).

Factor prices are also called input and service prices. They are the prices which are part of the production process, ie, the average prices actually charged in the locality or country of study. They usually vary frequently, requiring periodic surveys to assess their changes during the production cycle. The price data for these rates may be obtained by: a) expert and producer panels; b) research in the areas of production, from the suppliers of production factors; and, c) interviews with public and private organizations recognized in the collection of such data.

A technical coefficient is the physical relationship between the amount of inputs spent to produce a certain quantity of product. Both inputs as well as the product output are quantified considering the production cycle as the period of calculation. The technical coefficients are amounts generally expressed with reference to area unit (ha). Table 1 presents a few examples of technical coefficients.

Table 1. Example technical coefficients

Types of Technical Coefficients	Modes of Expression
Fertiliizers	ton/ha
Seed	kg/ha
Pesticide	liter/ha
Machinery and equipment	hour/ha
Human or animal labor	day/ha

Source: Prepared by the author

- **Key operational phases**:

The cost of production is essentially a reflection of the adopted technological standards and of the availability of the factors used in the different environmental situations of the geographical area that serves as the context for the operation of its calculation. Identification and characterization of the production cost involve several dimensions (accounting, economics, rural sociology, agronomy, animal science, food engineering, etc.) and therefore require a multidisciplinary team. Such peculiarities significantly influence the process of calculating the cost of production and demand the planning of its implementation which comprises the following phases:

a) Creating a team responsible for calculating the cost of production;
b) Raising awareness among the populations concerned to solicit interest regarding the importance of such calculations;
c) Reviewing the literature regarding production factors and costs;
d) Characterizing technological standards adopted in the geographical area;
e) Leveling the knowledge of team members;
f) Pursuing the collaboration of various organizations, such as universities and research centers, organizations representing farmers, factories for agricultural and agroindustrial machinery and equipment, and government agencies focused on agricultural and rural development;
g) Achieving adequate work procedures;
h) Constructing an action plan;
i) Surveying technical coefficients and prices of production factors;
j) Analyzing and interpreting the information and data collected;
k) Elaborating the final report.

➢ **Methodological resources for data and information collection in the field:**

A geographical area may not be homogeneous in nature and availability of production factors. Therefore, it is necessary to think of the possibility of different agro-ecological zones within that area. Such diversity associated with the multiplicity of production cost dimensions justifies the need to adopt several methodological resources. Under these conditions, it becomes relevant to use the triangulation of methods in order to verify the convergence, corroboration and correspondence of the results[12]. Main methodological features used in this approach include:

a) Agro-ecological zoning of the geographical area under study;
b) Construction of samples;
c) Questionnaires to collect data and information;
d) Panel of experts;
e) Interviews with producers.

5. Conclusion

Survival and / or competitiveness is a key requirement for the continued existence of any productive enterprise. Strategies adopted must be aligned with the market behavior in which the business is taking place and the stability of the market must also be able to be influenced by production cost behavior.

In a given geographic area, it is important to be aware of the production cost of the main productive activities. Such knowledge has the potential to facilitate improved management of private business and public initiatives.

The production cost is relevant in all sectors of the economic system and, especially in the agricultural

[12] For questions about the concept of triangulation, see Creswell & Clark (2011).

sector. It deserves to be thoroughly addressed within a strategic and multidisciplinary approach since it is an important management tool and involves multiple dimensions. Its characterization and its calculation require procedures based on appropriate tools, techniques and methods.

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CHAPTER 10

A Case Study of Lettuce, Kale, Tomato and Onion Gross Margins and Costs of Production Among the Horticultural Producers Supplying Maputo

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Using data from the 2014 horticultural multiple visits study conducted as part of the trilateral partnership between Mozambique, Brazil, and the United States, this chapter characterizes the costs, sales and gross margins of lettuce and kale in the *zonas verdes* of Maputo, and of onion and tomato in the nearby districts of Moamba and Boane supplying Maputo's horticulture market. A typology of ranked technological sophistication of the farmers included in this study is used to disaggregate and compare the results. Findings indicate that within each technological sophistication bracket, higher costs spent are correlated with less gross income earned. The greatest cost of those earning the largest gross margins per kilogram harvested across crops is for seed and/or seedling, and these farmers also evidence an increased share of costs spent on labor, particularly salaried labor. Producers in the *zonas verdes* tend to sell a greater share of the harvest they produce in comparison with producers in Moamba and Boane. And finally, costs spent on pesticide are generally low across all groups, however the producers that spend the most on pesticide per kilogram of product harvested tend to be characterized by less appropriate perceptions of pesticide toxicity and generally poorer pesticide management behavior.

1. Introduction

Cost of production estimates are useful for measuring producer spending, however they also serve as valuable indicators of opportunities for improving the management of productive establishments, risk prevention initiatives, public policies and government programs. In any economic sector of a given geographic area, the characterization and calculation of production costs are essential for targeting private and public performance strategies (Cribb, *forthcoming*). In this chapter, I characterize the costs, sales and gross margins of lettuce and kale in the *zonas verdes* of Maputo, and of onion and tomato in the nearby districts of Moamba and Boane supplying Maputo's horticulture market, using data from the 2014 horticultural multiple visits study conducted as part of the trilateral partnership between Mozambique, Brazil, and the United States. A typology of the farmers is then used to disaggregate and compare the results.

2. Production Areas and Sample

The horticultural production areas of the districts of Matola, Ka Mubucuana, and Ka Mavota are normally referred to as the *zonas verdes* of Maputo. Production in this area often takes place within or near the administrative boundaries of the municipality and is dominated by very small farmers (typical land holding of 0.1 ha), producing primarily green leafy vegetables under individual irrigation. The districts of Moamba and Boane, in contrast, are primarily characterized by centralized irrigation areas (*blocos*) in which farmers with larger land areas produce tomato, onion, cabbage, and other horticultural crops. A less numerous group of farmers in Moamba and Boane operates with individual irrigation along the rivers, outside the *blocos*. We refer to this latter group as the dispersed producers of those districts. Land holdings among both these types of farmers average 2.3 ha. (Cairns et al., 2013)

Because of the distinctly different production systems in each zone, the sample was stratified to represent all producers with less than five hectares of land cultivated with horticultural crops in each zone. The dispersed producers of Moamba and Boane most commonly appear among the least technologically sophisticated farmers in those districts. Lettuce and kale (commonly known as *couve*) were selected as the crops of study within the *zonas verdes* of Maputo (ZV), and tomato and onion as the crops of study within the districts of Moamba and Boane (M/B), on the basis of the highest frequency of crops produced in these respective areas. These crop cycles are spread across 4 "clusters" of farmers ranked according to a range of indicators of technological sophistication per the typology of farmers created using the data from the baseline study conducted by this same project in 2013 (see table 1).

Table 1. Crops and ranked clusters considered in this study (1 representing the group of least technologically advanced producers)

Typology	Crop				
Cluster	Kale	Lettuce	Onion	Tomato	Total
1	0	0	2	4	6
2	1	4	0	0	5
3	4	5	0	0	9
4	0	0	4	3	7
Total	5	9	6	7	27

As the majority of farmers in Moamba and Boane fell in the highest and lowest groupings across this spectrum, only producers from these areas were selected from clusters 1 and 4 for the study. Similarly, as the majority of the farmers in the *zonas verdes* fell in the two middle groups, only producers from the *zonas verdes* were selected from clusters 2 and 3. See chapter 3 of this report for more detail on how this typology was formed, and features that characterize the farmers in each group. There are 5 kale cycles, 9 lettuce cycles, 6 onion cycles and 7 tomato cycles across the cluster groupings included in this study. Each crop cycle captures all activities beginning with land preparation and planting, and ending with harvest of the area planted.

3. Gross Margin Estimates by Crop

Of the 4 selected crops of this study, tomato production varied the most in terms of gross margins, and so this group of crop cycles was divided into two separate groups – tomato cycles by producers in cluster 1, the least technologically sophisticated group, and those on the other end of the spectrum, in cluster 4. Gross margins per kilogram of product harvested are greatest for tomato by cluster 4 farmers (median 5/9 mzn/kg), followed by onion (by cluster 1 or 4 farmers, median ~5/6 mzn/kg), kale (3/4), lettuce (1.5/2) then tomato by cluster 1 farmers (-1.5/.5), see table 2.

Gross margin estimates vary greatly among the tomato cycles represented given many of these producers have difficulties selling in the markets at high enough prices to justify their costs and/or are not able to overcome the pressures of pests and diseases affecting these more susceptible crops. Evidently however, producers of tomato in these areas that are able to achieve a successful harvest have some of the greatest per kilogram gross margin estimates of the cycles considered in this study.

Gross margins per square meter of product harvested are greatest for kale (median 14/16 mzn/m^2), followed by lettuce (6/7 mzn/m^2), tomato by cluster 4 farmers (3/5 mzn/m^2), onion (~1 mzn/m^2) then tomato by cluster 1 farmers (-.5/.2 mzn/m^2). This is because the kale and lettuce producers of the *zonas verdes* tend to cultivate small areas of land, but very intensively.

Table 2. Gross margin estimates by kilogram and square meter of harvested crop, by crop group

			Gross Margin (MZN/kg)				Gross Margin (MZN/kg), including labor			
Area	Crop Group	Obs.	Mean	Median	Min	Max	Mean	Median	Min	Max
Zonas Verdes	Kale	5	4.3	4.2	2.2	5.7	3.8	3.9	1.4	5.7
	Lettuce	9	2.8	1.9	-0.5	8.9	1.5	1.4	-5.8	8.9
Moamba/ Boane	Onion	6	7.2	6.3	3.0	14.1	5.1	5.4	-5.9	14.1
	Tomato-Clust 1	4	-2.2	1.0	-15.2	4.4	-3.4	-1.4	-15.2	4.4
	Tomato-Clust 4	3	6.6	8.8	-0.7	11.7	4.1	5.4	-1.8	8.8
			Gross Margin (MZN/m^2)				Gross Margin (MZN/m^2), including labor			
Area	Crop Group	Obs.	Mean	Median	Min	Max	Mean	Median	Min	Max
Zonas Verdes	Kale	5	16.5	16.4	10.1	23.4	14.6	14.0	6.6	23.4
	Lettuce	9	11.2	7.5	-2.2	38.4	6.3	6.4	-23.7	38.4
Moamba /Boane	Onion	5	1.5	0.9	0.5	4.0	1.1	0.7	-0.7	4.0
	Tomato-Clust 1	4	0.0	0.2	-1.4	1.0	4.0	-0.6	-0.6	-1.4
	Tomato-Clust 4	3	3.9	5.6	-0.1	6.3	2.6	3.4	-0.3	4.7

*Labor includes an estimate of the portion of salaried permanent help as well as temporary or contracted labor for crop-related activities. It does not include a valuation of family labor.

Table 3. Median standardized costs and sale values by crop group

Costs and Sales (MZN/Kg harvested) (medians)										
Crop	Obs.	Seed	Seedling	Fertilizer	Pesticide	Other	Salaried Work	Temp/ Contracted Labor	Total Costs	Total Sale Value
Kale	5	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.9	5.6
Lettuce	9	0.0	0.3	0.4	0.1	0.0	0.0	0.0	2.9	5.3
Onion	5	1.5	2.2	0.7	0.0	0.3	0.0	0.3	7.3	13.4
Tomato-	4	2.8	3.5	2.3	0.0	0.0	0.0	0.0	8.5	9.5
Tomato-	3	0.0	1.2	0.2	0.4	1.3	0.8	0.4	6.4	11.8
Costs and Sales (MZN/m^2 harvested) (medians)										
Crop	Obs.	Seed	Seedling	Fertilizer	Pesticide	Other	Salaried Work	Temp/ Contracted Labor	Total Costs	Total Sale Value
Kale	5	0.0	0.6	1.3	0.4	0.0	0.0	0.0	18.4	20.1
Lettuce	9	0.1	1.0	1.4	0.5	0.0	0.0	0.0	21.3	22.6
Onion	5	0.3	0.1	0.1	0.0	0.1	0.0	0.2	1.9	2.2
Tomato-1	4	0.6	0.4	0.4	0.0	0.0	0.0	0.0	2.5	1.3
Tomato-4	3	0.0	0.5	0.1	0.1	0.3	0.5	0.2	2.1	6.8

Table 4. Cost shares by crop grouping

Cost	Kale	Lettuce	Onion	Tomato-cluster 1	Tomato-cluster 4
Seed & Seedling	21%	45%	52%	59%	28%
Seed	2%	20%	24%	30%	2%
Seedling	18%	25%	28%	29%	27%
Fertilizer	42%	17%	20%	19%	3%
Pesticide	9%	18%	0%	0%	5%
Other, including transport	1%	0%	12%	0%	15%
Labor	27%	20%	15%	22%	49%
Temporary	0%	2%	15%	18%	19%
Permanent	27%	17%	0%	4%	30%

Table 5. Median standardized costs and sale values by cluster

Costs and Sales (MZN/Kg harvested)									
Typology Cluster ID	Seed	Seedling	Fertilizer	Pesticide	Other	Salaried Work	Temp/Contracted Labor	Total Cost s	Total Sale Value
1	1.6	4.1	2.0	0.0	0.0	0.0	0.0	7.4	1.3
2	0.0	0.8	0.7	0.4	0.0	0.0	0.0	2.6	18.4
3	0.0	0.1	0.3	0.0	0.0	0.0	0.0	1.6	21.3
4	0.2	0.7	0.2	0.1	1.3	0.0	0.6	6.5	2.2
Costs and Sales (MZN/m^2 harvested)									
Typology Cluster ID	Seed	Seedling	Fertilizer	Pesticide	Other	Salaried Work	Temp/Contracted Labor	Tota l Cost	Total Sale Value
1	1.1	0.6	0.3	0.0	0.0	0.0	0.0	2.5	12.7
2	0.0	3.1	3.3	1.6	0.0	0.0	0.0	10.6	5.2
3	0.2	0.6	1.3	0.2	0.0	0.0	0.0	6.3	5.6
4	0.0	0.4	0.1	0.0	0.3	0.0	0.2	1.9	11.8

Table 6. Cost shares by cluster

Cost	1	2	3	4
Seed & Seedling	66%	19%	46%	34%
Seed	26%	0%	21%	16%
Seedling	40%	19%	25%	18%
Fertilizer	19%	31%	23%	13%
Pesticide	0%	32%	5%	2%
Other, including transport	0%	0%	1%	17%
Labor	15%	18%	25%	34%
Temporary	12%	4%	0%	21%
Permanent	3%	14%	25%	13%

To contextualize these overall estimates, the median total costs and sale values per kg and per m^2 for each crop category are shown in table 3 at the end of this report. Per kg costs are greatest among the cluster 1 (least developed) tomato cycles (8.5 mzn/kg harvested), followed by onion (7.3), cluster 4 tomato (6.4), lettuce (2.9) then kale (0.9). Costs per square meter however tell a different story, with onion cycles having the least total cost per square meter (1.9 mzn), followed by cluster 4 tomato (2.1), cluster 1 tomato (2.5), kale (18.4), then lettuce (21.3). Similarly, total per kg sale values (before costs are taken into account) are greatest for onion cycles, followed by cluster 4 tomato, cluster 1 tomato cycles, kale then lettuce. Total per m^2 sale values are greatest for lettuce, followed by kale, cluster 4 tomato, onion then cluster 1 tomato. It is interesting to note, however, that when costs and sales are isolated by clusters (grouping both crops within each cluster), higher costs spent are correlated with less gross income earned (table 5).

4. Cost Estimates by Crop and Cluster

Producer's reported costs are divided into the following categories and standardized by quantity of product harvested: seed, seedling, fertilizer, pesticide, salaried work, temporary/contracted work, and other. (See tables 3 and 5).

Among these, costs are greatest for fertilizer in the case of kale and lettuce producers in terms of value spent (.3 and .4 mzn per kg respectively, or 1.3 and 1.4 mzn per m^2), and correspondingly, the greatest share of the expenses among kale cycles is for fertilizer (42%), followed by permanent labor (27%). The greatest share of the expenses among lettuce crop cycles however is for seedling (25%), followed by seed (20%, compared to fertilizer at 17%). Cluster 2 producers of lettuce and kale spend close to 3 times more in total value on fertilizer than cluster 3 producers -- a median 3.3 mzn per m^2 of product harvested (0.7 mzn per kg harvested) compared to a median of 1.3 mzn per m^2 (0.3 mzn per kg). And whereas cluster 3 producers spend the greatest share of their expenses on combined costs of seed and seedling (46%), cluster 2 producers, those characterized by very average levels of appropriate perceptions and pesticide-use precautions (especially compared to their cluster 3 counterparts), spend the greatest share of their expenses on pesticide (32%), spending 4-8x greater per unit value on these as well, followed by a 31% cost share spent on fertilizer (see tables 5 and 6).

Although pesticide costs are smallest across the cost categories and crop cycles considered in this study (never more than .4 mzn/kg harvested), the cycles of lettuce evidence the greatest share of pesticide applied across all cost categories – 18% compared to 9% for kale, 5% by tomato cluster 4 producers, and 0% for onion or tomato cluster 1 cycles (table 4).

Costs are greatest for seedling in the case of tomato and onion producers in terms of value spent, followed by seed. Seedling costs are 3.5, 1.2 and 2.2 mzn per kg harvested for tomato cluster 1, 4 and onion cycles respectively. The greatest share of expenses among both onion and tomato cluster 1 producers, correspondingly, is for seed and seedling (combined at 52% and 59% respectively - table 4), with this share rising to 66% for seed and seedling for cluster 1 producers overall (table 6). Tomato and onion sellers in cluster one (the least technologically advanced farmers) spend 5 times greater median values for seedling than those in cluster 4 - a median value of 4.1 mzn compared to 0.6 mzn per kg of product harvested.

The largest costs in the "other" costs category are also found among the tomato and onion cycles. These costs include transport, fees to use water pump, renting a tractor or the per-season applied cost of a new sprayer, watering can or any other equipment purchased for use on the farm. For cluster 4 tomatoes, this per kg cost is slightly greater than the cost for seedling (1.3 mzn/kg harvested), driven primarily by the costs of transporting large quantities of product to the market, and occupies a 17% share of the cluster's overall cost portfolio.

Salaried or contracted/temporary labor costs are among the lesser of the costs attributed to these crop cycles generally, in value spent and in terms of shares although these costs do not include the obvious omission of any valuation for family labor on the farm (when 86% of the time at least 2 family members are reported to be involved in horticultural farming as their primary activity and many more reported having secondary help from additional family members as well according to the data from the baseline study). No crop category exceeded a combined 27% cost share for labor costs except for cluster 4 tomato cycles, where a combined share of 49% of the expenses incurred are spent on temporary (19%) or permanent (30%) labor, the greatest combined share of expenses for this group (table 4). Among the cluster 4 cycles overall (including the cluster 4 onion cycles), the same shares of cost are spent on temp/perm labor as on seed/seedling, both at a 34% share, in contrast to cluster 1 producers which spend a clear majority of their expenses on seed and seedling alone (66%), and only 15% on labor, primarily for temporary work (table 6)

5. Shares of Harvest Sold

Compared to the other areas in our study supplying Maputo's horticultural market in the peri-urban *zonas verdes*, producers in these two nearby districts typically have larger plots of cultivated land. Even the producers living in these areas which are grouped in cluster one, the least technologically advanced farmers, have average areas of land dedicated to the selected crop of interest of 170 square meters, in comparison with the farmers in the *zonas verdes* considered more technologically advanced, who have average areas of cultivated land of 14 square meters in cluster 2 and 15 square meters in cluster 3. For comparison, farmers in cluster 4 included had an average 280 square meters of land dedicated to the crop of interest, 15-20 times the size of the plots in clusters 1, 2 and 3.

Given the generally larger land sizes in Moamba and Boane, it is perhaps not surprising to have found that the greatest costs these producers have in their tomato and onion production tends to be seed (or seedling). Tomato and onion seed in these areas are purchased primarily from stores or other formal channels (such as a state-owned *casa agrária*) in the agricultural areas in which they farm, although also occasionally from stores in South Africa, and no clear difference in per gram seed prices was found in this study among different channels from which seed was purchased (formal or informal, in or outside the city).

Whereas producers of lettuce and kale in the *zonas verdes* tend to sell a greater share of the harvest they produce (less goes to waste or personal consumption, gift-giving, etc) compared to producers of onion and tomato in Moamba and Boane (see table 7), regression analysis does show that holding constant which crop was produced, the more land a producer has in cultivation and the more that he spends on seed, the greater the share of her harvest she manages to sell. Those spending the most on seed however (the tomato and onion farmers in M/B) are by in large earning the least in net profit from their sales. Given that producers in M/B with larger land plots are further from the city and have much greater transport expenses than those in the *zonas verdes*, we can speculate that this is likely because these farmers simply don't have the same benefits as producers located within or very close to the city limits in terms of market access, and have to deal with the many associated transaction costs involved in getting their product to market or to the consumers that might be most willing to pay higher prices for them.

Table 7. Share of harvest sold by crop

	Kale	Lettuce	Onion	Tomato
Share sold is greater than 2/3rds	100%	89%	50%	71%

Lastly, regression analysis indicates that the purchase of any other input besides seed has a negative (although insignificant) relationship to share of harvest sold. Note that this could potentially indicate that applying less pesticide is weakly correlated with greater shares of harvest sold, and likewise, that those applying greater amounts of pesticides are not selling as much of their harvest, which might be a sign of pest resistance due to excessive pesticide used. According to Snyder et al., 90% of farmers in the *zonas verdes* of Maputo are using highly toxic chemicals on their horticultural crops (76% in M/B), and are cropping intensively with little crop diversity. Also, those in the lower clusters of technological sophistication (and pesticide management practices) are using twice the rate of the active ingredient than those in the upper clusters. These factors all contribute to greater evolving pest resistance and the felt need to apply increasing levels of more toxic pesticide (Snyder et. al 2015).

6. Discussion

Implications of this study confirm that horticultural producers closest to the city are those standing most to gain in terms of gross margins given their proximity and facilitated access to centers of consumption, while producers in M/B benefit from their large areas of cultivated land in terms of the scale of their operations and the diversification of the crops they grow. For neither group of farmers is the increase of input purchases recommended (except in the case that additional land could be obtained in the *zonas verdes*), rather benefits that have not been explored in the current analysis could exist for minimizing the amount of inputs applied. Minimizing pesticide use among producers of lettuce and kale in the *zonas verdes*' cluster 2 seems to be called for in particular, where farmers are spending the greatest portion of their collective per kg harvest costs on pest prevention, 6 times the share and 4-8 times the amounts spent by their more technologically advanced cluster 3 neighbors, while at the same time are generally characterized in comparison as possessing lower levels of literacy to read product labels (less than 50%), wearing less protective clothing (if it all) while spraying (less than 50% using protective clothing other than boots), and adhering more loosely to other recommended pesticide behavioral protocol (Cairns et al., 2013).

Finally, this study corroborates the evidence emphasizing the importance of an improved post-harvest value chain, especially for the farmers in nearby districts to Maputo who could supply more of the demand of the city, given transaction costs could be minimized. Improved road infrastructure, cold-chains, information exchange, and perhaps the reduction of intermediaries along the value chain could be recommendations in this regard.

7. References

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