ANALYSIS OF ADOPTION AND PRODUCTION OF ORANGE-FLESHED SWEETPOTATOES: THE CASE STUDY OF GAZA PROVINCE IN MOZAMBIQUE

By

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ABSTRACT

ANALYSIS OF ADOPTION AND PRODUCTION OF ORANGE-FLESHED SWEETPOTATOES: THE CASE STUDY OF GAZA PROVINCE IN MOZAMBIQUE

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Vitamin A Deficiency is a major threat to women and children's health in Mozambique. In 2000, the Ministry of Agriculture and Rural Development launched a program to multiply and widely distribute vines of orange-fleshed sweetpotato varieties (OFSVs) to smallholders throughout the country. Since sweetpotatoes are grown and consumed by almost all small farmers, it was anticipated that widespread farmer adoption of OFSVs would have a major impact on reducing vitamin A deficiency.

Farmers (150) who had received vines in 2000 of recently-released OFSVs were surveyed to assess the adoption rate and investigate the key factors determining farmer adoption of the nutritionally-improved sweetpotato varieties.

Major factors associated with adoption include sweetpotato cultivated area, participation in field days/demonstration activities, number of OFSVs grown by farmers, and the number of times the respondent received vines. To spur adoption of OFSVs, it is recommended that more resources should be allocated to post-harvest research to identify appropriate storage and processing techniques, market opportunities for processed sweetpotato products, and effective ways to link OFSVs growers to potential processors and output markets, and funding to rehabilitate soil drainage systems in lowlands.

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KEY TO ABBREVIATIONS

AVRDC	Asian Vegetable Research and Development Center
CAP	Agriculture and Livestock Census
CEF	Center for Forestry Experimentation
CIP	Centro Internacional de la Papa (International Potato Center)
CRC	Caritas Regional Chokwe
DDARD	District Directorate of Agriculture and Rural Development
DNER	National Directorate of Rural Extension
FAO	Food and Agriculture Organization (of the United Nations)
GDP	Gross Domestic Product
GOM	Government of Mozambique
HKI	Helen Keller International
ICRW	International Center for Research on Women
IFPRI	International Food Policy Research Institute
IIAM	Mozambique Institute for Agricultural Research
IITA	International Institute of Tropical Agriculture
IMF	International Monetary Fund
INE	National Institute of Statistics
INIA	National Institute for Agronomic Research
INIVE	National Institute for Livestock Research
IPA	National Institute for Animal Production
IPC	International Potato Center

LWF	Lutherans World Federation
MADER	Ministry of Agriculture and Rural Development
MAF	Ministry of Agriculture and Fisheries
MISAU	Ministry of Health in Mozambique
MSU	Michigan State University
NGO	Non-Governmental Organization
OFSPVs	Orange-Fleshed Sweetpotato Varieties
PEM	Protein Energy Malnutrition
PROAGRI	National Agricultural Development Programme
SARRNET	Southern African Roots Crops Research Network
SIMA	Agricultural Market Information System
SINSE	Integrated National Extension System
SAP	Structural Adjustment Program
SSA	Sub-Saharan Africa
STC	Save the Children
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VAD	Vitamin A Deficiency
VITAA	Vitamin A for Africa
WFSPVs	White-fleshed Sweetpotato Varieties
WHO	World Health Organization
WRS	World Relief Services
WV	World Vision

CHAPTER I

INTRODUCTION

1.1 Background

During the past three decades, the performance of the agricultural sector in Mozambique has been drastically affected by more than 15 years of civil war (1975-1992), frequent occurrence of drought, and inappropriate macroeconomic and agricultural policies. However, between 1992 and 1997, agricultural production grew at an estimated average annual rate of 6.3 %, while marketed surplus through formal markets grew at an annual rate of 34 % (PROAGRI 1997). This substantial recovery in agricultural production has mainly resulted from area expansion and favorable climatic conditions, rather than an increase in productivity. Yield levels continue to be low and below the average levels for Sub-Saharan Africa (SSA), as shown in Table 1 (Mucavele F, 1998).

Table 1: Average Yields of Principal Crops in Mozambique and Sub-Saharan Africa.

Commodity	Average yield (tons / ha)	
	Mozambique	Sub-Saharan Africa
Maize	0.3 – 1.3	1.2
Sorghum	0.3 – 0.6	0.8
Cassava	5.0 – 7.0	7.5
Rice	0.5 – 1.0	1.6
Beans	0.2 – 0.4	0.7
Cotton	0.3 – 0.6	0.8

Source: Ministry of Agriculture and Fisheries, PROAGRI, 1997.

One of the major challenges to Mozambique's economy growth and development has been the absolute poverty[1] of the vast majority of the population (80%), who typically lack access to markets and are dependent on subsistence rainfed agriculture (see Appendix A for a brief description of the main agroclimatic and socioeconomic features of Mozambique).

Poverty is a primary cause of widespread malnutrition in Mozambique, including Vitamin A Deficiency (VAD). For example, a multi-sectoral assessment, conducted in 2002 by several national and provincial Mozambican governmental institutions in selected areas of several provinces (e.g. Maputo, Gaza, Inhambane, Sofala, Manica and Tete) estimated that an average of 6.4 % of children 6 to 59 months old suffered from acute malnutrition. Gaza province exhibited the highest levels (11.2%), followed by Maputo (8%); and Sofala revealed the lowest level (4%), followed by Inhambane (4.6%). The study also found that 41 % of the targeted population (children 6 to 50 months of age) had received at least one dose of Vitamin A supplement during the second half of 2002. Sofala province exhibited the lowest percentage (27%) and Maputo the highest (56%)(GOM, 2003). For a detailed discussion of Nutrition Policy in Mozambique and recent studies that document the incidence of micronutrient deficiency, see Appendix B.

It is important to point out that in order to be effective, Vitamin A supplementation programs must be implemented twice a year. However, in countries like Mozambique, where the majority of rural population lives in a very scattered pattern and characterized by poor network of roads and undeveloped health system, Vitamin A

[1] In Mozambique, poverty is defined as the "inability of individuals to ensure for themselves and their dependants a set of basic minimum conditions necessary for their subsistence and well-being in accordance with the norms of society". The absolute poverty line is defined as the sum of a food poverty line (approximately 2,150 calories per person per day) plus an amount for non-food expenses per person per day that varies from province to province (GOM, 2001).

supplementation program is difficult to implement, expensive, and thus unsustainable. Alternatively, a food-based approach - which promotes a more diversified crop production including plants rich in β-carotene that is convertible to Vitamin A by the human body - has the potential to improve (qualitatively and quantitatively) the diet of rural population.

In the 1990s, scientists at the International Potato Center (CIP) identified a group of orange-fleshed sweetpotato varieties (OFSVs) with high content of β-carotene (a chemical element used by the body to generate Vitamin A) and sufficient dry matter to satisfy consumer preferences and taste. Subsequent studies demonstrated that the consumption of just small amounts of foods derived from the new OFSVs could eliminate or greatly reduce Vitamin A deficiencies in both young children and pregnant and lactating women (HarvestPlus, 2003). In 2001/02, an international crop-based initiative to combat VAD in Sub-Saharan Africa was launched —known as VITAA or Vitamin A for Africa— involving agronomists, health experts, and nutritionists. This initiative was aimed at expanding the impact of the OFSVs in seven countries: Kenya, South Africa, Tanzania, Ethiopia, Uganda, Ghana and Mozambique.

During 1999/2000 and 2000/01 cropping seasons, the National Institute for Agricultural Research (INIA), with financial and technical support of Southern Africa Root Crops Research Network (SARRNET), conducted two consecutive rounds of multi-location trials to evaluate different orange-fleshed sweetpotato clones with respect to total yield, commercial yield, weight of roots damaged by root rot, number of damaged roots, harvest index, dry matter content, and their adaptability across various agro ecological conditions of Mozambique. Based on the results of these trials, eight clones were selected, which performed well across a range of different environments (Andrade and Ricardo, 1999; Andrade *et al.*, 2002) (Table 2).

Table 2: Characteristics of Eight Released OFSVs.

Variety Name	Total yield (t/ha)[a]	Total yield (t/ha)[b]	% of marketable roots	Dry matter content (%)	Habit growth	Virus resistance
Caromex	15.3	6.5	55.9	22.7	Prostrate	Good
CN 1448-49	15.7	8.4	48.3	22.7	Erect	Good
Japon Selecto	14.5	6.6	44.7	21.6	Erect	Good
Jonathan	16.1	6.0	43.4	21.2	Erect	Moderate
Kandee	14.5	5.5	36.6	25.3	Prostrate	Good
LO 323	13.6	6.0	43.4	21.0	Erect	Good
Resisto	14.5	7.2	55.9	27.2	Semi-erect	Good
Taimung 64	13.9	6.0	48.4	20.9	Prostrate	Good

Source: Adapted from IITA/SARRNET, 2003 and INIA/SARRNET (undated).

[a] Average total root yield of trials carried out in 14 locations from January to August 1999.
[b] Average total root yield of trials carried out in 7 locations from July 1999 to February 2000 in the dry season, but irrigated until the plants were established.

In 2001, a two-year project—supported by USAID through the INIA/SARRNET project with multiple sources of funding, including IITA and CIP—was launched to alleviate the negative impacts of the adverse cycle of floods/drought on the rural economy and on food security in the affected districts of Mozambique by increasing the production of improved cassava and sweetpotato varieties. The project's target population was comprised of 500,000 smallholders, distributed over 65 districts in nine provinces. The project had five objectives: (i) to provide improved sweetpotato and cassava planting materials to farmers through the establishment of a well-coordinated network of project and partners fields in selected districts across the country; (ii) to promote widespread cultivation and use of orange–fleshed sweetpotato, envisaged to reduce the risk of VAD in Mozambique; (iii) to promote household utilization and agro-processing of both crops through demonstrations of the use of improved tools and machines at workshops and field days, and (iv) to establish cassava and sweetpotato variety trials in order to select clones best adapted to the major agro ecological zones of Mozambique (INIA-IITA/SARRNET, 2003).

According to the baseline national survey, which was conducted in 2002 in five provinces of Mozambique and included 1,476 respondents, sweetpotato-growing households averaged about nine persons and 53% of the growers were women. Of the sweetpotato-growing farmers interviewed, 50% acquired land through inheritance, 29% by arrangement with local authorities, 14% rented land, and only 5% bought land. About 83% of the sweetpotato producers consumed most of their harvested sweetpotato roots, 8% sold more of their harvested sweetpotato roots and leaves than they consumed, and 9% sold as much as they consumed. About 97% of producers consumed sweetpotato leaves. About 34% of the sweetpotato producers interviewed planted the recently-released OFSVs. Approximately 68% reported that they did not grow orange-fleshed varieties, due to unavailability of planting materials and 43% or because they did not like the taste of OFSVs. Interestingly, about one-third of the respondents reported that they grew OFSVs because they wanted to grow a variety that was sweet and high-yielding, wanted a variety rich in pro-Vitamin A, wanted to mitigate hunger, or just because they were given the vines by an NGO (INIA-IITA/SARRNET, 2003).

1.2 Problem Statement

Although it is fully recognized that agrarian societies have developed strategies to minimize the impact of adverse climatic conditions (e.g. floods and droughts), the efficiency of these coping and survival mechanisms is strongly dependent on a variety of household characteristics, including levels of knowledge and experience, gender of household head, family labor availability, off-farm job opportunities, and accumulated wealth. The main coping strategies applied by farmers include cultivating drought-tolerant crops, raising livestock for sale, fishing, seeking casual labor within their communities, and consuming wild fruits and tubers.

In Mozambique, as part of their strategy to insure household food security, women grow mostly white-fleshed sweetpotato varieties (WFSVs)—primarily for household consumption but also to generate cash income. Recognizing the potential of OFSVs to reduce VAD, in 2000 the Ministry of Agriculture and Rural Development (MADER) launched a program to multiply and distribute planting material (vines) of OFSVs to smallholders throughout the country. Since sweetpotatoes are grown and consumed by almost all small farmers, it was anticipated that widespread farmer adoption of these improved varieties would have a major impact on reducing VAD.

While the goals of the OFSVs program are laudable, there exists an on-going debate regarding whether or not African consumers would accept OFSVs. Some researchers argue that consumers will not adopt these varieties because they are either too watery and/or too sweet to meet local taste preferences (HarvestPlus, 2003). However, a recent study conducted by the International Center for Research on Women (ICRW) revealed that in Kenya, women would accept orange-fleshed varieties if the clones are sufficiently high in starch, low in fiber, and are introduced through community-level education programs that emphasized the health of young children.

Furthermore, some recent studies in developing countries revealed that the level and intensity of farmer adoption of agricultural technologies are governed by farmer socioeconomic characteristics, institutional arrangements, agricultural policy, and environmental factors (Adesina and Moses, 1993, Sanders *et al.,* 1996, Akhter and Rajah, 1992, Mbata, 2001). Thus, there is a need to investigate the key determinants of the adoption of OFSVs from both the supply and demand sides. This study is aimed at generating insights that will contribute to: (i) improving the reliability of technology development and transfer; (ii) strengthening the linkages between research and extension, and (iii) designing agricultural policy conducive to higher and more widespread adoption of available improved varieties--thereby increasing sweetpotato production, mitigating food insecurity, and reducing VAD.

1.3 Study Objective

The objective of this study is to assess the socio-economic and institutional factors associated with the adoption of OFSVs by smallholders in two districts of the Gaza province. Although it is recognized that the promotion of OFSVs rich in pro-Vitamin A is likely to generate reasonable health impact, an analysis of these health effects falls outside the realm of this study[2].

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[2] An on-going collaborative project involving the Nutrition Division of the Ministry of Health in Mozambique, Michigan State University, World Vision International, Helen Keller International, the National Institute for Agronomic Research and the Southern African Root Crops Research Network, is addressing VAD and inadequate caloric intake through dietary diversification, improved feeding practices and improved serum retinol status, particularly in young children under five years of age in Zambezia province.

The research questions to be addressed by this study are as follows:

1) What are the socioeconomic characteristics of sweetpotato-growing farm households?

2) What is the adoption rate of the available OFSVs and what are the major determinants associated with farmer adoption/disadoption of the recommended nutritionally improved varieties (e.g., characteristics of the variety, contribution to cash income, perception of nutritional benefits of OFSVs, educational level, household size and composition)?

3) Do traders offer sweetpotato sellers the same price, a lower price (price discount), or a higher price (price premium) for the roots produced from the improved OFSVs (compared to WFSVs) and why?

4) What institutional and agricultural policy interventions are needed to spur the rate of technology adoption and thereby increase sweetpotato production and household income?

5) Will increasing OFSV production sufficiently increase the bioavailability and conversion of β-carotene so as to alleviate VAD, or are additional initiatives needed?

1.4 Summary of Data and Research Methods

In order to achieve the objectives above mentioned, existing secondary data were collected and analyzed in order to gain insights needed to better understand the history of the introduction and distribution of OFSVs to farmers. Similarly, interviews with key informants were conducted to gain insights about the history of the OFSVs program, sweetpotato cropping patterns, and factors influencing farmers' decision in adopting OFSVs. This background information was used to design the farmer questionnaire to collect data on farmers' household characteristics, and production circumstances with emphasis on understanding the farmers' decision-making process in adopting the nutritionally improved OFSVs. In addition, data on sweetpotato roots sales were collected to determine the structure of the marketing channel, and gain insights about the magnitude of marketed surplus and producer prices.

A trader questionnaire was designed to collect data on basic sweetpotato trading characteristics, the retail prices of both orange and white-fleshed sweetpotato roots, and traders' knowledge and acceptability of the improved OFSVs.

A considerable amount of time was devoted to pretesting in the field both farmer level and trader questionnaires in order to improve the ability to gather the needed data.

The data collected from the farmer questionnaire were used for descriptive analysis of socio-economic characteristics of sweetpotato growers and sweetpotato cropping patterns. In addition farm and farmers' characteristics, and measures of the institutional environment in which sweetpotato growers operate were used as explanatory variables in the probit model to determine the key factors governing farmers' adoption of improved OFSV.

Finally, data collected through the trader questionnaire were used for a descriptive analysis of sweetpotato commercialization, and to determine whether or not traders paid a price premium for nutritionally improved OFSVs.

1.5 Thesis Outline

This thesis is divided into six chapters. Chapter II provides a general description of the agriculture sector in Gaza province, and the orange-fleshed sweetpotato multiplication and distribution program. Chapter III briefly reviews the literature on the bioavailability and conversion of β-carotene to retinol (Vitamin A), the impact of food-based interventions to mitigate VAD, and adoption of new agricultural technologies. Chapter IV presents the research design and methodology. Chapter V reports survey results and descriptive analysis of sweetpotato production and producers, consumption, commercialization, and producers' evaluation of OFSVs. Chapter VI presents the factors influencing farmer adoption of nutritionally improved OFSVs, the probit model specification for the adoption of OFSVs, and a discussion of the results of this binary-choice model. Finally, Chapter VII provides the summary of the major findings and draws policy implications.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

2.1 Agro-climatic Features

2.1.1 Soils

Southern Mozambique is mostly characterized by light/coarse-textured soils with low available water content (AWC). Approximately 50% of the area has soils with an AWC less than 100 mm/m and 25% have less than 50 mm/m. Thus, the risk of drought is extremely high and most of the area has over 50% chance of dryland crop failure (Reddy (1986). In order to mitigate these adverse growing conditions, farmers exploit the lowland areas in which the residual soil moisture can be effectively used for crop production. While crop failure in the upland zone is due mainly to frequent soil water deficits throughout the year, yield losses in the lowland areas are also common—due to flooding and excessive soil moisture during the erratic and irregular rainy season.

In addition, hydromorphic soils are found in areas of water seepage, at the lower slopes of the escarpments, which form the transition between the beach ridges and coastal margins, and low areas (e.g., flat marshy zones and swampy depressions). These soils are saturated with water, either permanently or during most of the year. This results in lack of oxygen, which slows the process by which organic matter is broken down by bacterial activity. Although some mineralization is caused by anaerobic bacteria, this is much less than under dryland conditions (Bleeker, 1983). The accumulation of organic matter gives rise to an organic peat horizon, which can vary from 0.4 to 1.0 m depth.

Two types of hydromorphic soils are found in southern Mozambique. First, the organic (peat) soils, called *machongos*[3], are generally very fertile and continuously wet, as they receive fresh water all year round through seepage from the surrounding dune areas due to high infiltration and high recharge rates. These soils—which have very good soil structure for plant growth, a high water holding capacity, a high soil aeration, and good workability—are intensively used for small-scale agriculture. However, excessive drainage can contribute to mineralization of the peat, resulting in soil acidification. Second, the hydromorphic sandy soils are less rich in organic matter than the *machongos*, but their water table is closer to the soil surface. Due to the similarity of these soils, in terms of occurrence, wetness/drainage, land use, and vegetation, farmers also commonly call them *machongos*.

Due to a high accumulation of organic matter and water saturation of those soils throughout the year, they commonly have an accentuated acid reaction (pH 3.8-5.5) due to the release of hydrogen ions (H^+) during the decomposition of organic matter (Gomes *et al.*, 1998).

Once drained, a variety of crops can be successfully grown on machongos--mainly rice, maize, beans, and vegetables. However, rice[4] is the main crop grown on these soils, due to its rooting system which is well adapted to waterlogged conditions and since rice is grown during the hot and rainy season, when the peat soils are likely to be

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3 The importance of *machongos* for small-scale agriculture in southern Mozambique has been recognized for a long time. Between 1951 and 1957, a total of 2,800 ha were identified, surveyed (scale 1: 10 000), developed, and distributed among 4,200 farmers in Gaza province (Monteiro, 1957).

4 Some farmers recorded yields of 1.9-2.8 tons/ha for rice in the *machongos* of Gaza province (Monteiro, 1957).

flooded. During the dry season, these soils are especially desired for vegetable production, including sweetpotato cultivation.

However, since these soils are quite fragile, due to the absence of the mineral component, mismanagement can lead to their degradation and permanent loss for agriculture (Dykshoorn *et al.*, 1988, Gomes *et al.*, 1998).

In order to investigate the impact of excessive field drainage on peat soil properties and to monitor the changes in pH values, a detailed soil survey in Manguenhane (Gaza province) was conducted in which samples at different soil depths were collected and exposed to a drying process (Mafalacusser *et al.*, 1997). This study, and others carried out previously (Monteiro, 1957; Dykshoorn *et al.*, 1988), identified basic principles for a sustainable management of these soils, as described by Gomes *et al.*, (1998):

- Shallow drainage must be encouraged in order to prevent the water table from falling lower than 0.2-0.4 m in depth; drain spacing and depth should be determined for each case, according to the physical conditions of each site. Drains should be dug by hand and artisanal gates can be used to control the water table at the farm level;
- Fields should be irrigated as frequent as possible in order to maintain high water content in the upper layers and decrease soil temperature, especially during the hot season. The water should flow from the high to the low end of the field in order to lixiviate the salts downwards and avoid adverse salinization;

- Technology based on intensive use of manual tools should be promoted, since the potential for mechanization is limited due to the low carrying capacity of these soils;
- Land clearing should avoid burning vegetation and crop residues, as it also destroys the peat topsoil; and burning should occur outside the *machongo* area or in selected places with high water table levels to avoid its spread. Ashes can then be spread on the soil surface to improve the soil nutrient status;
- Crop selection and rotation should consider the conditions of these soils (e.g. shallow water table and soil acidity). Rice is the most suitable crop during the rainy season, and vegetables (with shallow rooting system and with tolerance to acidity) are most suitable during the dry season. Depending on the depth of the water table, crops such as maize and beans can also be considered.
- Cultivation in mounds or hills permits the farming of some crops (for example sweetpotato) while the soil is still poorly drained.
- Mulching with crop or vegetation residues will reduce the effect of solar radiation in the oxidation and decomposition of peat layers.

It is important to point out that since there is always a risk of floods during the wet season, which if not taken into account, all investments will likely be lost. Thus, intensive maintenance of the drainage system is crucial for the sustainable use and development of these important soil resources.

2.1.2 Climate

In the southern provinces of Mozambique, the mean annual rainfall pattern decreases from 800-1,000 mm along the coastline to less than 400 mm in the interior of Gaza province (Pafuri), with the rainy period concentrated between October and April (Reddy, 1986). Due to this spatial and temporal rainfall pattern, the coastal zones are the most heavily populated and characterized by high land use intensity (Snijders, 1986). This high land use intensity associated with light/coarse-textured soils, low soil fertility and low water holding capacity, leads to progressively lower yields over time.

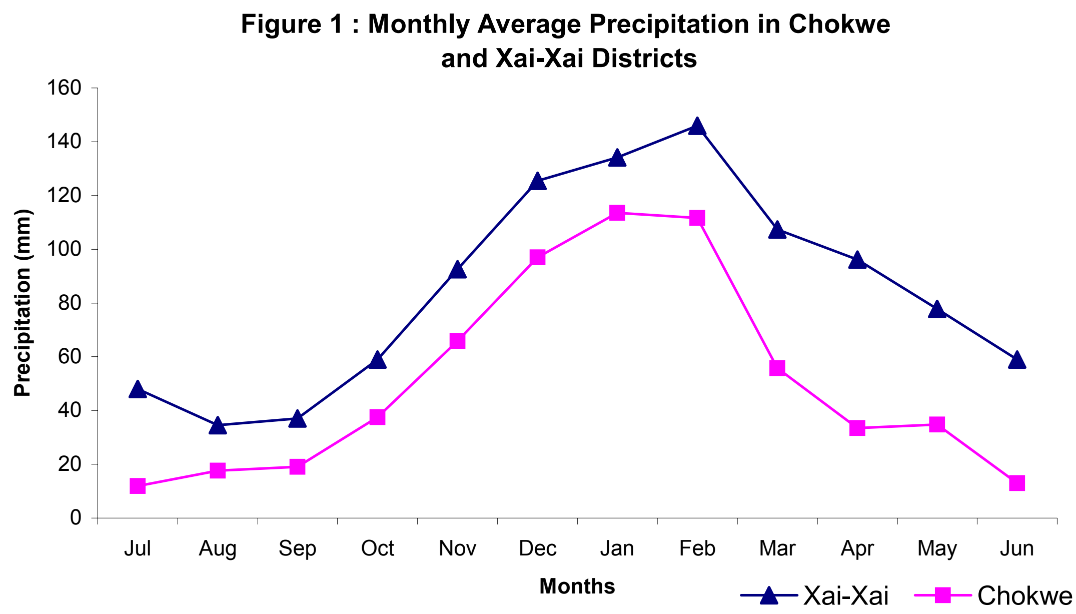
Analysis of more than a 30-years time-series data of Chokwe (1961-2000) and Xai-Xai (1951-2002), indicates that those two districts have different patterns of precipitation (Figure 1). Xai-Xai had relatively more total annual precipitation and more total precipitation during rainy season than Chokwe (Table 3). Although sweetpotato is considered to be a drought-resistant crop, optimum annual total precipitation is estimated at 750 -1,000 mm, with approximately 500 mm of rainfall registered during the growing season (Woolfe, 1992; Salunkhe et al., 1998).

Table 3: Descriptive Statistics of Total Annual Rainfall and Total Rainfall During Wet Season in Chokwe and Xai-Xai Districts (mm).

District	Description	Minimum	Maximum	Mean	Standard Error
Chokwe	Total Annual Rainfall	179.7	986.5	604.5	34.5
	Total during Wet Season	145.0	1009.8	500.4	31.5
Xai-Xai	Total Annual Rainfall	355.1	1744.3	1004.1	41.5
	Total during Wet Season	293.8	1395.0	748.7	36.8

Source: Survey 2004

According to Bouwkamp (1985), sweetpotato requires 18 mm/week during the initial stages of crop establishment, increasing gradually to approximately 44 mm/week during the midstage of the crop's vegetative cycle. Therefore, it is expected that *ceteris paribus*, sweetpotato farming in Xai-Xai would be relatively less constrained--given it has both higher total annual precipitation and more rainfall during the growing season than Chokwe[5].



Source of data: National Institute of Meteorology

The optimum temperature amplitude for obtaining good root yield and abundant vine growth is 20-30^{o} C. Temperatures lower than 10^{o} C negatively affect root development and cause chilling injury whilst temperatures above 30^{o} C promote excessive vegetative growth of aerial parts at the expenses of root development (Salunkhe *et al.*, 1998).

[5] According to the agroecological zoning of Mozambique, Xai-Xai and Chokwe are classified as R2 and R3, respectively (MAF, 1996).

2.1.3 Major Farming Systems

The southern region of Mozambique covers essentially three major agro-ecological zones, namely:

- Inland Maputo Province (R1)
- South Save Coastal Region (R2) and
- Central-North Gaza and Western Inhambane (R3)

Agroecological zones R2 and R3 cover Gaza province. The district of Xai-Xai belongs to R3 and Chokwe mostly falls within R3. The Coastal Region South of the Save River (R2), which comprises an extensive zone from southern Maputo province up to northern Inhambane province, has the highest country's population density. In contrast, central and northern Gaza province and the western part of Inhambane province, which are the most arid regions of the country, have a relatively low population density (Snijders, 1986).

In 1995, the Gaza's Provincial Land Use Planning team identified in Xai-Xai, 6,802 hectares of lowland alluvial fertile soils (*Bilene system*) and 3,363 hectares of peat soils that were potentially suitable for crop production by smallholders, but lacked drainage system rehabilitation (Nyamuno *et al.*, 1995). However, due to the severe flooding that took place in recent years in Gaza province and because very little or no investment has been made in the rehabilitation of drainage systems, the exploitation of these land resources with high potential for agricultural production has been hampered. Furthermore, frequent cases of flooding do occur in the region, due to the inadequacy of the drainage systems and poor management of those land resources.

Farmers in R2 and R3 follow several farming systems, depending on soil characteristics and access to irrigation (Table 4). Although farmers cultivate sweetpotato in upland sandy soils, the risk of crop failure is high due to drought and soil fertility depletion as a result of shorter or no fallow periods.

Table 4: Farming Systems and Main Characteristics of R2 and R3.

Farming Systems	Main Characteristics
Mixed cereal/cassava/pulse and cashew	Upland sandy soils are cultivated with intercropped maize, cassava, cowpea, pigeon pea, groundnut, and pumpkin, along with cashew trees.
Peat soils subsystem	Main crops are maize, rice, vegetables, banana, and sugar cane. Drainage is the most determinant factor for use and management of these soils.
Bilene system	Alluvial fertile soils used for maize grown in both cropping seasons, including other crops such as beans, cowpea, pumpkin, sweetpotato, sugar cane, and cotton.
Coconut and annual crops system	Sandy and loamy soils used to grow maize, cassava, sorghum, groundnut, cowpea, sweetpotato, coconut, and citrus.
Chokwe irrigation scheme system	Traditionally rice is the most important annual crop with maize grown as a second crop. Farmers grow maize, groundnut, cowpea, groundnut, and sweetpotato in plots other than the irrigation scheme.

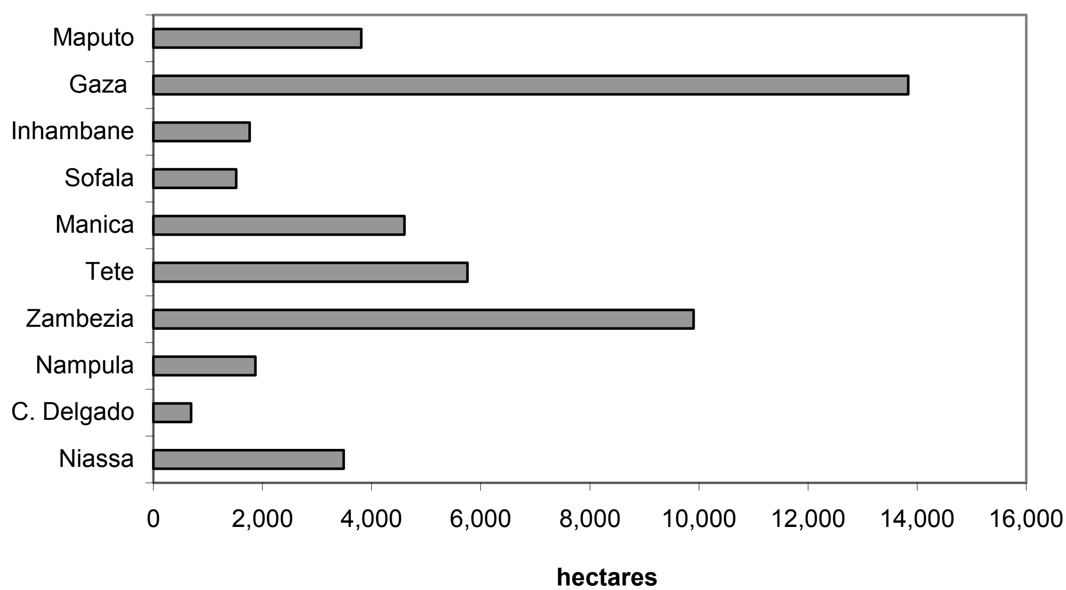
Source: Ministry of Agriculture and Fisheries, 1996

Alluvial fertile soils of bilene farming system are often heavy clay in texture. Consequently, a lack of access to animal traction or a tractor for land preparation and drainage are major constraints for sweetpotato farming. Conversely, the cultivation of peat soils is labor demanding for manual land preparation and is constrained by a lack of investment in drainage system improvement and a lack of organization among farmers to perform the regular maintenance of drainage systems.

2.2 Sweetpotato Production

Although there exists no current information regarding trends in sweetpotato production by province, available data indicates that in the 2000/01 cropping season, sweetpotato was cultivated on 7% of the total area devoted to roots and tubers crops, which was equivalent to approximately 1% (48,000 hectares) of the country's total area cultivated. Gaza province was the country's major sweetpotato cultivated area (29%), followed by Zambezia (21%), Maputo (10%), and Manica (9%) (Figure 2).

Figure 2: Area Cultivated of Sweetpotato in Mozambique (2000/01 Cropping Season)



Source: INE, 2002

Moreover, data from Agricultural and Livestock Census 1999/2000 (CAP) indicated that Mozambique produced a total of 196,646 metric tons (mt) of sweetpotato in the 1999/2000 cropping season. Zambezia province accounted for 21%, followed by Manica (16%), and Tete, Sofala and Gaza (12% each).

In recent years, there has been little change with respect to the sweetpotato area. A comparison of data from Agriculture Survey 1996 (TIA 96) and the Agricultural and Livestock Census 1999-2000 (CAP 2000) indicates that the total sweetpotato area –as a percentage of total country's cultivated area--was 1.3 and 1.2%, respectively. The estimated percentages of total holdings that cultivated sweetpotato apparently increased slightly from 9.4% (TIA 96) to 12.3% (CAP 2000).

Sweetpotato plays an important role in smallholder farming systems. The 2002 baseline national survey on cassava and sweetpotato production, processing and marketing--conducted in five of Mozambique's ten provinces and covering a total of 1,467 respondents--identified sweetpotato as the third most important crop after maize and cassava--based on their use for food (57% of respondents) and its value as either a source of household income (19%) or for use in exchange (11%). A total of 59 varieties were identified in the 43 districts of the five provinces surveyed. According to this baseline survey, 50% of the surveyed sweetpotato-growing farmers acquired land through inheritance, 29% by arrangement with local authorities, 14% rented land and only 5% bought land (INIA-IITA/SARRNET, 2003).

2.3 Historical Agricultural Development and Farmers' Characteristics

Historically, smallholders in the region practiced rainfed agriculture because the irrigation scheme were exclusively devoted to large-scale plantations or cropped by Portuguese farmers. Over the past 50 years, the southern region of Mozambique reflected the various phases of rural development that characterized Mozambique.

First, a differentiated peasantry was highly involved in providing forced labor for the large-scale, monoculture export crop plantations (e.g., sugar, tea, copra, and cotton), which were controlled by foreign capital, petty producers of cash crops, or often a combination of both.

Second, changes in the pattern of labor utilization in the peasant economy occurred at the expense of subsistence production. As a consequence of the introduction of cotton production, farmers switched from a more labor-demanding subsistence crop (i.e. sorghum) to a less labor-consuming one (i.e. cassava). Also, changes in the division of labor within the family occurred--women became responsible for subsistence production and men became responsible for supplying wage labor or producing cash crops.

Finally, successive changes have been implemented in post-independence agricultural policy, from the organization and mobilization of people into state farms and cooperatives to today's emphasis on agriculture reform and increased market orientation (Hermele, 1988; Wuyts, 1978).

According to a recent Agriculture and Livestock Census[6] (CAP)-- conducted from September 2000 to March 2001--the numbers of smallholder farms, medium-scale farms,

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6 CAP did not collect data on land with permanent trees, pasture, land under fallow, forestry land, and forestry areas used for social purposes.

and commercial farms (during the 2000/2001 cropping season) in Gaza province was estimated at 216,917; 2,544; and 80, respectively. Gaza province accounted for approximately 7% of the country's smallholders, 25% of its medium-scale farms, and 19% of its commercial holdings. During the same cropping season, smallholders in Gaza province cultivated 99% of total farms, accounted for 11% of the total area in basic food crops, and 29% of the total cultivated sweetpotato area, as shown in Table 5 (INE, 2002).

Table 5: Number of Farms, Total Food Crop Area, Average Area, and Sweetpotato Cultivated Area by Small, Medium, and Commercial-scale Farmers in Gaza Province, 2000-2001 Cropping Season.

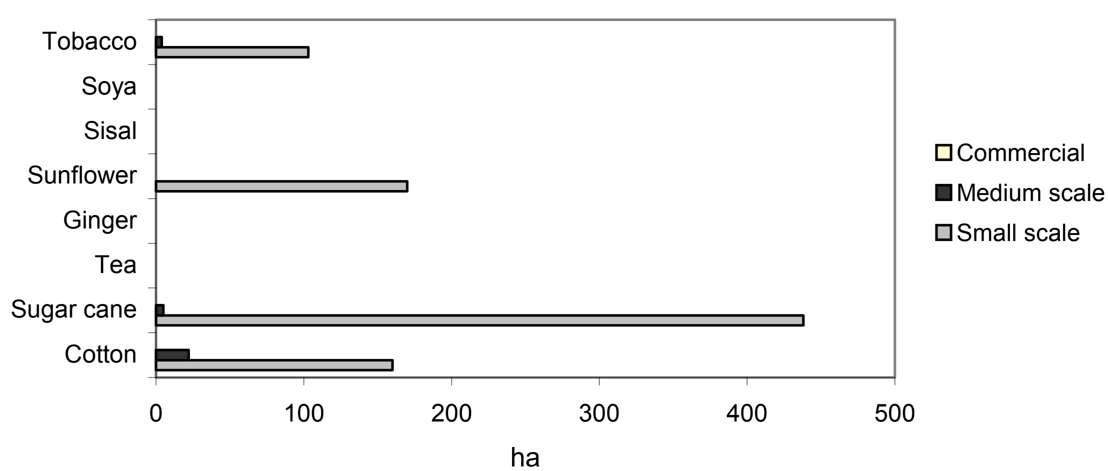
	Small-scale Sector		Medium-scale Sector (Number)	Commercial Sector (Number)	Total (Number)	Gaza's Share of National Total (%)
	Number	Share (%)				
Plots/Land Holdings	216, 917	98.8	2, 544	80	219, 541	7.1
Area Cultivated (ha)	435,865	94.8	20,792	3,282	459,939	11.9
Average Area Cultivated (ha)	2.0	NA	8.2	41.0	2.1	NA
Food Crops Area (ha)	340,550	10.8	14,793	2,574	357,917	11.2
Cash Crops Area (ha)	871	0.54	32	0	903	0.42
Sweetpotato Area (ha)	13,407	29.0	412	16	13,835	29.3

Source: INE, 2002 NA= Not applicable

In terms of area cultivated in the 2000/01 rainy season, sugar cane was the major cash crop grown by small-scale farmers, followed by sunflower, cotton, and tobacco. It is important to point out that the absence of a commercial sector engaged in cash crop farming reflects the recent shift from the large concession companies (Joint Ventures Companies) towards contract farming in which small-scale holders cultivate primarily cotton and tobacco. The main role of the companies is to provide inputs and a secure market for cotton.

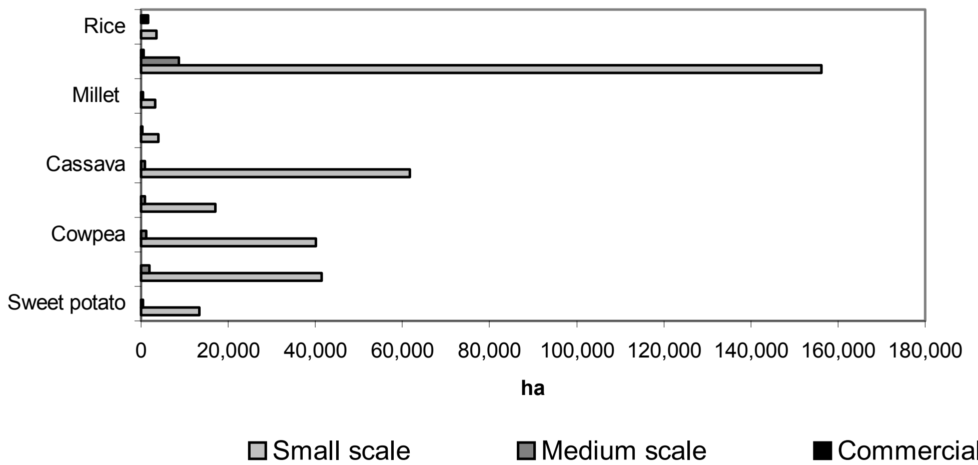
Maize was the most important food crop grown by small-scale farmers in Gaza province, followed by cassava, peanut, cowpea, beans, and sweetpotato. The highest percentage of land devoted to food crops reflects the paramount importance given to food security through subsistence agriculture, due to failures in rural output markets (INE/MADER, 2002). Thus, the small-scale farming sector is by far the most important and most representative agriculture activity in Gaza province (Figures 3 and 4).

Figure 3: Area Cultivated (ha) of Cash Crops in Gaza Province (2000/01 rainy season)



Source: INE, 2002

Figure 4: Area Cultivated (ha) of Food Crops in Gaza Province (2000/01 Rainy Season)



Source: INE, 2002

2.4 Sweetpotato Multiplication and Distribution Program

In February and March 2000, Mozambique experienced floods that devastated approximately 92,000 ha of cultivated land in the southern and central provinces of Maputo, Gaza, Inhambane, Manica, and Sofala. Soon after the floods, SARRNET (in close collaboration with INIA and other relevant stakeholders) launched a program to multiply and distribute planting materials of sweetpotato and cassava. This program was primarily targeted towards flood-affected rural people in an effort to boost agricultural production and mitigate the scourge of hunger, malnutrition, and food insecurity by encouraging farmers to plant improved varieties of sweetpotato and cassava. It is estimated that this multiplication and distribution initiative benefited approximately 378,000 households living in 65 out of the 128 districts of Mozambique (INIA-IITA/SARRNET, 2003).

To produce sufficient planting material, the program developed a well-coordinated network of 124 partners who planted both conventional (222 ha of sweetpotato, 218 ha of cassava) and rapid multiplication plots (3.2 ha of sweetpotato, 5.1 ha of cassava) (INIA-IITA/SARRNET, 2003). First, research stations identified the best source of planting materials of improved varieties and multiplied them in ***primary plots***, (e.g., uniformity, purity, physical and pathological characteristics). Subsequently, these varieties were multiplied at ***secondary plots***, which were managed by district agriculture institutions or NGOs. Finally, as the volume of planting materials increased, these improved varieties were further multiplied at ***tertiary plots***, which were operated and managed by farmer groups or individual farmers. The estimated areas of these multiplication plots, districts covered, and beneficiaries of the massive distribution program of vines of improved sweetpotato varieties, varied by region (see Table 6, in which data for Gaza province is in parentheses).

Table 6: Multiplication Plots, Districts Covered, and Beneficiaries of Sweetpotato Vines.

Region	Multiplication plots (ha)		Districts covered	Beneficiaries
	Rapid	Conventional		
Southern	8.2 (*2.4*)	69.3 (*45.8*)	20 (*11*)	29,074 (*10,150*)
Central	3.6	125.6	37	74,677
Northern	NA	30.55	25	46,765

Source: INIA-IITA/SARRNET, 2003 NA = Not Available

In Gaza province, ten institutions were actively involved in the multiplication and distribution program: Chokwe Research Station, Rural Extension, the Foundation for Community Development (FDC), Lutheran World Federation (LWF), Caritas Regional de Chokwe (CRC), World Relief Services (WRS), World Vision (WV) and Save the Children (STC), Christian Council of Mozambique (CCM), and “Associacao dos Tecnicos Agro-Pecuarios” (ATAP).

In addition to providing leadership to the program, SARRNET in close collaboration with its partners, conducted several training sessions to teach farmers about improved sweetpotato agronomic practices, their nutritional value, agro-processing techniques options for sweetpotato; developed teaching materials on nutritional concepts for primary school curriculum; and sponsored field days/demonstration activities at which food products made out of the roots of orange-fleshed sweetpotato were displayed (INIA-IITA/SARRNET, 2003).

2.5 Chapter Summary

The Mozambican economy had shown relatively high GDP growth rate over the recent post-war years (11.6% from 1998 to 2002). However, the livelihood of the majority of the population relies on subsistence agriculture. Thus, the low levels of production and productivity in conjunction with the relatively high population growth rate have contributed substantially to increased unemployment and widespread poverty.

The small-scale farming sector is by far the most important and most representative agriculture activity in Gaza province. The absence of a commercial sector engaged in cash crop farming reflects the recent shift from the large concession companies towards contract farming in which small-scale holders cultivate primarily cotton and tobacco. The main role of the companies is to provide inputs and a secure market for cash crops.

Gaza province has experienced a cycle of droughts and flooding. A program of multiplication and distribution program of OFSVs targeted to flood-affected rural people was launched in 2000 aimed at mitigating the hunger, malnutrition and food insecurity. In addition, SARRNET in close collaboration with its partners, conducted several training sessions to teach farmers about improved sweetpotato agronomic practices, their nutritional value, agro-processing techniques options for sweetpotato; developed teaching materials on nutritional concept for primary school curriculum; and sponsored field days/demonstration activities at which food products made out of the roots of orange-fleshed sweetpotato were displayed. One of the major constraints for crop production in Gaza province is the low and irregular rainfall during the growing season, resulting in high risk of crop failure. Thus, the development of short-duration (early-maturing) varieties is crucial towards an increased crop production under rainfed growing conditions. Furthermore, the lack of investments in drainage systems on lowland fertile soils threatens the use of these soils for agricultural development.

CHAPTER III

LITERATURE REVIEW

This chapter reviews the literature related to the potential contribution of β-carotene to alleviating VAD (the rationale for Mozambique's OFSVs distribution program), summarizes the findings of studies that have analyzed the impact of food-based interventions on mitigating VAD in developing countries, and highlights factors that have been found to affect farmer's adoption of new agricultural technologies in order to gain insights regarding constraints to the adoption of nutritionally improved OFSVs in the study area.

3.1 β-Carotene [7] as Precursor of Vitamin A

VAD results in various diseases, including follicular keratosis in the skin and pathological drying of the eye, leading to xerophthalmia[8] and sometimes keratomalacia[9] (Sommer, 1982, Davidson *et al.*, 1979).

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7 Beta-carotene is one of the sources of Vitamin A widely found in plant substances namely dark green leaves such as amaranth, sweetpotato and cassava leaves, mangoes, papaws, tomatoes, carrots, yellow, maize, and red palm oil (Lathan, 1979, West and Darnton-Hill, 2001).

8 Xerophthalmia is an extreme dryness and thickening of the conjunctiva resulting from VAD, characterized by lesions appearing as spots, either white or yellow, scattered along the sides of the blood vessels (Davidson *et al.*, 1979).

9 Keratomalacia is an advanced form of xerophthalmia frequently associated with protein-energy malnutrition (PEM) in young children and is characterized by softening and dissolution of the cornea (Davidson *et al.*, 1979).

Several studies have been conducted to elucidate the role of β-carotene as a precursor of Vitamin A[10] in human health. The conversion of β-carotene into Vitamin A, which takes place in the walls of the intestines and liver, is strongly determined and controlled by Vitamin A levels. Intestinal diseases (common in the tropics) tend to reduce the ability of the body to convert carotene to Vitamin A (Davidson *et al*., 1979, Lathan, 1979).

While the daily requirement for an adult female ranges from 750 to 1,200 μg of Vitamin A, children (0-59 months of age) require 250 to 300 μg of Vitamin A (FAO/WHO, 1967). However, some countries have their own recommended daily allowances (RDA). For instance, the RDA for adult women in the United States is 800 μg of retinol, while for children the RDA is estimated at 375 μg from birth to about one year of age, 400 μg from one to three years, and 500 μg of retinol per day from four to six years of age (NRC, 1989).

Bioavailability of dietary carotenoids and their conversion to retinol are influenced by several factors, including the type of carotenoid; amount of carotenoid in a meal; matrix in which the carotenoid is incorporated; presence of absorption modifiers (e.g., fiber which inhibit carotenoid absorption, and dietary fat which enhances absorption); nutritional status of population groups; and human-related factors (e.g. age, gastro-intestinal infections and parasites (West, 2000; de Pee *et al.*, 1998, van het Hof *et al.*, 2000).

[10] Vitamin A is an important component of the visual purple of the retina of the eye and appears to play an important role in immune competence at the level of both the surface tissue (i.e., skin and mucous membranes) and the immune system (Jamison, 2003).

De Pee and West (1996) suggested that studies are required to quantify the impact of these factors, especially related to the matrix, human-related factors, and absorption modifiers. According to Lathan, (1979), if no animal products are being consumed and the human body entirely relies on carotene as a precursor of Vitamin A, larger quantities should be consumed[11]. Secondly, carotene is poorly utilized in a low fat diet and, in most cases, diets that are deficient in Vitamin A are also deficient in fat. Thirdly, intestinal diseases limit the conversion of carotene and the absorption of Vitamin A. Finally; infants and young children do not convert carotene to Vitamin A as readily as adults. In the human body, provitamin A carotenoids are converted to retinol by a cleavage enzyme (located in the intestinal cells) that is directly exposed to various consumed food components. However, the properties of this cleavage enzyme are not yet well known and the regulatory mechanism of the dioxygenase still needs to be examined in terms of the nutrition of pro-Vitamin A carotenoids (Olson and Hayaishi, 1965).

A study which evaluated the effects of dietary components on metabolism of β-carotene in intestinal cells revealed that intestinal infection levels of young children heavily hamper the absorption and conversion of sources of β-carotene to Vitamin A in most developing countries (Nagao, *et al.*, 2000).

A study conducted in Indonesia revealed that β-carotene fortified wafer significantly improved the serum retinol concentrations in lactating women. However, no improvement in Vitamin A status occurred when the same amount of β-carotene was

[11] About one third of β-carotene in food is absorbed and available. Due to losses occurring during the conversion of carotenes into Vitamin A, one μg of absorbed β-carotene has the biological activity of half μg of retinol. Thus, one μg of β-carotene in a mixed diet is equivalent to one-sixth μg of retinol (FAO/WHO Expert Group, 1967; Lathan, 1979, NRC, 1980). However, other scientists argue that 21 μg of β-carotene from fruits and vegetables are required to provide one μg of retinol (West, 2000).

provided in the form of dark-green leafy vegetables. The authors suggested that β-carotene from dark-green leafy vegetables is not readily absorbed because it is trapped in a complex matrix within plant cells (de Pee *et al.,* 1995, de Pee *et al.*, 1998).

Recent studies revealed that Vitamin A plays an important role in a number of nutrient-nutrient interactions. Excessive doses of Vitamin K may reduce absorption of Vitamin A. Vitamin C may impair the toxic effects of hypervitaminosis A. By protecting against the oxidative destruction of Vitamin A, the therapeutic efficacy of this vitamin is enhanced by Vitamin E. Zinc deficiency reduces the bioavailability of Vitamin A and thus, limits its functionality (Jamison, 2003). According to Rahman *et al.*, (2002), combined zinc and Vitamin A supplementation improved Vitamin A nutriture in Vitamin A-deficiency young children. Similarly, significant protein deficiency may impair the impact of Vitamin A in mitigating related diseases, since protein plays an important role in transporting Vitamin A from liver stores to target cells. Several studies revealed that the presence of Protein Energy Malnutrition (PEM) increases the risk of xerophthalmia by approximately the same order of magnitude, as does the occurrence of diarrhea and respiratory diseases (Davidson *et al*., 1979). Thus, successful prevention and treatment of VAD and its adverse consequences, requires a careful consideration of the targeted population's protein status (Sommer and West, 1996).

3.2 Impact of Food-based Interventions to Mitigate VAD

Several studies have documented the impact of food-based initiatives envisaged to prevent VAD. In many developing countries, pro-Vitamin A carotenoids are the major source of dietary Vitamin A, contributing more than 80 % of the total Vitamin A intake. However, the lower bioavailability of Vitamin A in vegetables and fruits, and probably also the seasonal variability of production of vegetables and fruits in household gardens, are factors underlying the causes of VAD in these regions (Bloem *et al*., 1998).

Studies conducted in developing countries, such as Bangladesh and India, documented low dietary Vitamin A intakes by preschool-age children and found that most of the nonbreast milk Vitamin A intake was derived from plant sources (Zeithin *et al*., 1992). Although mothers declared that their young children had frequently consumed dark-green leafy vegetables, the amounts consumed were considered too small to satisfy their Vitamin A requirements. In addition, it was observed that young children were likely to consume exorbitant quantities of mangoes and papayas, which were available for short period of time. Thus, given the poor and seasonal patterns of dietary Vitamin A intakes, low fat intakes, parasitic infections, and the reduced bioavailability of Vitamin A from dark-green leafy vegetables, these diets were inadequate to meet the Vitamin A requirements of preschool-age children (one to three years old) without the inclusion of animal-based sources of Vitamin A and prolonged breast-feeding (Ramakrishnan *et al.*, 1999).

A study, aimed at determining the efficacy of boiled and mashed orange-fleshed sweetpotato[12] in improving the Vitamin A status of 5-10-year-old school children in South Africa, concluded that the Vitamin A status of the targeted population (measured by the modified relative dose response (MRDR[13]) improved relative to the control group, who received boiled and mashed white-fleshed sweetpotato (van Jaarsveld *et al.*, 2003).

A study conducted in South Africa showed that fortification of a biscuit[14] with iron, iodine, and β-carotene significantly improved the micronutrient status of primary school children-- 40% of whom exhibited subclinical VAD at the baseline assessment, due to low availability of β-carotene in the dark-green leafy vegetables which they consumed on a regular basis (van Stuijvenberg *et al.*, 1999).

A study carried out in South Africa, designed to determine the effect of an integrated home-gardening program plus primary health care program on improving dietary intake of yellow and dark-green leafy vegetables and serum retinol concentrations of young children, concluded that school children in both villages (experimental and control) had comparable serum retinol concentrations. Consequently, it was assumed that the two groups of 2-5-year-old children would have the same mean serum retinol

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12 Boiled and mashed orange- fleshed sweetpotato provided 1,031 μg of Retinol Activity Equivalent (RAE[12]) per 125 grams serving, which corresponds to 250% of Recommended Dietary Allowance (RDA) (van Jaarsveld *et al.*, 2003).

13 MRDR value is the ratio of the serum concentrations of vitamin A_2/vitamin A_1 as described by Tanumihardjo *et al.*, 1996. Although this MRDR is considered as the most practical method for field collection is more sensitive to changes in vitamin A status (by distinguishing between normal (DR:R <0.060) and abnormal (DR:R >0.060) vitamin A status) than in serum retinol concentrations alone.

14 The fortified biscuit was designed to provide 50% of the recommended daily dietary requirement of iron (5 mg of ferrous fumarate), iodine (60 μg potassium iodate), and β-carotene (2.1 mg) to 7-10-year-old school children.

concentrations. Furthermore, a follow-up study found no significant difference in anthropometric indexes of nutrition between children in both villages (Faber *et al.*, 2002).

A study by Shankar *et al*., (1998), designed to compare the relationship between access to home gardening and animals among households with and without xerophthalmic children in rural Nepal, found that although access to gardens for both groups was high and not significantly different, there was no difference in the consumption of Vitamin A-rich vegetables. This suggested that there was no relationship between the frequency of consumption of carotenoid-enriched vegetables[15] and home garden size. Conversely, there was an increase of non-carotenoid-enriched vegetables and all fruits.

In Bangladesh an integrated homestead gardening program, which also promoted primary health care and nutritional education, demonstrated the potential impact of a comprehensive program. Among 2-5-year-old children, the serum retinol concentrations were strongly associated with increased intake of dark-green leafy vegetables (Bloem *et al.*, 1996).

Furthermore, West and Darnton-Hill (2001), argued that food-based interventions that are implemented with the active participation of women with community engagement through social marketing[16] approaches are likely to introduce food habit changes, improve Vitamin A intakes, and eventually enhance Vitamin A status. However,

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[15] In this study, carotenoid-enriched vegetables included dark-green leafy vegetables and ripe pumpkin and carotenoid-rich fruits included papayas, mangoes, and jackfruit.

[16] Social marketing is defined as “the design, implementation, and control of programs calculated to influence the acceptability of social ideas, involving considerations of product, planning, pricing, communications and market research” (Kotler and Zaltman, 1971). This approach requires the community participation in the identification of problems and needs, implementation, monitoring and evaluation of the programs. This approach increases the community responsibility in planning, monitoring and assessment of collective actions that were agreed upon and proved necessary to be undertaken (Neill, 1992).

Neill, (1993) found no clear evidence that the Indonesian nutritional education project had a long-term impact on the mortality of children under five years of age and continued implementation of such a program is unlikely without long-term financial support from donors.

De Pee and West (1996), in their review of the literature (a total of sixteen studies conducted in developing countries) regarding dietary carotenoids and their role in combating VAD, pointed out that while many cross-sectional, case-control, and community-based studies have shown that increased intake of fruits and vegetables is related to improved Vitamin A status, this does not entirely prove causality. Furthermore, many experimental studies that indicated a positive effect of fruits and vegetables intake can be criticized for their poor experimental design. Furthermore, recent experimental studies have found no effect of vegetable intake on Vitamin A status. Thus, the effectiveness of carotene-rich foods in improving Vitamin A status and ways of improving carotene bioavailability need further investigation (de Pee *et al.*, 1996, West, 2000).

Currently, researchers utilize the food frequency method, developed by the Helen Keller International (HKI), to identify people at-risk of suffering from VAD. For example, using this method, researchers (based on a positive change in HKI scores) concluded that food-based interventions in Ethiopia, Kenya, and Tanzania enhanced Vitamin A status (Johnson-Welch, 1999). However, findings of research in other countries showed that improvements in HKI scores, as a result of an increase in consumption of dark-green leafy vegetables alone, did not result in improvement of Vitamin A status.

In fact, due to a variety of foods, HKI scores were improved (de Pee *et al.*, 1995). Thus, Johnson-Welch (1999) emphasized the need to develop methodologies to better assess the nutritional impact of food-based intervention trials conducted in developing countries.

3. 3 Adoption of New Technologies

Many studies have sought to explain farmer adoption of new technologies, including specific traits of improved varieties. A Kenyan study, which evaluated the effect of women farmers' adoption of OFSVs in raising Vitamin A intake, found that several of the new OFSVs grown in on-farm trials were adapted to the agro-ecological conditions with respect to yield, pest and disease tolerance, as well as having reasonable beta carotene content. This study found that women farmers were likely to adopt the OFSVs if the clones were sufficiently high in starch, low in fiber, and if they were introduced through community-level education programs that focused on the health of young children (Hagenimana and Oyunga, 1999). According to this study, the new OFSVs were widely accepted (with respect to their appearance, taste, and texture) by both producers and consumers, and substantially contributed to the alleviation of VAD.

Furthermore, a recent *ex ante* impact case study by economists from Michigan State University and the International Potato Center estimated that widespread distribution of the new orange-fleshed cultivars could benefit an estimated 50 million children under age six, who currently suffer from VAD in Sub-Saharan Africa (Low *et al.*, 2001).

A study by Maredia and Minde (2002), which explored the relationship between profitability of agricultural technologies and its adoption by farmers in Eastern Africa, identified three groups of technologies: First, some profitable technologies were widely adopted, such as improved cassava varieties in Uganda and improved coffee varieties in Kenya. Second, some technologies were profitable under researcher-controlled environments, including technologies that were not as fully adopted as expected, and/or had been restricted to on-farm demonstration plots (e.g., wheat variety and hybrid maize in Ethiopia and the application of inorganic fertilizer on maize in Kenya). Third, some technologies were unprofitable under specific circumstances, such as animal draught-power technology for weed control when applied on farms less than 2 hectares. In these studies, profitability was estimated using partial budget analysis, gross margin analysis, net present values, and value cost ratios. Furthermore, the authors drew two major conclusions: i) the productivity gap in Africa is heavily determined by non-technological constraints (e.g. infrastructure, policies, input/output markets, and adverse climatic conditions), which reduced profitability and adoption of new technologies, and ii) there is a need for continuous efforts to supply technologies that are adapted to the prevailing environmental conditions in order to make them profitable for farmers.

A study of the key factors associated with the adoption of hybrid maize in Latin America and the Caribbean region by Kosarek *et al.,* (2001), reported that farmers' decision to adopt hybrid maize was determined by the expected returns (i.e. profitability) of the technology, the availability of hybrid seed, and risks associated with uncertainty regarding the expected outcomes of the new technology. Moreover, they found that the structure of the seed market, the organization of the seed industry, and the cost of technology generation and development were key determinants of the profitability of supplying hybrid maize seed. One of the major conclusions of this study was that public research plays a vital role in insuring that the needs of small-scale and subsistence-oriented farmers are met in zones where the welfare of the population is entirely dependent on maize production.

Exploring the key determinants of the adoption of technologies by farmers growing upland rice and soybeans in Central-West Brazil, Strauss *et al.*, (1991), reported that farmer adoption of technology is an economic decision based upon discounted expected marginal benefits and costs. Furthermore, the major findings of this study included: (i) farmer's education level contributed positively to the probability of soybean farmers performing soil sample analysis to determine the quantity of fertilizer that they should apply on their rice fields; (ii) time of residence in the region was positively related to rice growers' adoption of blast control and to the probability of adopting certain planting techniques for soybeans; and (iii) the use of certified rice seed, soil sample analyses, type and quantity of fertilizer application per hectare, and inoculation of soybean seeds were positively related to availability and quality of the extension and research.

Similarly, a study by Rahm and Huffman (1984), designed to evaluate the role of human capital and factors that affected the adoption of reduced tillage in corn production, found that farmers' education and experience play a crucial role in enhancing the efficiency of the adoption decision. Moreover, they concluded that the probability of farmers adopting reduced tillage practices was strongly depended on soil characteristics, the cropping systems, and farm size.

Various studies reported that risk aversion is likely to be negatively associated with adoption and for any level of farmer's risk aversion, the likelihood of technology adoption is positively correlated with the availability and accuracy of information about the performance of the specific new technology (Feder and Slade, 1984, Feder *et al.,* 1985, Kristjanson, 1987).

Recent studies conducted in Eastern Africa, designed to better understand key determinants of farm-level technology adoption/disadoption, revealed that the major reasons for technology non-adoption were: (1) farmer's unawareness of the improved technologies or a lack of information regarding potential benefits accruing from them; (2) the unavailability of improved technologies; and (3) unprofitable technologies, given the farmer's agro ecological conditions and the complex set of constraints faced by farmers in allocating land and labor resources across farm and off-farm activities (Doss, 2003).

In recognition of two decades of on-going market reforms in Sub-Saharan Africa, Kelly *et al*., (2003), suggested the need to assess the profitability of input use and potential explanations of non-profitability before drawing any conclusion regarding market failure or the limited impact of government intervention, such as input distribution programs oriented towards smallholders. Profitability studies carried out in Mozambique and Ethiopia revealed that, after adjusting for the effects of market distortions (i.e., taxes, subsidies and currency overvaluation), application of fertilizers on cereals was unprofitable--given existing input and output marketing costs.

Notwithstanding the limited availability of empirical data on the potential role played by farmer associations in absorbing some of the transaction's costs of input procurement, Kelly *et al*., (2003) reported that farmer associations in the irrigated rice zone of Mali have reduced costs for their members by using transparent bidding procedures for sourcing inputs and by securing bank loans to guarantee timely repayment to suppliers. Additionally, to decrease the transaction costs of inputs acquisition and output marketing, some NGOs have promoted the establishment of and consolidation of farmer associations.

A study by Adesina and Sanders (1991), designed to evaluate the adoption and farm-level effects of cereal technologies in Niger, documented the ability of peasant farmers to adapt their cropping strategies to the low and erratic rainfall patterns by: (i) growing a mix of varieties with different maturity lengths and (ii) making appropriate and sequential decisions based on rainfall expectations, such as applying several different planting densities, planting in different dates, and/or applying fertilizers when the rains are early. They concluded that, in general, small farmers in Sub-Saharan Africa (SSA) were more likely to adopt labor intensive technologies, as they used relatively more family labor which had a low opportunity cost. Furthermore, Kristjanson (1987), using an econometric model to determine the relationship between rainfall variables and crop yields, found similar farmer behavior in Burkina Faso.

A study designed to estimate the effect of key exogenous socio-economic characteristics on the adoption of animal traction technology in Maseru, Lesotho (Mbata, 2001) showed that while two-thirds of female farmers adopted animal traction, only a low percentage of male farmers did so. This was explained by the recognition that men, as the head of household, bear responsibility for obtaining income from off-farm activities--such as working in South African mines. Consequently, women in rural areas relied on animal traction to alleviate the burden of the heavy farm workload. Due to the high interest rates charged by private moneylenders and the non-eligibility of many small farmers for receiving loans from the Lesotho Agricultural Development Bank, the main source of capital for adopters of animal traction was personal savings.

Feder *et al.*, (1985) argued that off-farm income might affect adoption by providing a source of cash flow to buffer the risk associated with the introduction of new crop management practices. Moreover, the existence of effective extension services, adequate provision of inputs, timely credit availability, transportation, and functional marketing channels are of paramount importance to foster the adoption of new technologies (Feder *et al.,* 1985, Mbata, 2001, Rauniyar and Goode, 1992).

A study designed to assess the role of agricultural technology in improving food security and providing more employment in Bangladesh evaluated the welfare implications of the irrigation-induced technological change (i.e. modern varieties, fertilizers, and pesticides) in rice production. This study found that irrigation-induced technological change could substantially reduce the percentage of the rural population below the poverty line by increasing the income of the poor population through augmented employment opportunities. However, rapid expansion of irrigation was deemed as a condition *sine qua non* for farmer adoption and achieving high productivity (Akhter and Sampath, 1992).

3.4 Chapter Summary

Several studies highlighted the importance of β-carotene as predominant source of pro-Vitamin A in preventing VAD in developing countries. However, the bioavailability, conversion of β-carotene into Vitamin A, and effective utilization of this Vitamin A by humans is conditioned by a complex set of factors--including type and amount of carotenoid in a meal, matrix in which the carotenoid is incorporated, presence of absorption and conversion modifiers, health status of the target population, and the presence of other micronutrients.

Studies aimed at assessing the impact of food-based interventions in developing countries revealed that these initiatives yielded different results from country-to-country. Furthermore, the seasonal availability of enriched sources of β-carotene, the low bioavailability and conversion of β-carotene into Vitamin A, and the prevalence of infectious diseases hampers the efficacy of home-gardening initiatives to mitigate VAD in developing countries.

Currently, a multidisciplinary study, which is being conducted under the auspicious of VITAA (Vitamin A for Africa), is evaluating the potential for reducing VAD and inadequate caloric intake through dietary diversification, improved feeding practices, and improved serum retinol status--particularly in young children under five years of age in Zambezia province. This study will provide more insight regarding the impact of this food-based intervention in mitigating VAD.

Recent studies have identified many socioeconomic and policy related factors that affect farmers' technology adoption decisions, including access to farm labor, farm machinery, storage and distribution facilities, inputs and output markets, credit availability, farm size, level of education, land tenure, profitability of the technology, farmer's awareness of existing technologies, and government policies. However, the effect of those explanatory variables and interactions among them on farmer's technology adoption varies from region to region. Thus, extrapolation of results from one farming system to a completely different one should be avoided. Rather, country-specific studies need to be carried out to understand factors associated with farmer adoption of a specific technology in a specific location.

CHAPTER IV

RESEARCH METHODS AND DESIGN

This chapter presents the theoretical and empirical model used to analyze farmers' adoption decision and describes the sampling approach and data collection methods used in this study.

4.1 Technology Adoption Decision (Objective 2)

4.1.1 Theoretical Model

Qualitative response models--also called binary-choice, discrete or dichotomous models--are often used to evaluate the farmer's decision-making process concerning the adoption of agricultural technologies. Those models are based on the assumption that households and farmers are faced with a choice between two alternatives (adoption or no adoption) and the choice depends upon identifiable characteristics (Pindyck and Rubinfeld, 1997). Based on the assumption that the decision made by farmers, regarding adoption of a particular technology, is guided by a utility maximization objective, a technology 2 (t_2) is preferred to technology 1 (t_1) as long as the utility derived from technology 2 is greater than the utility derived from technology 1.The utility function ranking the i_{th} farmers' preference for technologies is represented as follows (Rahm and Huffman, 1984):

$$U\ (R_{ti};\ A_{ti})$$

Where utility U depends on a vector R_{ti} , describing the distribution of net returns for technology $\mathbf{t_j}$, and a vector A_{ti} ,corresponding to other attributes associated with the technology $\mathbf{t_j}$. The variables R_{ti} and A_{ti} are not observable, but a linear relationship is postulated for the $\mathbf{i_{th}}$ farmer between the utility derived from the $\mathbf{t_j}$ technology and a vector of observed farm and farmer characteristics X_i and a zero mean random disturbance term μ_t:

$$U_{ti} = X_{it} + \mu_t \quad \text{where } t = 1, 2 \text{ and } i = 1, 2, \ldots.n. \qquad (1)$$

As mentioned previously, the $\mathbf{i_{th}}$ farmer adopts $\mathbf{t_2}$ if $\mathbf{U_{t2}}$ is greater than $\mathbf{U_{t1}}$. A qualitative variable Y can represent the farmer's adoption decision.

$Y = 1$ if $U_{t2} > U_{t1}$ and new technology $\mathbf{t_2}$ is adopted replacing $\mathbf{t_1}$ and

$Y = 0$ otherwise (2)

The probability that Y_i is equal to one is expressed as a function of specific farm and farmer characteristics:

$$Pi = \Pr(Y = 1) = \Pr(U_{t1} < Ut2)$$

$$\Pr(X_i\, \alpha_1 + \mu_{1i} < X_i\, \alpha_2 + \mu_{2i})$$

$$\Pr[\mu_{1i} - \mu_{2i} < X_i(\alpha_2 - \alpha_1)]$$

$$\Pr(\gamma_i < Xi\, \beta) = F(X_i\beta) \qquad (3)$$

Where

Pr (.) is a probability function,

$\gamma i = \mu_{1i} - \mu_{2i}$ is a random disturbance term

$\beta = \alpha_2 - \alpha_1$ is a coefficient vector and;

$F(X_i\beta)$ is a cumulative distribution function for γ_i evaluated at $X_i\beta$.

The marginal effect of a variable X_j on the probability of adopting new technology can be calculated by differentiating P_i with respect to X_j:

$$\partial Pi / \partial Xij = f(Xi\beta) \,.\, \beta j, \qquad (4)$$

Where f (.) is the marginal probability density function of γ_i and j = 1, 2,……J is the number of explanatory variables. The general form of the univariate dichotomous choice model is expressed as:

$$P_i = P_i (y_i = 1) = G (X_i, \theta) \text{ where } i = a, 2, \ldots n. \qquad (5)$$

Equation (5) states that the probability that the i_{th} farmer will adopt a specific technology is a function of the vector of explanatory variables X_i and the unknown parameter vector θ.

Three alternative functional relationships are commonly used by researchers to specify G: Linear Probability (LP), Probit, and Logit models. A Linear probability model ($Yi = \alpha + \beta X_i + \mu_i$) has been used extensively in econometrics applications. However, its specification has caused estimation problems and the non-normality of the disturbance terms makes the use of traditional tests of significance (t-test and F-test) inadequate. Pindyck and Rubinfeld (1997) summarize the limitations of the LP functional form as follows:

1. It gives a heteroscedastic regression model and its variance-covariance matrix varies systematically with the independent variables;
2. The predicted value of X β is not restricted to lie between 0 and 1, which is inconsistent with the definition of Y_i as a conditional probability;
3. Some studies have revealed that adoption decision functions are curvilinear rather than linear. Thus, Ordinary Least-Squares (OLS) would produce inefficient parameter estimates.

Given the problems associated with the linear probability model, economists have developed alternative functions that confine the estimated probabilities between 0 and 1.

The two most common functions used in econometric applications are the logistic and the cumulative normal distributions, creating the logit and probit models, respectively. Thus, the probability that a farmer will adopt a new technology is expressed as a function of:

$P(Y = 1) = F(X\beta)$

According to the logit model, the probability of an individual household (farmer or firm) adopting a new technology $\mathbf{t_2}$, given a well-defined set of socio-economic and physical characteristics (X), is represented as:

$$P(t_2 \mid X) = \exp^{(X\beta + \mu)} / [1 + \exp^{(X\beta + \mu)}]$$

Likewise, the probability of not adopting the new technology $\mathbf{t_2}$ (continuing with technology $\mathbf{t_1}$) is given by:

$$P(t_1 \mid X) = 1 - P(t_2 \mid X) \qquad = 1 - \{\exp^{(X\beta + \mu)} / [1 + \exp^{(X\beta + \mu)}]\}$$

$$= 1 / [1 + \exp^{-(X\beta + \mu)}] \qquad (6)$$

The relative odds of adopting versus not adopting a new technology are given by

$$P(t_2 \mid X) / P(t_1 \mid X) = [\exp^{(X\beta + \mu)}] \{1 + \exp^{(X\beta + \mu)}\} / [1 + \exp^{(X\beta + \mu)}]$$

$$= \exp^{(X\beta + \mu)} \qquad (7)$$

Taking the logarithm of both sides: $\ln [P(t_2 \mid X) / P(t_1 \mid X)] = X\beta + \mu$ (8)

In a logit model, the parameter estimates are linear and, assuming a normally distributed disturbance term (μ), the logit maximum likelihood (LML) estimation procedure is used to get efficient, consistent, and asymptotically normal estimators. Those estimates will represent the effects and statistical significance of the explanatory variables on the adoption of a particular technology (Pindyck and Rubinfeld, 1997). In a logit model, the marginal effect of the explanatory variable is generally computed at the mean value of the independent variable for continuous variables; while the marginal effects of categorical variables are estimated by the difference before and after the change takes place.

The probit model is also more appealing than the linear probability model, since it incorporates nonlinear maximum-likelihood estimation. Probit analysis accounts for heteroscedasticity of the error terms and restricts predictions to lie between 0 and 1 range. The probability of a farmer adopting or not improved technology in the probit model is defined in terms of an index that may have any value between $-\infty$ and $+ \infty$. This index is converted into probability values by using a standard cumulative normal distribution and this transformation guarantees that all corresponding probability values are confined between 0 and 1(Pindyck and Rubinfeld, 1997, Maddala G., 1983). The functional form is represented as follows:

$$P_i = F(Z_i) = 1 / (2 \pi)^{0.5} \int \exp^{-\mu 2/2} d\mu$$

$$\text{Where } Z_i = X_i \beta + \mu_i$$

An estimated β value in a logit or probit model does not give the change in the dependent variable, due to a unit change in the explanatory variable. This effect is obtained by computing the partial derivative of the Prob ($Y_i = 1$) with respect to β.

Since logit and probit models yield similar results in the case of binary choice models (Nayga and Capps, 1992, Maddala, 1983, Amemiya, 1981), the choice of one above the other is a matter of convenience. This study uses the probit model to evaluate factors associated with a sweetpotato grower's decision to grow OFSVs (rather than WFSVs) in the 2003/04 wet season.

4.1.2 Empirical Model

Data gathered, regarding household cultivation of orange-fleshed varieties in the last cropping wet season (2003/04), were used to define two categories of sweetpotato farmers:

- *Adopter*, a farmer who planted OFSVs in his/her field in the 2003/04 wet season (the period when the survey took place), and
- *Disadopter,* a farmer who previously received vines of one or more improved orange-fleshed variety, but did not grow any of them during the 2003/04 wet season. However, all the interviewed respondents grew and harvested improved orange variety at least once.

The probit procedure for estimating key determinants of orange-fleshed sweetpotato variety adoption is specified as follows:

$$Pr = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_n X_{nt}$$

Where:

Pr = 1 if the farmer cultivated any orange-fleshed variety in 2003/04 and 0 otherwise

t = 1, 2, 3 ……………. t are observations

X_{nt} = the *n*th explanatory variable for the *t*th observation

n = 0,1, 2…………….., n

β_n = an unknown parameter; n = 0,1……….., n

The variables included in the probit model were selected based on both adoption literature, regarding factors that have influenced technology adoption in several countries, and location-specific factors that key informants hypothesized would affect the adoption of OFSVs. The explanatory variables, including the direction of their expected effects, are described as follows:

- Respondent age (-): The units of this variable are years (***age***).

- Level of education (+): This variable is measured as the number of years of formal education completed by the respondent ***(educ***).

- Young children (+): This variable is specified as a dummy, taking a value of one if the respondent has young children (under five years of age) and zero otherwise (***young).*** Since the message delivered to farmers focused on young children as the target population to be benefited from consumption of OFSVs, it is hypothesized that household with young children are more likely to adopt OFSVs.

- Extension services (+): This variable is measured as the number of times the farmer visited or was visited by an extension technician regarding any technological issue related to orange-fleshed sweetpotato farming during the last two years ***(extvis).***

- Field days/demonstrations (+): This variable is specified as a dummy, taking a value of one if the respondent participated in field days/demonstration activities regarding OFSVs processing techniques and zero otherwise ***(fdemo).*** It is hypothesized that farmers who attended these events would be more likely to adopt OFSV in order to make OFSVs processed products.

- Livestock ownership (-): This variable, a proxy for income, represents the number of cattle owned by the respondent (***tbov).*** Key informants hypothesized that wealthier farmers are likely to adopt new technologies since they are more able to assume risk.

- Frequency of vines distribution (+): This variable is measured as the number of times the farmer received vines of OFSVs ***(vinrec).*** Key informants hypothesized that farmers who received vines more times would more likely to be growing them in 2003/04 wet season.

- Experience with varieties (+): This variable is measured as the number of different OFSVs that the respondent received ***(varexp).*** It is hypothesized that farmers who received several varieties would be more likely to identify a preferred variety and continue to grow it.

- Off-farm activity (+): This variable is specified as a dummy, taking a value of one if the respondent and/or spouse participated in off-farm activities in 2003 and zero otherwise ***(offarm).***

- Gender of the respondent (+): This variable is specified as a dummy, taking the value of one if the respondent was female and zero otherwise (***female).*** Key informants hypothesized that since sweetpotato is a woman's crop, they would be more likely to adopt OFSVs.

- Family size (+): This variable is measured as the number of people who lived in the household at least nine months during 2003 (***famsize)***. Key informants hypothesized that larger households would be more likely to adopt a technology that increases subsistence food production.

- Sweetpotato cultivated area in the 2003/04 wet season (+): This variable is expressed in hectares ***(sparea).*** Key informants hypothesized that households with a larger sweetpotato area considered it to be an important crop, so they would be more interested in new OFSVs.

- Awareness of sweetpotato processing techniques (+): This variable is specified as a dummy, taking the value of one if the respondent is aware and zero otherwise ***(praware).*** Key informants hypothesized that farmers who were aware of sweetpotato processing techniques would be more likely to adopt OFSVs in order to make processed products out of them.

- Average annual precipitation (+): This variable is specified as a dummy[17], taking a value of one if Xai-Xai district and zero if Chokwe district. This variable captures the difference in average annual precipitation between the two districts covered by this study ***(distpr).*** Rainfall varies greatly between the two districts. Ceteris paribus, as sweetpotato production is less constrained by rainfall in Xai-Xai district, farmers are more likely to have been able to maintain vines received in 2000 and in subsequent years.

- Sweetpotato root consumption (+): This variable is measured as the number of times per week the household consumed sweetpotato roots during the months when roots are available ***(rootcs).*** Key informants hypothesized that farmers who were more dependant on sweetpotato as a food source would be more interested in growing Vitamin A-enriched OFSVs.

- Commercialized sweetpotato in wet season (+). This variable is measured as the quantity (kg) of orange-fleshed sweetpotato roots sold in the 2003 ***(rsold).*** Key informants hypothesized that farmers who sold OFSVs roots, as a source of cash income would be more interested planting higher-yielding OFSVs.

- Respondent experience in processed products (+): This variable is specified as a dummy, taking the value of one if the respondent has actually made at least one sweetpotato processed product and zero otherwise ***(proexp).*** Key informants hypothesized that farmers who had made processed products from OFSVs would be more likely to continue to grow them.

- Total household farmland (+): This variable is measured as the total area (hectares) cultivated by the household in the 2003/04 wet season ***(tland).*** Key informants hypothesized that since households with larger farms were more dependant on agriculture, and more able to assume risk, they would be more likely to adopt a new agricultural technology.

[17] It is recognized that this dummy variable might capture the effect of all other no included factors on farmer adoption of OFSVs. However, given the fact that most respondents reported having lost their planting materials due to flooding, it seems that the difference in average annual precipitation influenced the rate of adoption of OFSVs in both districts.

4.2 Prices Traders Offer for Roots (and leaves) Produced from Orange-fleshed Varieties (Objective 3)

There is an increasingly demand for products with improved safety (e.g. lower or no contamination levels of pesticides or other pathogens) and high nutritional attributes or characteristics (e.g. Vitamin-B12, Vitamin A, Vitamin-B6, phosphorus, magnesium, iron, lower fat content), since their availability is strongly related to improved social health status and consequently lower health care expenses. However, economists have only recently attempted to measure the benefits accruing from food safety and nutritional attributes. Also, these benefits are difficult to evaluate because safety and nutrition characteristics are often deemed as nonmarket goods associated with market failures, due to a lack of sufficient or asymmetric information for market participants.

The nonmarket valuation research of greatest relevance to food safety and nutrition emphasizes estimating the value of reduced morbidity and the value of preventing deaths or disease outbreak in a specific target population or region (Fisher *et al.*, 1989). Among the methodologies used to value food safety and nutritional quality, contingent valuation has been widely employed by economists (Caswell, 1995).

A formal willingness to pay analysis is beyond the scope of this study. However, to gain insights regarding consumers' willingness to pay for the nutritional characteristics of OFSVs, the researchers planned to interview sweetpotato traders in urban markets to investigate whether they offer sellers the same price, a lower price (price discount), or a higher price (price premium) for orange-fleshed varieties, compared to white-fleshed varieties. However, due to the lack of sweetpotato (especially OFSVs) in the market, only three interviews were conducted in Xai-Xai and Chokwe.

4.3 Description of Data and Sampling Approach

4.3.1 Key Informant Interviews

Both primary and secondary data were collected. Interviews with key informants (e.g. extension officers, researchers, farmer's association representatives, NGOs, and staff of input and output marketing agencies and traders operating in the study area were conducted to gain insights about the history of the orange-fleshed sweetpotato program and what factors govern farmers' decision-making process and affect the cropping patterns of the study area. These data were used to redesign the structured questionnaire.

4.3.2 Sweetpotato Growers Survey[18] (Objectives 1, 2 and 5)

A multi-stage sampling technique was used to select a sample of 150 sweetpotato growers. First, Gaza province was selected, due to its importance as a major sweetpotato-producing area. Second, two districts (i.e. Xai-Xai and Chokwe) were chosen, using the criterion mentioned above. Third, from the list of NGOs operating in selected districts, five NGOs were selected, based on their participation in the first massive distribution of OFSVs planting materials. At INIA headquarters, lists of farmers who received vines of OFSVs in early 2000 from the NGOs were obtained and a random systematic sample of 15 farmers per village was selected. Thus, the sample size of this survey-based study was 150 farmers, all of whom received planting materials of improved OFSVs from the multiplication and distribution program.

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[18] The survey carried out in November 2003 focused on the supply-side of sweetpotato production it collected neither some data required to explain the key factors of adoption or disadoption of the new orange-fleshed varieties nor information regarding consumers' taste and preferences for roots and/or leaves of these new orange-fleshed varieties.

A structured questionnaire was used to collect data from the farmers by means of face-to-face interviews. The farmer questionnaire was used to collect data on the socio-economic characteristics of the household, (e.g., age, gender, family size, household total farmland, level of education, off-farm activities, livestock ownership, etc.), agronomic practices followed (e.g., manual land preparation versus animal traction, intercropping or monoculture, planting, etc.), labor used in sweetpotato production (e.g. family labor and/or hired labor), farmer's criteria for preferring all or some of the new orange-fleshed varieties, access to market for outputs, and access to extension services (see Appendix C for a copy of the questionnaire).

In addition, secondary data from previous household surveys and agricultural censuses were collected from relevant governmental and non-governmental institutions.

4.3.3 Sweetpotato Traders (Objective 3)

Three open markets, located in the study area, were selected for data collection. In each market, the researcher expected to select and interview 15 vendors who sold sweetpotato tubers and leaves in order to collect data regarding the sweetpotato marketing system, type of sweetpotato tubers and leaves sold, consumer preferences for cream/white versus OFSVs, and prices at which they sold tubers and leaves of each type of variety. However, due to widespread flooding in the lowland areas, all the cultivated crops were destroyed, including sweetpotato. Thus, since few vendors were found in the markets of Chokwe, Lionde and Xai-Xai, it was only possible to conduct three traders interviews. In addition, four traders interviews were conducted at formal and informal markets of Maputo. These data are used to provide a basic description of the sweetpotato marketing system and to tentatively assess whether orange-fleshed varieties are being sold at the same, a lower (price discount), or a higher (price discount) price than white/cream-fleshed varieties.

4.4 Chapter Summary

This chapter presents the conceptual framework and literature regarding binary-choice models, describes the sampling approach used to implement this study, and describes the research instruments that were used to collect data needed to evaluate farmer decision-making process regarding the adoption of improved orange-fleshed varieties.

Using a multi-stage sampling approach, a sample size of 150 sweetpotato growers in Chokwe and Xai-Xai districts was selected from the lists of farmers who benefited from the massive distribution program of vines of OFSVs that took place in 2000. First, a structured questionnaire was used to collected data on the socio-economic characteristics of the household, agronomic practices followed, labor used in sweetpotato production, farmers' assessment of the traits of some of the new orange-fleshed varieties, access to market for outputs, and access to extension services. Second, a structured questionnaire was used to collect data on the commercialization of sweetpotato (both white/cream and orange-fleshed), consumer tastes and preferences, prices traders offer to sellers, and consumer prices. The cross-sectional data gathered through the farmer questionnaire were used to describe the characteristics of sweetpotato producers and their production system; and to determine the factors affecting farmer adoption of OFSVs.

CHAPTER V

DESCRIPTIVE ANALYSIS OF SWEETPOTATO PRODUCERS, PRODUCTION AND FARMERS' EVALUATION OF OFSVs.

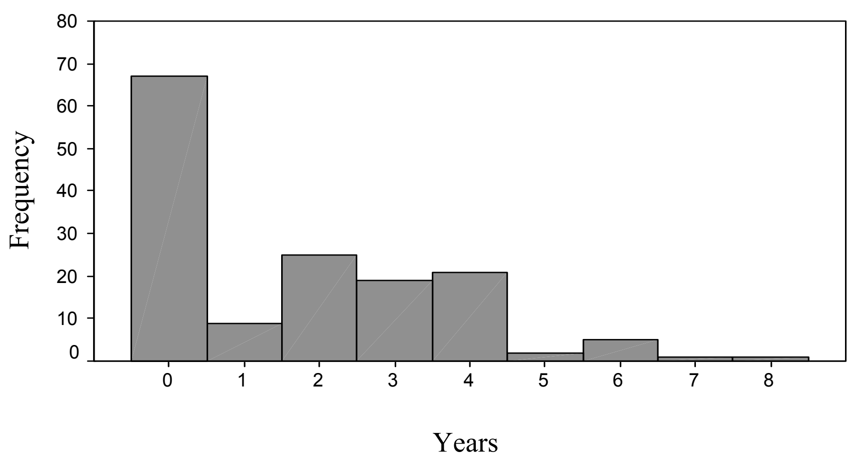
5.1 Socio-Economic Characteristics of Sweetpotato Growers

5.1.1 Education Level, Age and Gender

Respondents in the study area had little formal education. The average sweetpotato grower had completed only 1.7 years of schooling--44.7% were illiterate, 49.3% had completed primary school (4 years), and only 6.0% had completed more than 4 years of school (Figure 5). Similarly, in Gaza province, the level of illiteracy is estimated at 38.6%, being 63.3 for women and 24.3% for men (INE/MADER, 2001).

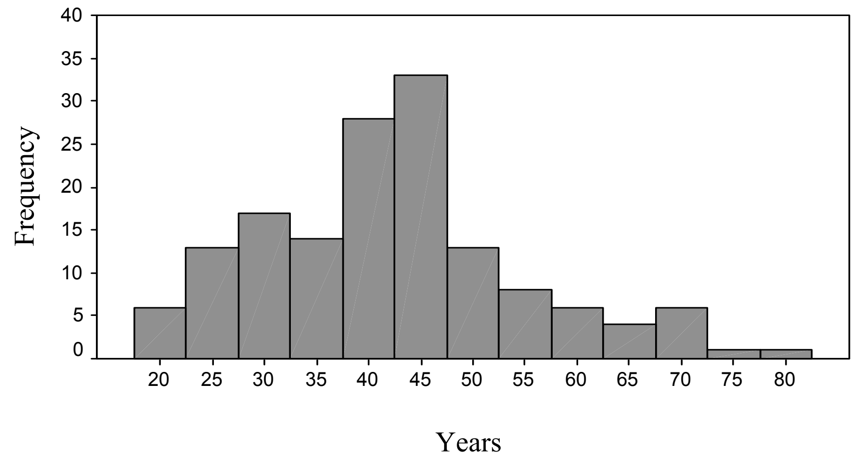
The average age of the sweetpotato producers was 42.3 years old. However, 55.4% were between 26 and 45 years old, 29.3% were between 46 and 65 years of age, and only 6.0% were older than 66 years of age (Figure 6).

Figure 5: Distribution of Years of School Completed,
Xai-Xai and Chokwe, Mozambique (N=150)



Source: Survey 2004

Figure 6: Respondents' Age Distribution, Xai-Xai and Chokwe, Mozambique (N=150)



Source: Survey 2004

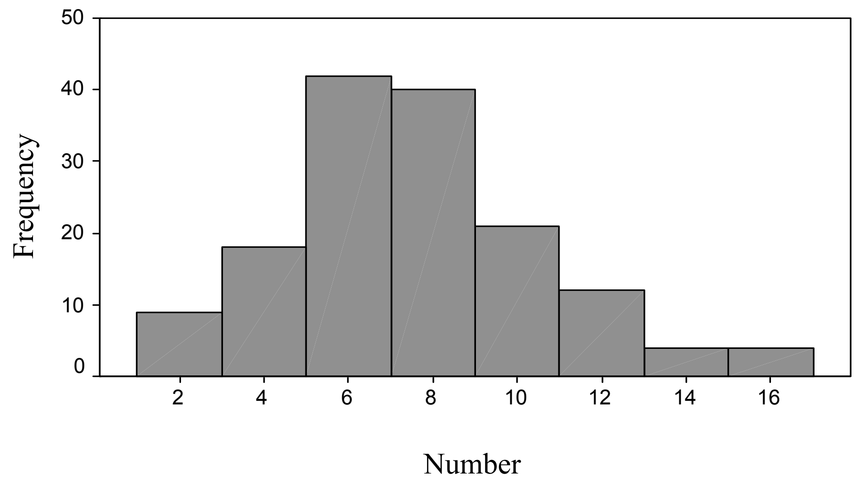
In terms of gender, of the 150 randomly selected respondents, 144 were female (96%). Although some men's names were selected from the NGOs' lists of vine recipients, most of them reported that while they received the vines as the household head, their wives were responsible for growing sweetpotato.

5.1.2 Household Size and Number of Children (less than 18 years of age)

Household size--defined as the total number of people living in the household at least 9 months per year--across all 10 villages averaged 7.1 (ranging from 1 to 15) (Figure 7). These households had an average of 3.4 children younger than 18 years of age (ranging from 0 to 8), 2.0 young children under 5 years of age (ranging from 0 to 7, as shown in Figure 8), 3.6 adults (ranging from 1 to 11), and 0.8 household member living away from home (ranging from 0 to 10). The respondents had lived in the same village for an average of 25.8 years (ranging from 3 to 72 years).

Figure 7: Respondents' Family Size Distribution,

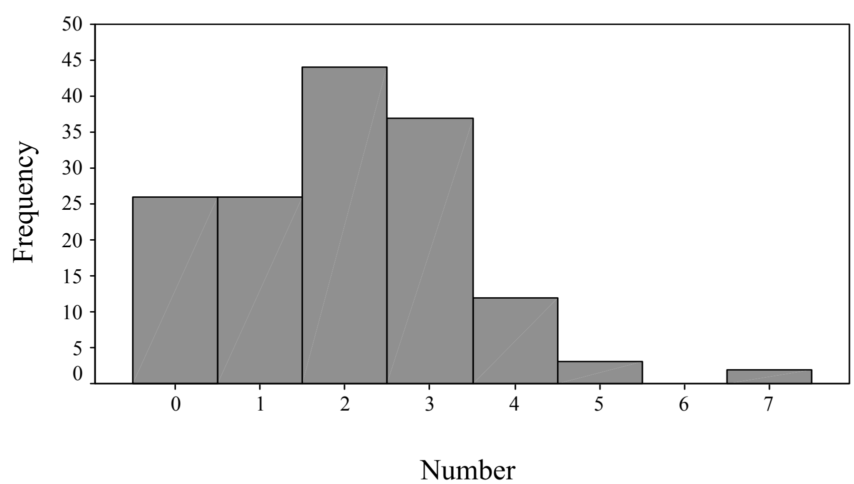
Xai-Xai and Chokwe, Mozambique (N=150)



Source: Survey 2004

Figure 8: Distribution of Young Children in Households

Xai-Xai and Chokwe, Mozambique (N=150)



Source: Survey 2004

Few household members participated in off-farm activities. In 2003, only 3.3% of respondents engaged in off-farm activities. In addition, 25.3% of respondents' spouses participated in off-farm activities in 2003. Most of the respondent's spouses were primarily working in South Africa, Maputo and/or Xai-Xai city. However, it is important to point out that 28.7% of the respondents reported that they did not have a spouse, as they were either widowed or divorced.

5.1.3 Livestock Ownership and Household Total Farmland

Livestock (cattle and small ruminants) is a proxy of household wealth, a source of draft power for land preparation and transportation, and a source of income[19]. In most developing countries, particularly in Southern Africa, livestock ownership is strongly associated with a privileged social status. According to the Agriculture and Livestock Census (CAP, 1999-2000), about 72% of cattle keepers use draft power, either for ploughing or for transporting agricultural products, fuelwood, and water. Approximately, 38% of cattle owners in the Gaza province commonly use animal traction for ploughing and/or transportation, followed by Inhambane and Tete provinces with 24 and 18%, respectively.

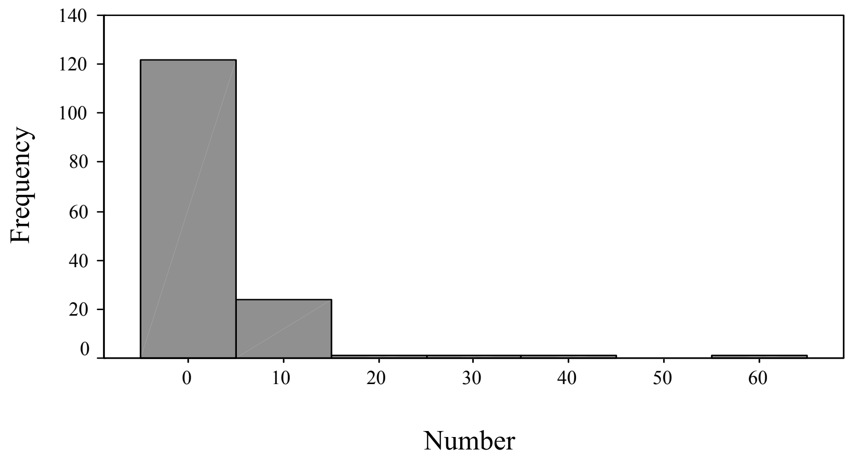
Among the survey households, 48% of the respondents owned livestock--27.3% owned cattle and 39.3% owned small ruminants. Among households owning cattle, about 32% had fewer than 5 bovines and 46% owned between 5 and 10 bovines (ranging from 1 to 57, as shown in Figure 9). Among households owning small ruminants (pigs, goats

[19] The geographical distribution of cattle population and number of holdings is strongly determined by two major factors: (ii) culture (in the southern region, cattle ownership is traditionally associated with social status and welfare) and; (ii) the predominance of tsetse fly, in most areas of central and northern Mozambique, people cannot raise cattle.

and sheep), 61% raised fewer than 5 animals and 32% owned between 5 and 10 small ruminants (ranging from 1 to 25).

Figure 9: Distribution of Households' Total Cattle,

Xai-Xai and Chokwe, Mozambique (N=150)



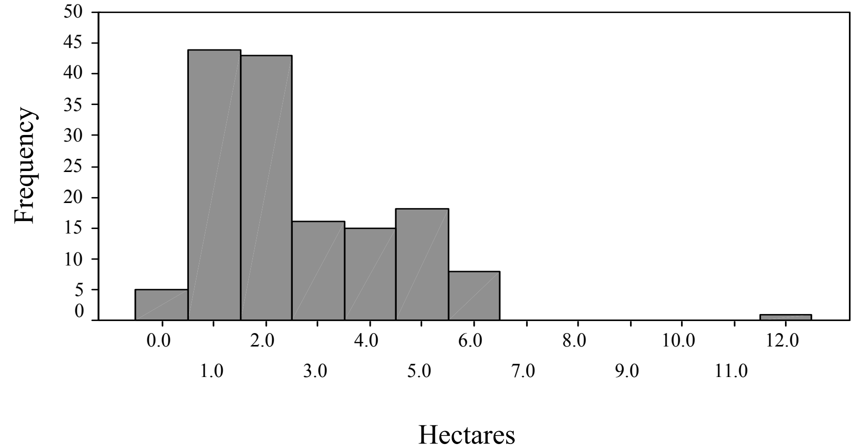
Source: Survey 2004

Apparently, in the study area land is not a constraint. On average, household planted 2.4 hectares to annual crops (Figure 10). Approximately 67% of the respondents prepared their fields manually, using hand tools. Of the households (33%) who used animal traction, 9% used it on a rental basis[20].

[20] According to the Agriculture and Livestock Census 1999-2000, of the total of producers in Mozambique using animal traction for land preparation and/or transportation, 32% are in Gaza province (INE/MADER, 2001).

Figure 10: Distribution of Households' Total Farmland,

Xai-Xai and Chokwe, Mozambique (N=150)



Source: Survey 2004

5.1.4 Awareness and Extension Services Provided to Farmers

Taking into account the importance of technical knowledge as a key determinant of technology adoption (see the literature review chapter), questions were included in the questionnaire to determine the frequency, source, and type of technical assistance that farmers had received during the last two years, with respect to orange-fleshed sweetpotato farming. Firstly, the respondents were asked how often during the last two years they participated in field days and/or on-farm demonstration events and to name the institution (s) that organized or funded those awareness activities. Secondly, the respondents were asked how often any technician from public or NGO extension services had visited them during the last two years and what type of technological message was delivered. Finally, they were asked whether they were aware of the nutritional benefits associated with the consumption of OFSVs (OFSPV) and who provided that information (Table 7).

Table 7: Frequency, Sources, and Type of Technical Assistance Received by Farmers, Chokwe and Xai-Xai, Mozambique (% of Respondents, N= 150)

Source of Technical Assistance	Field Days & Demonstration Activities	Extension Visits		Nutritional Benefits of Consumption of OFSPV
		Related to Sweetpotato Production	Not Related to Sweetpotato Production	
Public extension	0	16.0	4.0	1.3
SARRNET	6.0	NA	NA	NA
NGO	8.7	4.0	1.3	78.7
Health Institutions	NA	NA	NA	3.4
TOTAL	14.7	20	5.3	83.4

Source: Survey 2004 NA = Not applicable

Field days events were mainly devoted to exposing the farmers to the various products that could be made out of OFSVs (e.g., juice, cakes, biscuits, flour, improved porridge, and chips). Approximately 15% of the respondents reported having participated in an orange-fleshed processed product demonstration event organized by SARRNET (6%), Lutheran World Federation (8%) and Save the Children (0.7%) during the last two years (Table 7).

Regarding the number of times extension technicians visited farmers during the last two years, 17.3% reported having been visited once, while 8% received two visits. About 20% of the farmers reported having received technical information about OFSP production. The technological messages included the benefits of planting in ridges (versus the traditional and common method of planting in mounds) and planting 1-2 vines per hole (versus the traditional number of 8-10 vines per hole). Messages not related to sweetpotato production included information on planting methods for maize, beans, and vegetable crops, the use of inputs in rice, maize, beans, and vegetable crops farming, and pest control for major cash crops (vegetables, rice, and maize).

A surprisingly large percentage of the respondents (83%) were aware of the nutritional benefits of orange-fleshed sweetpotato (OFSP) varieties to young children and pregnant and lactating women. Respondents reported that they had learned about these benefits from several different sources, including extension services (public and NGOs), rural health institutions, and the media.

In recent years, the development literature has highlighted the role of social capital in facilitating the exchange of information among farmers (Huysman M., *et al.*, 2004). Considering farmer associations as a proxy for social capital, respondents were asked whether they and/or their spouses were members of any kind of farmer associations and to what extent they had benefited from membership. Only 18% of the respondents were members of a farmer association[21]. These farmers and/or their spouses belonged to ten different farmer associations in the study area. All the farmer associations were directly or indirectly supported by NGOs, which assisted farmers by providing inputs and technical assistance or sponsored food-for-work projects. Nine out of the ten farmer associations mentioned were primarily engaged in crop production, while one promoted animal husbandry on a rotational basis[22].

The 18% of respondents who were members of a farmer association identified the following benefits from their participation:

(i) Agricultural products (derived from collective production) for household consumption (56%);

[21] According to the Agricultural and Livestock Census, 2.8% of the total households in Gaza province were members of a farmer association in 2000/01 cropping season.

[22] The beneficiary of distributed cow is obliged to give one calf to other member of the farmer association.

(ii) Planting materials of vegetable crops (produced under irrigation in collective plot) for transplanting in their individual fields (18%);

(iii) Profit from sales of products derived from collective plot (11%);

(iv) Access to animals (on a rotational basis) (8%), and

(v) Use of association's animal traction for land preparation in their individual fields (7%).

Clearly, only a small share of the farmers was served by a farmer association. The sustainability of these farmer' associations is questionable, since continued provision of NGO-supported technical assistance and input depends on continued access to funds from the international development community. Furthermore, other bottlenecks threaten the functionality and sustainability of these farmer associations[23], including the absence of a crop marketing system and the non-availability of credit opportunities for farmers.

5.1.5 Land Tenure and Cropping Systems

All respondents cultivated family-owned land. Approximately 40% cultivated three plots, 28% cultivated two plots, 20% grew crops in four plots, and 7% cultivated only one plot. The median number of plots per household was three. About 97% intercropped maize; beans, groundnuts, roots and tubers, and 3% grew rice, maize, and/or vegetable crops (e.g. tomato, onion) in monoculture.

Farmers cultivated plots in two different environments. Depending upon the season, from 69 to 81% of the respondents cultivated plots in lowland alluvial soils, 4 to

[23] The ten farmer associations found in the study area are as follows: Voz da Frelimo, Fidel Castro, Samora Machel, Graca Machel, Gandlhazi, Vamos a Frente, Grupo de Agricultores (Macunene village), Tsakhane, Mapimo Manene, and Agro-Pecuaria (Muzumuia village).

8% farmed lowland peat soils, and 14 to 26% cultivated upland light-textured soils plots, either as their first, second, or third household field.

Typically, farmers cultivated upland and lowland fields in order to reduce crop failure risk due to drought or flooding. However, across the three cropping seasons, farmers gave priority to planting in high fertility alluvial soils, as these soils are likely to produce the highest yields and thereby to contribute to smallholder food self-sufficiency (Table 8).

Table 8: Sweetpotato Plots Cultivation Across Different Soil Types (% of Plots), Chokwe and Xai-Xai, Mozambique (2002/03 and 2003/04 Seasons).

Soil Types	Cropping Season		
	2002/03 Wet	2002/03 Dry	2003/04 Wet
Lowland alluvial soils (*bilene*)	70.3	80.7	69.1
Upland sandy soils (*serra*)	25.2	13.5	26.4
Lowland peat soils (*machongos*)	4.5	5.8	4.5

Source: Survey, 2004

5.2 Descriptive Statistics of Sweetpotato Production

5.2.1 Identified Varieties Grown by Households

The respondents planted several different sweetpotato varieties, including 17 white/cream-fleshed and 5 OFSVs, namely: Jonathan, Resisto, Japing Selecto, Taimung 64, Lo 323, and Cordner. The four varieties most frequently grown in the 2002/03 wet season, the 2003/03 dry season, and the 2003/04 wet season are presented in Table 9.

Table 9: Four Most Frequently Grown WFSP and OFSP Varieties, Chokwe and Xai-Xai Districts, Mozambique (N=150)[a]

Variety Name	Flesh Color	Cropping Season		
		2002/03 Wet	2002/03 Dry	2003/04 Wet
Sector	White	67.1	61.2	68.2
Mudiliva	White	55.0	49.3	43.7
Jonathan	Orange	33.1	35.5	35.9
Resisto	Orange	28.6	37.0	30.3

Source: Survey 2004

[a] The total percentages of respondents are greater than 100% because most farmers planted more than one variety.

5.2.2 Sweetpotato Cultivated Area

In order to gain insights regarding the evolution of their sweetpotato areas, farmers were asked to estimate their sweetpotato areas in the 2003/03 wet season, the 2002/03 dry season, and the 2003/04 wet season (Table 10), and the proportion of the area they planted to white/cream-fleshed relative to orange-fleshed varieties.

In all three seasons, more than 50% of the respondents cultivated less than 80 m^2 of sweetpotato and approximately 10% of the respondents cultivated between 250 and 2,500 m^2. In the 2002/03 dry season, the percentage of respondents who planted less than 80 m^2 of sweetpotato increased, since some of them did not cultivate sweetpotato during the dry season due to the low rainfall and no water for irrigation.

Table 10: Sweetpotato Area[a] Cultivated by Smallholders in Different Cropping Seasons in Chokwe and Xai-Xai Districts, Mozambique.

Statistics	2002/03 Wet Season (N=150)	2002/03 Dry Season (N=123)	2003/04 Wet Season (N=150)
Area (m^2)			
Mean	206	107	215
Median	80	30	80
Mode	80	0	125
% of Respondents with			
Area less than 80 m^2	55.3	78.7	50.7
81 - 150	24.7	10.0	25.3
151 – 250	10.0	4.6	12.7
251 – 500	6.0	4.7	7.3
501 – 2,500	2.7	1.3	2.7
2,501 – 5,000	1.3	0.7	1.3

WFSVs = White-fleshed Sweetpotato Varieties
Source: Survey 2004

[a] Sweetpotato areas planted in the 2002/03 wet and dry seasons were estimated based on recall data provided by respondent. Data for the 2003/04 wet season are based on the researcher estimates. In cases when the respondent was not able to provide information in hectares or square meters, she was asked to compare the magnitude of her sweetpotato-cultivated area with the standard size household residential plot and this estimate was converted to square meters.

In all three seasons, the respondents planted a far greater share of their fields to white versus orange-fleshed varieties, ranging on average from 83 to 86% in the 2003/04 wet season, and 2002/03 dry season. In general, more than 70% of the respondents planted more than 75% of their sweetpotato fields to WFSVs (Table 11).

Presently, farmers do not apply the entire technological package for orange-fleshed sweetpotato farming, which includes fertilizers, and pesticides. Moreover, there is no evident difference in terms of agronomic practices and production costs between white and orange-fleshed sweetpotato farming.

Table 11: Proportion of Sweetpotato Area Smallholders Planted to WFSVs in Different Cropping Seasons in Chokwe and Xai-Xai Districts, Mozambique.

Statistics	2002/03 Wet Season (N=150)	2002/03 Dry Season (N=123)	2003/04 Wet Season (N=150)
Proportion of WFSVs			
Mean	84	86	83
Median	90	100	90
Mode	90	100	100
% of Respondents with			
Proportion less than 50	11.3	7.3	5.3
50	4.7	0.7	2.0
51 - 75	14.0	15.4	18.0
76 - 100	70.0	76.6	74.7

WFSVs = White-fleshed Sweetpotato Varieties
Source: Survey 2004

Farmers reported several reasons for planting different proportions of their farms to white/cream versus OFSVs (Table 12). The main reasons (which varied by season) the respondents reported for cultivation a higher proportion of white/cream varieties included the limited availability of OFSP vines, limited off-season propagation capacity of OFSVs, abundant availability of planting materials of white/cream varieties, and the relatively low drought-tolerance of OFSVs. Conversely, the major reasons respondents gave for planting an equal or greater proportion of OFSVs included perceived high-yield, the better taste of orange-fleshed varieties, and a desire to experiment with new varieties.

Considering that there is no difference in terms of production costs the incremental gross margin revenue between WFSVs and OFSVs would be exclusively determined by the yield differential between these two types of varieties.

Table 12: Farmers' Reasons for Planting Different Proportions of Sweetpotato Varieties (% of Respondents), Chokwe and Xai-Xai, Mozambique.

Farmers' Reasons	2002/03 wet season (N=106)	2002/03 dry season (N= 60)	2003/04 wet season (N=77)
Planting greater proportion to WFSVs			
Limited quantity of OFSV vines	79.2	15.0	5.2
Limited off-season propagation capacity of OFSVs	4.7	46.7	45.5
OFSVs not tolerant to water stress on upland	1.9	3.3	1.3
Abundant planting materials of WFSVs	1.9	0	0
Respondent not familiarized with OFSVs	0.9	5.0	5.2
Time constraints to increase area of OFSVs	0.9	3.3	0
WFSVs are more appropriate for animal feeding	0.9	1.7	1.3
OFSVs are watery and too sweet	0	3.3	3.9
WFSVs are more productive than OFSVs	0	1.7	5.2
Planting equal or greater proportion to OFSVs			
High-yield	3.7	11.7	18.2
Experimentation of new varieties	1.8	3.3	0
High-yield and better taste	1.9	5.0	13.0

WFSVs = White-fleshed Sweetpotato Varieties
OFSVs = Orange-fleshed Sweetpotato Varieties
Source: Survey 2004

It is important to point out that the percentage of respondents who grew OFSVs differed from one cropping season to another. In the 2002/03 wet season, approximately 71% of the respondents grew at least one OFSV, while in 2002/03 dry season and 2003/04 wet season the adoption rate was only 38% and 51%, respectively (Table 13).

The lower percentage of respondents who grew OFSVs in the dry season is associated with erratic and insufficient rainfall in the upland areas or a lack of water for irrigation in the lowlands during the dry season.

Table 13: Adoption (%) of OFSVs in Each Zone Covered by NGO, and by Season in Chokwe and Xai-Xai Districts, Mozambique.

	NGO-Covered Area[a]					
Household Cultivated OFSPV	LWF	CRC	WRS	WV	STC	Total Adoption
In 2002/03 wet season	100	50.0	86.7	40.0	76.7	70.7
In 2002/03 dry season	60	16,7	36.7	6.7	70.0	38.0
In 2003/04 wet season	96.7	40.0	40.0	6.7	70.0	50.7

LWF = Lutheran World Federation CRC = Caritas Regional Chokwe WR= World Relief Services
STC = Save the Children WV = World Vision
Source: Survey 2004

[a] Two villages covered by each NGO were selected, and 15 farmers per village were interviewed.

Furthermore, the highest percentage of respondents who grew OFSVs lived in Cuamba and Punguine villages, where vines of OFSVs were recently distributed to farmers (February 2004) by the Lutheran World Federation (Appendix D, Table D-1). Farmers in these villages mainly planted vines in the uplands, since the lowlands were waterlogged due to “excessive rainfall” which occurred during this year in the region. However, the heavy rains contributed substantially to better crop establishment and development of OFSVs in the uplands.

5.2.3 Planting Methods of Sweetpotato Varieties

In addition to distributing vines, the program’s extension services promoted two improved agricultural practices, namely: planting in ridges (versus the traditional method of planting in mounds) and planting one to two vines per hole (versus eight to ten per mound). Approximately 55% of the respondents planted sweetpotato in ridges. Among the respondents who planted in mounds (45%), their justification included their habit of doing so (82%) and that they did not know any planting method other than planting in mounds (13%). Among the respondents who reported using different planting methods for white versus orange-fleshed varieties (42%), 51% planted 1-2 vines of OFSVs per hole, 44% planted OFSVs in ridges while planting WFSVs in mounds, and 5% reported that planting in mounds was more appropriate for upland growing conditions, characterized by erratic rainfall and sandy soils with low water holding capacity.

Soil type and topography influence whether farmers plant sweetpotato on mounds, in ridges, or on flat land. Particularly in lowland peat soils with a higher water table and poor drainage, cultivation on mounds is recommended since it increases both soil drainage and the topsoil layer (Woolfe, 1992). Most farmers who cultivated lowland alluvial (heavy clay) soils planted sweetpotato along the borders delimitating their fields or along drainage canals on manually formed mounds. In contrast, farmers who ploughed using animal traction mostly used ridges. In the uplands, characterized by light texture and well-drained soils in which deep cultivation is required to provide room for roots to grow, farmers often plant sweetpotato on flat ground (Woolfe, 1992a). However, in both districts surveyed, very few cases of planting on flat were observed in uplands.

5.2.4 Varieties Grew and Vines Received by Households

Households in the selected villages were exposed to OFSVs in different ways and the frequency of vine distribution varied among NGOs operating in the sampled villages. Most respondents received vines of OFSVs once (69%), although 8% received them twice, and 23% received them three times. About 73% of the respondents grew one and 23% grew at least two different OFSVs.

Table 14 shows the reasons reported by the respondents who received vines of OFSVs more than once (31%). More than 22% justified having lost the varieties they had previously received due to adverse agroclimatic conditions--mainly due to either drought or flooding in the lowlands.

Table 14: Major Reasons Reported by Farmers Who Received Planting Materials of OFSVs More than Once (N= 46), Chokwe and Xai-Xai Districts, Mozambique.

Major Reasons	Frequency
First distributed materials lost due to drought and the second due to flooding (poor soil drainage in lowlands)	52.0
Planting materials of OFSP lost due to severe drought	28.3
Distribution is free of charge, even if they previously received an OFSPV	11.0
Different varieties in each distribution and willing to increase OFSPV area	6.5
Other	2.2

Source: Survey 2004

As mentioned above, characteristics of lowland soils and the lack of an operational drainage system contributes substantially to frequent flooding in the region. However, despite the fact that farmers experienced devastated flooding, if they actually valued those nutritionally improved OFSVs, they should have been able to save these varieties by transferring them to an upland field or planting them in their backyard.

Interestingly, farmers who lost their orange-fleshed varieties were able to save their WFSVs. This suggests that, notwithstanding the adverse climatic and edaphic growing conditions, farmers may have failed to save their orange-fleshed varieties because they were pretty sure that they would be able to receive free of charge more planting materials from an NGO. As mentioned previously, the frequency of vine distribution and the number of OFSVs distributed varied by NGO (Table 15).

Table 15**:** Frequency of OFSPV Vines Distribution, and Number of Varieties Each Household Received from 2000/01 and 2003/04 Wet Season by NGO, Chokwe and Xai-Xai, Mozambique.

Variable	Number	NGO-Covered Area[a] LWF	CRC	WRS	WV	STC	Total
Frequency of OFSP Vines Distribution	One	NA	80	100	100	66.7	69.3
	Two	NA	20	0	0	20.0	8.0
	Three	100	0	0	0	13.3	22.7
Number of OFSP Cultivars Received	One	80	80	100	80	23.3	72.7
	Two	20	20	0	20	76.7	27.3

LWF = Lutheran World Federation CRS= Caritas Regional Chokwe WRS= World Relief Services
STC = Save the Children WV = World Vision NA = not applicable

Source: Survey 2004

[a] Two villages covered by each NGO were selected and 15 farmers per village were interviewed.

All respondents in both villages covered by the Lutheran World Federation (Cumba and Punguine, Chokwe district) reported receiving vines three times. In contrast, in villages covered by World Relief Services (Macunene and Malhazene, Chokwe district), Save the Children (24 de Julho, Xai-Xai district), and World Vision (Fidel Castro and Siaia, Xai-Xai district), respondents reported receiving vines only once (Appendix D, Table D-2).

Both Caritas Regional Chokwe and World Relief Services covered almost all villages in Chokwe district during the massive distribution effort in 2000 and later their staff carried out more restricted distributions to specific targeted groups of farmers in some of these villages.

Save the Children distributed vines directly to farmers once, without any involvement of local authorities. In addition, this NGO provided vines two more times to a farmer association for multiplication and further distribution to farmers under the responsibility of the association leadership. Unfortunately, these multiplication efforts failed twice, due to severe drought in 2002 and flooding in 2004.

World Relief Services carried its first massive distribution in 2000 and later provided orange-fleshed planting materials to groups of farmers working with its village activists.

Compared to the other NGOs, World Vision followed a slightly different approach for its massive distribution of vines to farmers just after the devastating flood of 2000. Under the auspices of the Food Security project, this NGO established and managed several conventional and rapid multiplication plots. However, due to a lack of financial resources and a desire to promote sustainability, responsibility for managing those conventional multiplication plots was handed over to the farmer association--but unfortunately without success.

The overall performance of the distribution program raises an issue regarding the sustainability of these kind of promotional activities, since their longevity is determined mainly by the duration of project funding--as soon as project funding phases out, they are likely to collapse.

5.3 Producers' Evaluation of OFSVs

5.3.1 Producers' Perceptions about the Performance of OFSVs.

Producers were asked their opinions regarding the OFSVs they had planted (Table 16). In terms of the weighted average, 40% of the responses indicated that OFSVs had relatively low drought-tolerance (compared to WFSVs), particularly when planted in upland sandy soils, but also under lowland growing conditions without irrigation.

Table 16: Respondents' First and Second Opinions Regarding the Performance of OFSVs, Chokwe and Xai-Xai, Mozambique.

Opinions about OFSVs	Percentage of Responses		
	First Comment (N= 111)	Second Comment (N= 60)	Weighted[a] Average
Not tolerant to drought conditions	50.5	20.0	39.8
High-yield under favorable growing conditions	32.4	3.3	22.2
Nutritionally better for young children	6.3	25.0	12.9
Bigger root size than WFSP varieties	1.8	26.7	10.5
Low off-season propagation capacity	4.5	20.0	9.9
Others	4.5	5.0	4.7

Source: Survey 2004

[a] All the responses received proportionally the same weight regardless their order.

Their opinion is consistent with the reason why farmers reported losing their orange-fleshed materials and their justification of the need for receiving vines more than once. Other farmers reported that orange-fleshed varieties were high-yielding under favorable growing conditions (22%), nutritionally better for young children (13%), produced bigger roots (11%), and have a low off-season propagation capacity (5%).

Considering that any good embodies both desirable and undesirable characteristics, producers were asked to evaluate several traits of orange-fleshed varieties (i.e. crop yield, crop duration, propagation capacity, taste of fresh and boiled roots, consistency, etc.), compared to "local" white/cream sweetpotato varieties. Generally, in making their assessment, the farmers compared the OFSVs with the most widely cultivated white-fleshed varieties such as Sector and/or Mudiliva.

Farmers' assessment of two of the orange-fleshed varieties--Jonathan and Resisto--reported in Table 17. Both of these orange-fleshed varieties where ranked positively with regard to total yield, root size, taste of both fresh and boiled roots, taste of the leaves and cooking time.

In contrast, these two OFSVs were ranked negatively in terms of off-season propagation capacity, dry matter content, and tolerance/resistance to drought, pests, and diseases.

The low figures for taste of leaves is associated with a high number of respondents who reported not consuming leaves--either because they were not used to eating them or they did not like the reddish color of the leaves of some OFSVs, such as Jonathan and Japon Selecto.

According to Collins *et al.*, (1995), throughout the world where people eat sweetpotato as a staple food, the most preferred sweetpotato root type is high in starch, white colored, and moderately sweet tasting, while orange-fleshed roots are acceptable as a dessert. Although tastes and preferences vary from region to region, results from a survey conducted by the Asian Vegetable Research and Development Center (AVRDC)

Table 17: Farmers' Evaluation[24] of the Performance of OFSVs Versus "Local" Cultivated Varieties[25], Chokwe and Xai-Xai Districts, Mozambique.

Variety Traits		Jonathan (N=128)		Resisto (N=40)	
		(+)	**(-)**	**(+)**	**(-)**
Production-Related Traits					
Total yield	(*Higher/ Lower*)	64.1	23.4	85.0	7.5
Crop duration	(*Shorter / Longer)*	57.8	26.6	50.0	12.5
Off-season propagation capacity	(*Better / Worse*)	1.6	86.7	7.5	92.5
Root size	(*Bigger / Smaller*)	75.0	10.2	82.5	7.5
Consistency (dry matter content)	(Mealy / *Watery*)	28.9	62.5	20.0	65.0
Tolerance/Resistance to drought	(*Higher / Lower*)	5.5	84.4	5.0	72.5
Tolerance/Resistance to pests	(*Higher / Lower*)	9.4	55.5	2.5	45.0
Tolerance/Resistance to diseases	(*Higher / Lower*)	4.7	56.3	7.5	45.0
Consumption-Related Traits					
Taste of fresh root	(More *sweet / Less sweet*)	74.8	7.8	75.0	15.0
Taste of boiled root (1)	(*More sweet / Less sweet*)	80.5	12.5	80.0	10.0
Taste of boiled root (2)[a]	(More *sweet / Less sweet*)	47.7	6.3	57.5	7.5
Cooking time	(*Shorter / Longer*)	66.4	3.9	72.5	0
Taste of leaves	(More *sweet / Less sweet*)	35.9	5.5	37.5	5.0

(1) Respondent's comment (2) Opinion of respondents' spouses.

[a] Approximately 23.4% of respondents do not have spouses, and 17.2% of respondents do not know their spouses' opinion.

[24] Some respondents evaluated the traits as being equal (no difference between white and orange varieties). Thus, the sum of (+) and (-) do not sum up to 100%.

[25] Other orange-fleshed varieties (Japon Selecto, Taimung 64 and Lo 323) were grown by farmers in the selected villages. However, since few responses were obtained (8, 6 and 2 respectively), they are not reported in Table 16.

found that 77% of the respondents preferred dry and moderately dry textured varieties, whereas moist textured varieties were only preferred in developed countries. Furthermore, more than 50% of the respondents surveyed revealed a preference for white or cream-fleshed varieties, while 30% preferred orange-fleshed ones (Lin *et al.*, 1992).

5.3.2 Major Constraints to Sweetpotato Production

Producers were asked to identify the three most important constraints to sweetpotato production (Table 18). Among water/drainage related factors, respondents reported (in terms of weighted average) drought (33%), flooding (21%), and poor/sandy upland soils (4%). These constraints contribute to a high risk of crop failure. As elaborated in Chapter 2, most of the flooding events occur as a result of poor drainage of the peat and alluvial heavy-clay soils in the lowlands. Consequently, while the irrigated land has a high potential for agriculture production and development, it is not being fully exploited due to the poor quality of the drainage systems, which contributes to flooding, salinity, and sodicity-related problems. This is especially a constraint to sweetpotato, since the crop is sensitive to alkaline and saline growing environments (Woolfe, 1992a).

Under the prevalent conditions of low, erratic, and irregular precipitation in the region, lowlands are extremely important for crop production. Therefore, rehabilitation of drainage systems in lowlands is extremely important to increasing the sweetpotato production in general, particularly high-yield OFSVs that have relatively higher water crop and nutrient requirements.

Table 18: Constraints of Sweetpotato Production, Chokwe and Xai-Xai, Mozambique.

Identified Major Constraints	Percentage of Responses			
	First (N=145)	Second (N=127)	Third (N=46)	Weighted[a] Average
Water/drainage related constraints				
Frequent severe drought	58.6	13.4	12.5	33.9
Frequent flooding	14.5	30.7	15.0	21.0
Poor sandy soils not suitable for SP growing	2.1	4.7	7.5	3.9
Low off-season propagation of OFSV	1.4	3.9	0	2.2
Institutional related constraints				
Lack of animal traction	11.0	22.8	30.0	18.5
No market for output surplus in the village	1.4	16.5	25.0	10.8
Lack of agricultural tools	2.8	4.7	7.5	4.2
Pests (rodents, snails, grasshoppers, etc)	5.5	0.8	0	2.8
Others	2.8	2.4	2.5	2.6

Source: Survey, 2004

[a] All the responses received proportionally the same weight regardless their order.

While sweetpotato is a perennial crop, it is often grown as an annual. Thus, having sufficient rainfall during the non-growing season (dry) is extremely important, since farmers must maintain vines during the dry season as planting material for the main cropping season (wet). Both districts are characterized by extremely low rainfall during dry season, averaging less than 150 mm and 300 mm in Chokwe and Xai-Xai, respectively. In contrast, optimum rainfall during the dry season is estimated at 250–500 mm (Woolfe, 1992a). Therefore, low rainfall during the dry season is a constraint to off-season propagation of sweetpotato varieties in general, and particularly orange-fleshed varieties. While not reported by farmers as a major water/drainage related constraint, they assessed OFSVs as much worse than white/cream in terms of off-season capacity during the dry season.

Furthermore, farmers reported that 'local' WFSVs are relatively more tolerate to drought conditions, since they can withstand longer period of water stress and they easily propagate as soon as rain falls during wet season.

Among institutional related constraints, respondents reported lack of animal traction (19%), lack of market for sweetpotato surplus in the villages (11%) and limited provision of agricultural tools (4%). These constraints provided no incentive to increasing area for sweetpotato and adoption of OFSVs.

5.3.3 Proposed Actions Needed to Improve OFSVs.

In order to improve sweetpotato production, including the adoption of OFSVs, producers were asked to propose the most important actions that needed to be undertaken. Most farmers gave only two responses (Table 19).

The most important actions that farmers proposed were: (i) providing access to credit for animal traction (33%); (ii) distributing vines of orange-fleshed varieties that are more tolerant to drought (27%), and (iii) improving the drainage system in the lowlands (19%).

The high percentage of responses regarding credit for animal traction is justified, since most of women interviewed were either widows or their husbands worked away from home--making labor the major constraint for agricultural production. Thus, animal traction could play an important role in removing this bottleneck, particularly in lowland heavy clay soils.

Table 19: Main Actions Proposed by Respondents for Improving Sweetpotato Production, Chokwe and Xai-Xai Districts, Mozambique.

Proposed Actions	Percentage of Respondents		
	First (N=132)	Second (N=60)	Weighted [a] Average
Establish credit system for animal traction	31.1	35.0	32.6
Distribute vines of OFSPV more tolerant to drought	25.8	28.3	26.6
Improve the drainage system in lowlands	20.5	16.7	19.3
Organize transport of SP roots to the market	11.4	5.0	9.4
Control pests (rodents, snails, locust, etc) control	2.3	8.3	4.2
Improve roads	4.5	3.3	4.1
Disseminate production and processing techniques	1.5	1.7	1.6
Others (H_2O pump, agric. tools, market in the village)	3.0	1.7	2.6

Source: Survey 2004

[a] All the responses received proportionally the same weight regardless their order.

Finally, given the current frequency of flooding in the lowlands, improving the drainage system is obviously a priority action that is needed to improve agricultural production in all villages covered by this survey, including sweetpotato production.

5.4 Consumption and Commercialization of Sweetpotato

5.4.1 Sweetpotato Consumption Patterns

Fresh sweetpotato roots are typically boiled or roasted and consumed at breakfast, usually served with tea[26]. However, sweetpotato is not deemed to be a major staple food in the study area[27].

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[26] According to Woolfe, (1992b), the sweetpotato consumption pattern in the study area suggests that this commodity is fulfilling the role of a special food (1-7 meals per week, but only at one particular meal).

[27] Sweetpotato are consumed in a variety of ways in other countries, including baked, boiled, served with meats, in soups, candied, in salads, desserts, cereals, cakes, and are used to make various cold and alcoholic beverages. Also, they can be used to produce syrup and flour (Cockerham *et al.*, 1921; Woolfe, 1992a, IPC, 2002).

To assess the importance of sweetpotato in the diet, the respondents were asked how often they consumed sweetpotato roots and about their knowledge of processed products derived from sweetpotato (Table 20). Approximately 64% of the respondents consumed sweetpotato four or more months per year and 68% ate sweetpotato roots at least four times a week during the months they consumed them. While a high percentage of the respondents reported being aware of sweetpotato processed products (70%), few made any processed sweetpotato product.

Table 20: Household Consumption of Roots, Awareness, Experience in Processing Products Out of Sweetpotato.

	Months HH Consumed Roots			Times per Week HH Consumed Roots			Knowledge of Processed Products	Experience in Processing Products
	6	4	3	3	4	5		
Percentage of Respondents	41.3	22.7	17.3	47.3	20.7	18.0	70.0	4.0

Source: Survey 2004

Most of the respondents reported that while they had been told about those products (juice, cakes, flour, chips), they had not had an opportunity to see how to prepare them in practice. Respondents who participated in field days/demonstrations reported they did not make processed products because they lacked the necessary ingredients. Others smartly argued that since they began planting OFSVs, they have not yet obtained good yields. Thus, they did not have a sufficient quantity of roots to use for any purpose other than for traditional consumption (i.e., boiled, roasted, or porridge with "mafurra[28]".

Processing of sweetpotato into diversified, which contributes to nutritional value and convenience of use, could play an important role in promoting and increasing sweetpotato consumption among different segments of society. However, it is important to point out that in general, an inverse relationship has been observed between levels of consumption of sweetpotato with income levels (Woolfe, 1992; Omosa, 1997), suggesting that sweetpotato is deemed to be an inferior good.

Clearly, changing consumption food habits by incorporating new products into the diet or by introducing changes in the way food is traditionally prepared is a challenging and time-consuming task. Success will require a more consistent and comprehensive strategy that not only targets the rural area, but also the urban people--assuming that the latter are more educated and thus, more likely to have a greater "potential" demand for these new value-added and nutritious sweetpotato products. For example, a study conducted in Kenya found that preference for new sweetpotato processed products--biscuits, bread, chips, crisps, porridge and cakes--was dependent upon income and staple food habits. Moreover, greater awareness about and interest in sweetpotato products was found among households with low and middle-income levels (Omosa M., 1997).

[28] A tree specie (*Trichilia emetica)* found in Sub-Saharan Africa commonly in open riverine forests and open savannah woodlands. From the seed aril is made a milky suspension used for cooking while seed oil is used to manufacturing soap and cosmetics and producing candles (FAO, 1986).

Scientists in developed countries are also trying to promote sweetpotato products. For instance, in the U.S., the North Carolina Sweetpotato Commission Foundation (NCSCF) has been strongly involved in identifying new value-added sweetpotato products, in order to achieve its target of increasing sweetpotato consumption by 25%. Presently, American per capita sweetpotato consumption is estimated at only 4.1 pounds, compared to 140 pounds of white potatoes.[29] New value-added sweetpotato products that are being tested include: (i) sweetpotato casserole pudding and bread pudding; (ii) scalloped sweetpotato; (iii) sweetpotato bran muffins; (iv) sweetpotato beverages; and (v) sweetpotato tarts.

In terms of sweetpotato leaves, 63% of the respondents reported that their households consumed leaves. Among households which did not consume sweetpotato leaves, the main reasons, included: (i) not being used to consuming sweetpotato leaves (20%); (ii) disliking eating leaves of sweetpotato (8%); and (iii) disliking the reddish color of some orange-fleshed varieties (6%).

Scientists have documented the superior nutritional value of sweetpotato leaves--compared to other leafy vegetables, such as, spinach, amaranth, cabbage and head lettuce--in terms of Vitamin B_2 content (Villareal *et al*., 1995). Furthermore, one study found that among various leaf qualities (i.e., tenderness, flavor, stem and leaf color, and hairiness) accounted for 64% of the variation in overall consumers' leaf acceptability (Villareal *et al.*, 1979). Although, leafy vegetables are widely consumed in the study area--including cowpea, amaranth, pumpkin and other legumes as a vegetable-based

[29] North Carolina Sweetpotato Commission Foundation, 2004. Value-Added Sweetpotato Products Now on Market: Success May be a Taste Away. http://www.ncsweetpotatoes.com/foundation.htm, August 2004.

complement to maize porridge--sweetpotato leaf color is a factor that is likely to affect adoption.

While OFSVs are promoted as being especially good for children, approximately 79% of the respondents fed both (white/cream and orange-fleshed varieties) to their children and 13% fed them only WFSVs. Some of the latter respondents justified this by saying that their children preferred WFSVs. However, one possible alternative explanation for this behavior is that these respondents may not be aware of nutritional value of OFSVs (approximately 13%) or they may be disadopters who only produce and consume WFSVs in their households.

It was hypothesized that there might be an association between the NGO that covered the villages and the level of awareness and household use of processed sweetpotato products. Presumably, greater knowledge regarding processing techniques should lead to a greater percentage of households making these products.

As shown in Table 21, in the villages covered by Lutheran World Federation, World Relief Services, and Save the Children, higher percentages of respondents were aware of processed sweetpotato products. However, the relationship between level of awareness and adoption is relatively weak. For example, in the villages covered by World Relief Services, 100% were aware, but only 3.3% had made processed products, compared to the villages covered by Save the Children (73.3% aware, 6.7% adopted). More information regarding levels of awareness and adoption of processed products by village is presented in Appendix D, Table D-3.

Table 21: Respondents' Levels of Awareness and Use of Processing Techniques of OFSVs in Each Zone Covered by NGOs in 2003/04 Wet Season, Chokwe and Xai-Xai Districts, Mozambique (% of Respondents).

Variable	NGO Covered Area[a]					Total
	LWF	CRC	WRS	WV	STC	
Respondent is aware of OFSV processed products	100	46.7	100	30.0	73.3	70.0
Respondent made at least one processed product from OFSV	10	0	3.3	0	6.7	4.0

LWF = Lutheran World Federation CRC = Caritas Regional Chokwe WR= World Relief Services
STC = Save the Children WV = World Vision
Source: Survey 2004

[a] Two villages covered by each NGO were selected and 15 farmers per village were interviewed.

5.4.2 Commercialization of Sweetpotato

Since farmers grew sweetpotato in two seasons, questions were included in the questionnaire to investigate the existence and volume of sweetpotato commercialization in both the wet and dry seasons (Table 22). The results indicate that sweetpotato is not widely commercialized in the study area. The respondents unanimously justified this on the grounds that a surplus of sweetpotato was not available. However, during group interviews, key informants mentioned that sweetpotato roots are sometimes used for in-kind payment of labor hired for agricultural activities.

Some respondents expressed a concern regarding the nonexistent market for sweetpotato, noting that while traders visited some of the villages to buy cassava and other agricultural products, they seldom bought sweetpotato roots and leaves. Particularly in the villages located far away from the main primary and secondary roads, poor tertiary roads result in high transaction costs, which limit the commercialization of sweetpotato and thereby limit the potential contribution of sweetpotato to increasing households' cash income.

Table 22: Indicators of Sweetpotato Commercialization, Chokwe and Xai-Xai, Mozambique

	Cropping Season	
	2002/03 Wet	2002/03 Dry
Respondents (%) who sold sweetpotato roots	18.7	2.0
Respondents (%) who sold orange-fleshed roots (OFSPV)	6.0	0.0
Respondents (%) who sold less than 100 Kgs of OFSPV [a]	5.4	0.0
Maximum (Kg) sold of OFSPV [b]	120	0.0
Mean (Kg)	3.6	0.0

Source: Survey 2004 NA = Not applicable

[a] Few respondents (9%) sold less than 100 Kg of sweetpotato roots (both color-fleshed varieties) in the 2002/03 wet season and 1% in the 2002/03 dry season.

[b] The maximum quantities of sweetpotato roots sold were 600 Kgs in 2002/23 wet season, and 475 Kgs in 2002/03 dry season.

Depending on the size and quality of sweetpotato roots, the retail price ranged from approximately 2,500 to 3,800 Meticais[30] per Kg in Xai-Xai and from 6,600 to 10,000 Meticais per Kg in Maputo city. Despite the extensive awareness campaign regarding the superior nutritional value of OFSVs, this aspect is not yet reflected in price differences between white/cream-fleshed and orange-fleshed varieties, since both types were sold at the same price.

Furthermore, while sweetpotato vendors in Chokwe and Xai-Xai reported that consumers preferred WFSVs on the grounds of habits and custom, vendors interviewed in Maputo reported that consumer's preferences did not show a preference for either

[30] Meticais is the Mozambican currency. In average, the exchange rate in 2002 was 23,180.40 Mt = 1 USD (INE, 2002)

type. Because the sample size of sweetpotato vendors in Xai-Xai and Chokwe was small (N=3), they may not be representative. However, the vendors revealed that some consumers bought OFSVs when WFSVs roots were not available. Moreover, they hypothesized that some consumers' preference for WFSVs roots was related to higher dry matter content and good taste, while the preference for OFSVs was associated with sweeter taste and higher nutritional value in Vitamin A. No vendor was found selling leaves of sweetpotato, which they argued was due to a limited demand for leaves. However, some vendors reported that when they occasionally sold leaves, they sold leaves of both types at the same price per bunch.

Since sweetpotato is seldom traded in world markets, its price is endogenously determined within producer countries. The major constraints to exporting are related to the difficulty of maintaining high fresh root quality, due to the high perishability of roots, and the high cost of post-harvest handling methods that are required to preserve the roots, including curing, cooling/heating, and ventilation (Collins, W. *et al.*, 1995).

Technological change contributes significantly to increasing aggregate output, which in turn leads to lower production costs per unit of output. Assuming that there are no market constraints and the demand is relatively elastic, farmers can maintain or increase their profits--even if they sell the product at a cheaper price. However, the extent to which consumers benefit from lower production costs depends largely on the food marketing and distribution system. The food marketing and distribution system must be sufficiently competitive in order to ensure that cost savings at the farm gate are passed up through the marketing chain and not exclusively captured (as additional profits) in the marketing chain (Hazell *et al.*, 2001). Moreover, in areas where an imperfect market system leads to a large discrepancy between farm and retail prices for food crops, a bias toward food crop production to ensure food security is likely to encourage farmers to give priority to meeting home consumption needs at the expenses of income generation (Goldman R. *et al.*, 1981).

For instance, in Xai-Xai district, the farm gate prices of sweetpotato roots varied from 1,300 to 1,500 Meticais (MT) per Kg, while at Xai-Xai market sites, roots were sold for 2,500 to 3,800 MT per Kg. At formal and informal markets in Maputo city, sweetpotato roots were sold for 6,600 to 10,000 MT per Kg. Notwithstanding the limited number of farmers and vendors who sold roots, the estimated transportation costs[31] range from 150 to 200 MT per Kg to Xai-Xai market and 2,380 MT per Kg to Maputo city. Thus, the difference between farm gate and retail prices in Xai-Xai market (transportation costs included) ranges from 1,000 to 2,100 MT per Kg, while the difference ranges from 2,920 to 6,120 MT per Kg in Maputo city.

Despite the high price in city markets, a low percentage of the respondents sold sweetpotato roots during the last two seasons. This may indicate that sweetpotato growers used sweetpotato roots largely for household consumption. In addition the high consumer price in the city markets could impair the sweetpotato consumption by low-income people in urban areas.

[31] Transportation costs per Kg of sweetpotato roots were computed, assuming that the farmer paid for the round trip to the market site and transported an average of four sacks of sweetpotato roots.

5.5 Chapter Summary

In the study area, sweetpotato is mostly grown by middle-aged women. Due to the lack of job opportunities in most of villages covered by this study, few households (27%) participated in off-farm activities in 2003. Most respondents' spouses were working away from home primarily in South Africa or in Xai-Xai and Maputo cities.

The average family size was 7 people with an average 2 young children (under 5 years of age) and 3 children (under 18 years of age). While about 27% of households owned cattle, livestock ownership was highly skewed in both districts. Apparently land tenure is not a major constraint, since all respondents own family land averaging 2.4 ha of total farmland per household. One of the major constraints farmers reported was a lack of draft-power for land preparation, particularly the lowland heavy-clay soils since only a third of respondents used animal traction in 2003/04 wet season. In addition, lowland alluvial and peat soils play an important role in the overall smallholder crop farming. However, due to the lack of investment in poor drainage improvement, these land resources have been frequently flooded.

Public and NGO extension services have focused on providing information to farmers about orange-fleshed sweetpotato cropping practices, and nutritional education regarding the benefits of consuming the roots and leaves of OFSVs. However, only 20% of respondents had received technical information related to sweetpotato production from an extension agent in the past two years. Surprisingly, a huge percentage of respondents (83%) were aware of the nutritional benefits of consuming OFSVs for young children and pregnant and lactating women.

Notwithstanding the small percentage of respondents (15%) who participated in field days and demonstration events, most of respondents (70%) reported having heard about the products made out of OFSVs (cakes, juice, flour, chips) from SAARNET, extensionists, health workers and the media. Unfortunately, a weak relationship was observed between awareness and adoption of these products at the household level allegedly due to the lack of know-how and/or insufficient production of orange-fleshed roots for purposes other than the traditional methods (boiled, roasted or porridge). Thus, changing food habits by incorporating new products into the diet or by introducing changes in the way food is traditionally prepared is a long-term task and still to be addressed. Despite the fact that the majority of respondents (63%) reported having consumed sweetpotato leaves, the reddish stem color of some of OFSVs is likely to affect the adoption of these varieties specifically for leaf consumption.

Few respondents (18%) are members of the area's ten farmer associations. However, the functionality and sustainability of these farmer associations are threatened by the high dependence on external funding from the international development community in addition to the limited crop marketing system and lack of credit opportunities for farmers.

Farmers' assessment of two OFSVs[32] (Jonathan and Resisto) revealed that these varieties were rated positively in terms of total yield, root size, taste of both fresh and boiled roots, taste of leaves, and cooking time. Conversely, the same varieties were rated negatively with respect to dry matter content of roots, tolerance to rainfed growing conditions (drought), and tolerance to pests and diseases. In addition, the major

[32] Other OFSVs were assessed. However, few responses were gathered regarding Japon Selecto (8), Taimung 64 (6), and LO 323 (2).

constraints to increasing sweetpotato production as identified by the respondents, include frequent drought and flooding, a lack of animal traction, no market for sweetpotato roots in the villages, and low off-season propagation capacity of OFSVs due to the low rainfall during the dry season.

Sweetpotato roots were rarely commercialized. Few respondents (19%) reported having sold sweetpotato roots (only 6% sold orange-fleshed roots) in 2003. Poor road infrastructure linking the remote sweetpotato producing areas to the nearest (semi)-urban markets, increases the transaction costs for sweetpotato commercialization, and consequently hampers the potential contribution of this commodity to overall household cash income.

The commercialization chain is characterized by a huge gap between farm-gate and retail prices. For instance in Xai-Xai district, the retail price (3,150 Mt) was on average 125% higher than the farm-gate price (1,400 Mt). This gap increased proportionally as the distance from producer area to the market site increases. For example, at the Maputo markets, the consumer price (8,300 Mt) was on average 493% higher than the producer price in Xai-Xai district. Despite the superior nutritional value of OFSVs, there is no difference in price between white/cream and orange-fleshed roots.

Presently, farmers do not apply the entire new technological package for orange-fleshed sweetpotato farming, which includes fertilizers, and pesticides. Few respondents (10%) reported having given vines of orange-fleshed sweetpotato to neighbors and/or relatives and there is no evidence of vines being sold in the study area. Moreover there is no difference in terms of agronomic practices and production costs between white and orange-fleshed sweetpotato farming. Thus, the difference in terms on gross margin revenue between white and orange-fleshed varieties is exclusively determined by the yield differential between these two types of varieties.

Assuming that nutritional education is successful in increasing the consumption of orange-fleshed varieties, there are additional health benefits associated with prevention of Vitamin A deficiency that should be taken into account in evaluating the impact of orange-fleshed sweetpotato varieties.

CHAPTER VI

FACTORS INFUENCING FARMER ADOPTION OF OFSVs

6.1 The Adoption of OFSVs.

All respondents received vines of OFSVs in 2000 and some again received vines in later years. However, during the last three to four years, the study area alternately experienced frequent drought and excessive rain, especially in March 2004, which flooded the lowland cultivated fields. As a result, most respondents lost their OFSVs planting materials--mainly due to drought, floods or both, but also due to pests (rodents, locust and snails) and goats eating the vines.

6.1.1 Definitions of Explanatory Variables

The specified probit model used in this analysis includes one dependent variable and 18 explanatory variables. As previously mentioned, the dependent variable takes the value Y =1, if the farmer cultivated orange-fleshed variety in the 2003/04 wet season, and Y=0, if the farmer did not cultivate orange-fleshed varieties in the 2003/04 wet season.

The explanatory variables, including the direction of their expected effects, are described as follows:

X_1 Respondent age (-): the units of this variable are years (***age***).

X_2 Level of education (+): the number of years of formal education completed by the respondent ***(educ***).

X_3 Young children (+): a dummy variable taking a value of one if the respondent had young children (under five years of age) and zero otherwise (***young).***

X_4 Extension services (+): the number of times the farmer visited or was visited by an extension technician regarding any technological issue related to OFSV farming during the last two years ***(extvis).***

X_5 Field days/demonstrations (+): a dummy variable taking a value of one if the respondent participated in field days/demonstration activities regarding OFSVs processing techniques and zero otherwise ***(fdemo).***

X_6 Livestock ownership (-): the number of cattle owned by the respondent (***tbov).***

X_7 Frequency of vines distribution (+): the number of times the farmer received vines of OFSVs ***(vinrec).***

X_8 Experience with varieties (+): the number of different OFSVs that the respondent received ***(varexp).***

X_9 Off-farm activity (+): a dummy variable taking a value of one if the respondent and/or spouse participated in off-farm activities in 2003 and zero otherwise ***(offarm).***

X_{10} Gender of the respondent (+): a dummy variable taking the value of one if the respondent was female and zero otherwise (***female).***

X_{11} Family size (+): the number of people who lived in the household at least nine months during 2003 (***famsize)***.

X_{12} Sweetpotato area cultivated by the household in the 2003/04 wet season (+): the sweetpotato area in hectares ***(sparea).***

X_{13} Awareness about sweetpotato processing techniques (+): a dummy variable taking the value of one if the respondent was aware and zero otherwise ***(praware).***

X_{14} Average annual precipitation (+): a dummy variable taking a value of one if Xai-Xai district and zero if Chokwe district. This variable captures the difference in average annual precipitation between the two districts covered by this study ***(distpr).***

X_{15} Sweetpotato root consumption (+): the number of times per week the household consumed sweetpotato roots during the months when roots are available ***(rootcs),***

X_{16} Commercialized sweetpotato in wet season (+): the quantity (kg) of orange-fleshed sweetpotato roots sold in the 2003 ***(rsold),***

X_{17} Respondent experience in processed products (+): a dummy variable taking the value of one if the respondent actually made at least one sweetpotato processed product and zero otherwise ***(proexp).***

X_{18} Total household farmland (+): the total area (hectares) cultivated by the household in 2003/04 wet season ***(tland).***

The summary statistics for these explanatory variables are presented in Table 23. The correlation matrix (Appendix D) shows that these explanatory variables are not highly correlated.

Table 23: Summary Statistics of Explanatory Variables in Xai-Xai and Chokwe Districts, Mozambique (N=150)

Variable No	Code	Type	Mean	Std. Error	Minimum	Maximum
X_1	*age*	C	42.3	12.4	19	79
X_2	*educ*	C	1.70	1.88	0	8
X_3	*young*	D	0.83	0.38	0	7
X_4	*extvis*	C	0.31	0.60	0	2
X_5	*fdemo*	D	0.14	0.35	0	1
X_6	*tbov*	C	2.40	6.52	0	57
X_7	*vinrec*	C	1.53	0.84	1	3
X_8	*varexp*	C	1.27	0.45	1	2
X_9	*offarm*	D	0.03	0.18	0	1
X_{10}	*female*	D	0.96	0.20	0	1
X_{11}	*famsize*	C	7.13	3.11	1	15
X_{12}	*sparea*	C	0.02	0.06	0.008	0.5
X_{13}	*praware*	D	0.71	0.45	0	1
X_{14}	*distprec*	D	0.40	0.49	0	1
X_{15}	*rootcs*	C	3.60	1.15	1	7
X_{16}	*rsold*	C	3.13	15.37	0	120
X_{17}	*proexp*	D	0.04	0.20	0	1
X_{18}	*tland*	C	2.41	1.72	0.1	11.5

Source: Survey 2004 C = Continuous D = Dummy

6.1.2 Results of the Probit Model

Based on the probit procedure, the maximum likelihood parameter estimates for the unrestricted (full) model were computed (Table 24). First, the coefficients (β_i) of the explanatory variables in the full (unrestricted) model were examined and assessed with respect to *a priori* expectations of the signs (according to adoption of technology theory) and the statistical significance of the coefficients. Second, a restricted model (Table 25) was estimated, which excluded four variables from the full model, which had

Table 24: Maximum Likelihood Estimates of the Unrestricted (full) Model for Factors Influencing Adoption of OFSVs in Xai-Xai and Chokwe districts (N=150), Mozambique

Variable	Coefficient	Standard Error	p-value
intercept	-2.8028	1.4208	0.049
age	-0.0145	0.0130	0.264
educ	0.0139	0.0823	0.866
young	-0.6485	0.1474	0.110
extvis	0.3870	0.3408	0.233
fdemo	1.2989	0.7185	0.064*
tbov	-0.0245	0.0185	0.185
vinrec	0.8071	0.2608	0.002***
varexp	0.9732	0.4579	0.034**
offarm [a]	-0.5440	1.8229	0.765
female [a]	0.4748	1.0511	0.651
famsize	0.0734	0.0634	0.247
sparea	0.0030	0.0013	0.023**
praware	0.1994	0.3507	0.570
distpr	-1.0659	0.5020	0.034**
rootcs [a]	0.0011	0.1144	0.992
rsold	-0.0078	0.0011	0.482
procexp [a]	0.0139	0.9468	0.988
tland	0.1653	0.1022	0.106

Log Likelihood = -59.1180 Likelihood Ratio test χ^2(19 df) = 89.68
Prob > χ^2 = 0.0000 Pseudo R^2 = 0.4313
* significant at 10 % ** significant at 5% *** significant at 1%
Source: Survey 2004
[a] Excluded in restricted model

signs inconsistent with adoption theory and/or were not jointly significant likely due to the absence of variability among the respondents, including ***offarm*** (household off-farm activities in 2003), ***female*** (respondent gender), ***rootcs*** (frequency of household consumption of sweetpotato roots), and ***procexp*** (representing the experience of the respondent in processing sweetpotato products).

Table 25: Maximum Likelihood Estimates of the Restricted Model for Factors Influencing Adoption of OFSVs in Xai-Xai and Chokwe districts (N=150)

Variable	Coefficient	Standard Error	Marginal[33] Effect	p-value
intercept	-2.7868	1.3628	NA	0.041
age	-0.0145	0.0129	-0.0051	0.262
educ	-0.0151	0.0818	-0.0053	0.854
young	-0.6659	0.4642	-0.2028	0.151
extvis	0.3722	0.3363	0.1307	0.268
fdemo	1.3005	0.7071	0.3211	0.066*
tbov	-0.0247	0.0183	-0.0087	0.176
vinrec	0.7977	0.2584	0.2801	0.020**
varexp	0.9877	0.4476	0.3468	0.027**
famsize	0.0766	0.0610	0.0269	0.209
sparea	0.0030	0.0013	0.0011	0.023**
praware	0.2049	0.3458	0.0734	0.553
distpr	-1.0746	0.4808	-0.3806	0.025**
rsold	-0.0076	0.0109	-0.0027	0.485
tland	1.6489	0.1019	0.0579	0.106

Log Likelihood for restricted model= -59.1658 Likelihood Ratio χ^2(14 df) = 89.59
Prob > χ^2 = 0.0000 Pseudo R^2 = 0.4309
* significant at 10 % ** significant at 5% *** significant at 1%
Source: Survey 2004 NA = Not Applicable

In order to check whether the coefficients of the excluded explanatory variables were indeed zero (jointly are not statistically significant), a subsequent likelihood ratio statistic was computed. This likelihood ratio statistic has an asymptotic chi-square distribution with degrees of freedom equal to the number of restrictions being tested (Wooldridge J., 2003). The test indicated that the restricted model performed similarly to the full model. The likelihood ratio test of the restricted model shows that the coefficients are jointly significant at the 5% level.

[33] The marginal effects were computed using the average values of the explanatory variables.

6.2 Discussion of the Results

Five variables included in the restricted model were statistically significant. The dummy variable ***fdemo*** (participation of respondent in field days and demonstrations activities regarding processed products derived from OFSVs roots and leaves) is statistically significant at the 10% level. Its positive coefficient indicates that farmers who participated in these events were more likely to have planted OFSVs in the 2003/04 wet season.

The variable ***varexp (***number of OFSVs grown by the respondent) is statistically significant at the 5% level. Its positive coefficient indicates that farmers who planted more than one OFSPV were more likely to have grown nutritionally improved varieties in the most recent season. This suggests that the probability of a farmer obtaining an OFSPV that meets her/his tastes and preferences increases with the number of alternative varieties at his/her disposal.

The variable ***vinrec*** (number of times the respondent received vines of OFSVs***)*** is statistically significant at the 5% level. Its positive coefficient indicates that farmers who received OFSVs more times were more likely to have grown them in the most recent season. This result could be partially explained by the high risk of crop failure in the study area. For instance, most of the respondents in Punguine and Cuamba had recently received vines (August 2003 and/or February 2004) and grew them in the 2003/04 wet season.

The variable ***sparea*** (sweetpotato-cultivated area) is statistically significant at the 5%. Its positive coefficient indicates that farmers who planted a larger area of sweetpotato were more likely to have planted OFSVs in the most recent season. This result suggests that farmers who considered sweetpotato an important crop were more interested in improved sweetpotato technologies.

The ***distpr*** (difference in terms of average precipitation between the two districts) is statistically significant at the 5% level. Its negative coefficient (i.e., lower adoption in Xai-Xai versus Chokwe) is consistent with farmers' observation that the consequences of erratic precipitation (i.e., drought, flooding) are problematic for sweetpotato farming. As mentioned in Chapter II, sweetpotato is mostly grown in lowland alluvial and peat soils where drainage is a serious constraint. The occurrence of high and relatively intense rainfall during the wet season, combined with poorly drained soils, increases the risk of flooding in the region. This risk is exacerbated in the coastal district of Xai-Xai, which is characterized by low altitude, extensive lowland alluvial and peat soils, and poorly functioning drainage systems. However, in both districts, farmers reported having lost their OFSVs planting material due to flooding in the lowlands—which is due to a lack of investments in rehabilitation of the drainage systems.

6.3 Goodness-of Fit

Using STATA, the estimated probability of each respondent being an adopter was computed. Using 50% as the cut-off probability[34] of being an adopter, a comparison of the observed numbers of adopters and disadopters versus the estimated numbers was made (Table 26). The model correctly predicted 78% of the total outcomes, correctly predicted 71% of adopters and 85% of disadopters). This measure of goodness-of fit indicates that the model has relatively good explanatory power, although disadopters are more accurately predicted than adopters.

[34] Estimated probability of adoption less than 50% is considered as being disadopter.

Table 26: Comparison of Observed and Predicted Outcomes of Adoption of OFSVs, Xai-Xai and Chokwe, Mozambique (N=150)

	Predicted Adopters	Predicted Disadopters	Total
Observed Adopters	54 (71%)	22 (29%)	76 (100%)
Observed Disadopters	11 (15%)	63 (85%)	74 (100%)
Total	65	85	150

Correctly Classified (117 out of 150) = 78%
Source: Survey 2004

6.4 Chapter Summary

The restricted model identified five factors that influenced the adoption of OFSVs among farmers in Xai-Xai and Chokwe districts. These factors include: (1) participation in field days and demonstration activities, (2) the number of OFSVs received by the respondent, (3) the number of times the farmer received vines, (4) the household's sweetpotato cultivated area, and (5) the district where the respondent resided.

These results suggested that in order to increase adoption, there is a need to: (1) provide farmers with several different varieties; (2) provide vines several times to farmers; (3) continue to conduct field days and demonstration activities, and (4) invest in improving drainage in lowland areas.

CHAPTER VII

SUMMARY AND POLICY IMPLICATIONS

7.1 Summary

In Mozambique, the majority of the population relies on subsistence agriculture. Thus, the low levels of production and productivity, in conjunction with the relatively high population growth rate, have contributed substantially to a high unemployment rate, extensive poverty, and widespread VAD--especially among children and pregnant and lactating women.

In early 2000, Mozambique experienced a severe flood that devastated cultivated land throughout the southern and central provinces of Maputo, Gaza, Inhambane, Manica and Sofala. Soon after the floods subsided, the government launched a program of to multiply and distribute OFSVs. The program, which targeted the flood-affected rural people, was aimed at mitigating hunger and food insecurity, and reducing VAD. In addition, SARRNET, in close collaboration with its partners, conducted training activities to teach farmers about improved sweetpotato agronomic practices, the crop's nutritional value and agro-processing techniques for sweetpotato; developed teaching materials on nutritional concepts for the primary school curriculum; and sponsored field days/demonstration activities at which food products made out of the roots of OFSVs were displayed.

Several studies have highlighted the importance of β-carotene as the predominant source of pro-Vitamin A in preventing VAD in developing countries. However, the bioavailability (conversion of β-carotene into Vitamin A and effective utilization of this

Vitamin A by humans) is conditioned by a complex set of factors, including the type and amount of carotenoid in a meal, the matrix in which the carotenoid is incorporated, the presence of absorption and conversion modifiers, the health status of the target population, and the presence of other micronutrients. Studies aimed at assessing the impact of food-based interventions in developing countries revealed different results from country-to-country. Furthermore, the seasonal availability of enriched sources of β-carotene, the low bioavailability and conversion of β-carotene into Vitamin A, and the prevalence of infectious diseases hamper the efficacy of food-based initiatives to mitigate VAD in developing countries.

The willingness of farmers to grow OFSVs will greatly affect the program's impact on reducing VAD. Recent studies have identified many social and economic factors that affect farmers' technology adoption decision--including access to farm labor, farm machinery, storage and distribution facilities, inputs and output markets, credit availability, farm size, level of education, land tenure, profitability of the technology, farmer's awareness of existing technologies, and government policies. However, since the effect of those explanatory variables (and interactions among them) on farmer's technology adoption varies from region to region, location-specific studies are required to understand factors that affect adoption of a new technology in a given country.

In Gaza province--one of the provinces targeted by the OFSVs multiplication and distribution program and the focus of this study--small-scale farming is by far the most important sector. The absence of a commercial cash crop sector reflects the recent shift from large concession companies towards contract farming, in which small-scale holders cultivate primarily cotton and tobacco. The main role of the companies is to provide inputs and a secure market for cash crops. One of the major constraints to crop production (including sweetpotato) in Gaza province is the low and irregular rainfall during the growing season, resulting in high risk of crop failure. Thus, the development of short-duration (early-maturing) varieties is crucial to increasing crop production under rainfed growing conditions. Furthermore, the lack of investments in drainage systems, which are required to farm lowland fertile soils, discourages the use of these soils for agricultural development.

To assess the adoption of OFSVs in Gaza province, a multi-stage sampling approach was used to select a sample of 150 sweetpotato growers in Chokwe and Xai-Xai districts. Respondents were drawn at random from lists of farmers who received OFSVs vines in 2000. A structured questionnaire was used to collect data on the socio-economic characteristics of the sampled household, agronomic practices followed, labor used in sweetpotato production, farmers' assessment of traits of some of the new OFSVs, access to output markets, and access to extension services.

In the study area, middle-aged women mostly grow sweetpotato. Due to the lack of local opportunities, few households engaged in off-farm activities in 2003. However, most of respondents' spouses worked away from home, primarily in South Africa or in Xai-Xai and Maputo cities.

All respondents cultivated family-owned family land averaging 2.4 ha per household. On average, farmers planted approximately 200 m^2 of sweetpotato. Most farmers cultivated lowland alluvial and peat soils. However, due to the lack of investment in drainage improvement, farmers reported that their fields were frequently flooded resulting in crop losses.

Only 27% of households owned cattle and the livestock distribution was highly skewed in both districts. Thus, while farmers needed draft power for land preparation, especially when cultivating heavy-clay lowland soils, only one third of the respondents used animal traction in 2003/04 wet season.

While public and NGO extension services have promoted orange-fleshed sweetpotato cropping practices, few farmers (20%) received technical information related to OFSV cropping. However, most respondents (83%) were aware of the nutritional benefits of consuming OFSVs for young children and pregnant and lactating women.

Although few respondents (15%) participated in field days/demonstration activities, most of the respondents (70%) reported having heard about the products made out of OFSVs (e.g., cakes, juice, flour, chips) from SAARNET staff, extensionists, health workers and the media. Unfortunately, there was little relationship between awareness and adoption of these products by households--likely due to a lack of know-how and/or insufficient production of OFSVs roots for purposes other than the traditional methods (boiled, roasted or porridge). Farmers assessed two OFSVs[35] (Jonathan and Resisto) varieties positively (compared to their WFSVs) in terms of root size; taste of fresh and boiled roots, and cooking time. Conversely, the same varieties were ranked negatively with respect to dry matter content of roots, tolerance to rainfed growing conditions (drought), pests and diseases.

The farmers reported several constraints to increasing sweetpotato production, including frequent drought and flooding, no market for sweetpotato roots in the villages,

[35] Other OFSVs were assessed. However, few responses were gathered regarding Japon Selecto (8), Taimung 64 (6), and LO 323 (2).

a lack of animal traction, and low off-season propagation capacity of OFSVs due to the low rainfall during the dry season.

While most respondents reported having consuming sweetpotato leaves, they did not like the reddish stem color of some of OFSVs--which is likely to affect the adoption of these varieties for leaves consumption.

Sweetpotato roots were rarely commercialized. Only 19% of the respondents sold sweetpotato roots (mostly white-fleshed roots) in 2003. Poor road infrastructure linking the remote sweetpotato-producing areas to the nearest semi-urban and urban markets increases the transaction costs for sweetpotato commercialization, which hampers the potential contribution of this commodity to overall household cash income.

A huge gap existed between farm-gate and retail prices. For instance, in Xai-Xai district the retail price averaged 125% higher, compared to the farm-gate price; while in Maputo markets, the consumer price averaged 493% higher than the producer price in Xai-Xai district. Despite the superior nutritional value of OFSVs, there is no difference in price between white and orange-fleshed roots.

All farmers received one or more OFSV in the 2000 wet season from an NGO and some again received OFSVs in a subsequent season. However, the percentage of farmers who continued to plant OFSVs varied by season, ranging from 71% in 2002/03 wet season to 51% in 2003/04 wet season. Most farmers planted only a small percentage of their sweetpotato area to OFSVs--ranging from 10% in 2002/03 dry season to 20% in 2002/03 and 2003/04 wet seasons. Reasons farmers reported for not planting a larger area to OFSV in 2003/04 wet season low off-season propagation capacity and low drought-tolerance of OFSVs, and abundant planting materials of WFSVs. While many farmers lost their OFSV to flooding and/or drought, they were able to rescue their WFSVs suggesting that they valued their WFSVs more than OFSVs.

A probit model was used to identify factors affecting farmer adoption of OFSVs. Five factors were statistically significant and positively associated with adoption--participation in field days and demonstration activities, the number of OFSVs received by the respondent, the number of times the farmer received vines, the household's sweetpotato cultivated area, and the district where the respondent resided (e.g. higher adoption in Chokwe due to relatively less frequent flooding).

7.2 Policy Implications

The findings of this study have policy implications for agricultural research institutions, rural extension and development, agricultural and rural development directorates, NGOs, and health institutions.

7.2.1 Agricultural Research & Development[36]

Firstly, this study revealed a significant positive relationship between the number of different OFSVs received by farmers and adoption of improved varieties. Sweetpotato is used for two purposes --root and leaf consumption. Farmers reported preferences for varieties based, on both their leaf and root characteristics, and likely continued to plant

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36 By enhancing the nutrient quality of sweetpotato, agricultural research can play an important role in improving the diet diversification. However, breeding programs face several challenges, including developing varieties with: (i) high nutrient-density with little or no yield trade-off to guarantee their widespread adoption by farmers, and (ii) traits desired by consumers (e.g., storability, cooking time, appearance and taste (Hazell et *al*,. 2001).

the varieties that met their preferences. Thus, crop scientists should develop OFSVs with traits that better meet farmers' tastes and preferences for both roots and leaves.

Secondly, many respondents reported that they received vines more than once because they lost the OFSVs, which they originally received, due to drought. Thus, research institutions should develop OFSVs that are both suitable[37] for farmers' rainfed growing conditions (characterized by erratic and irregular rainfall) and meet farmers/consumers' tastes and preferences.

This suggests the need for on-farm research trials in which farmers participate in evaluating and selecting OFSVs[38] for multiplication and distribution. To implement this initiative, the program could utilize its existing partnership with researchers, extensionists, and NGOs to establish a network of on-farm research trials. Farmers' active participation at an early stage in assessing the performance of promising improved OFSVs would provide useful feedback to researchers, regarding relevant traits that need to be incorporated into OFSVs to insure that released varieties are suitable for the region's agroclimatic conditions and have other traits that are desired by farmers/consumers. Furthermore, the participation of farmers at the early stage of technology generation and dissemination would give farmers a greater sense of ownership of future improved varieties--and thereby increase the likelihood of adoption.

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[37] Goldman R. *et al*., 1981, argued that evidence from the Green Revolution revealed that the key determinant of new technology adoption is the adaptability/compatibility of the new seed variety/planting material and associated cultivation practices with the site-specific agroclimatic environment.

[38] Some studies reported that orange flesh color and dry matter content are negatively associated. Thus, the development of nutritionally enriched pro-vitamin A orange-fleshed sweetpotato variety that meets the consumers' preference for high dry matter will be a challenge to research institutions (Jones, 1977; Collins, *et al.*, 1995).

Thirdly, most of the surveyed sweetpotato growers reported that the market for orange-fleshed sweetpotato was very limited, particularly in villages far away from markets. Notwithstanding the limited resources available for research, a post-harvesting research program on sweetpotato should be incorporated into the national research agenda. The research should focus on identifying potential orange-fleshed sweetpotato-based products for agro-enterprise development. The creation of new market for value-added orange-fleshed sweet potato-based products would raise sweetpotato from subsistence to a cash crop, and thereby play an important role in promoting increased adoption and production of OFSVs.

Finally, most of the respondents reported only consuming sweetpotato roots during 3 to 5 months per year. Thus, seasonal availability of sweetpotato roots constrains the potential of this commodity to mitigate VAD. Post-harvesting research should investigate and test appropriate methods of storing sweetpotato roots in order to extend the availability of sweetpotato roots for human consumption.

7.2.2 Rural Extension & Development

First, since the majority of sweetpotato growers are women, who have a low level of literacy (average of 1.7 years of school), extension materials written in Portuguese are not appropriate for them. Thus, there is a need to produce good quality and understandable extension materials, which are written in local languages. Furthermore, the rural extension network (provincial level, in close collaboration with NGOs and community-based associations) should disseminate those materials to sweetpotato growers. While interpersonal contacts (e.g. field days and demonstrations) should be relied on as much as possible to promote OFSVs, there is also a need to continue to produce and broadcast awareness programs via radio using local languages (e.g., nutritional value of OFSVs, market opportunities in urban areas).

Second, women are both the decision-makers regarding orange-fleshed sweetpotato farming and are responsible for child feeding practices in their households. To date, food-based interventions have focused on women. However, men's tastes and preferences affect what women feed the family and men strongly influence the household purchase of food and/or health services[39]. Thus, there is a need to target messages about the nutritional value of OFSVs towards men in order to increase their awareness about nutritional issues.

Third, few respondents reported having made any of the disseminated processed orange-fleshed sweetpotato products that were promoted through field days and demonstration events. In order to enhance the adoption of processing techniques, special attention should be paid to assessing the practicability and feasibility of making these products-- taking into account locally available ingredients, specific local food preparation knowledge, and consumer' preferences. In addition, at demonstration sessions, the consumption of alternative sources of micronutrients that are locally available and accepted should be equally promoted. For instance, some of the villages covered by this study are suitable for the production of pumpkins, pineapple, papaya, banana, citrus and mangos. Thus, the integrated promotion of production, agro-processing, and consumption of these commodities, as alternative sources of

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39 Results from Kenyan and Tanzanian studies on food-based interventions showed that involving men in the process enhanced the adoption of orange-fleshed sweet potato varieties, solar drying technology, and related nutritional messages (Johnson-Welch, 1999).

micronutrients, should be emphasized in order to ensure that households have access to an improved and balanced diet, throughout the year given the seasonal availability of different crops[40] in the farming systems.

7.2.3 DDARDs and NGOs

First, due to the lack of investment in drainage systems, the frequent occurrence of flooding is a serious bottleneck for sweetpotato production. Thus, the District Directorates for Agriculture and Rural Development (DDARDs) and NGOs should search for financial resources to improve drainage systems in the lowlands. This investment would make more fertile land available for agricultural development in general, and particularly for sweetpotato farming.

Second, the heavy texture of alluvial soils limits the effectiveness of manual land preparation. Thus, DDARDs and NGOs should facilitate the formation of farmers' associations, aimed at promoting animal husbandry (mainly cattle) by providing credit to members on a rotational basis among members. In the long run, greater access to draft power would contribute substantially to increasing the average area cultivated per household. This would contribute to supporting an integrated food-based intervention by providing rural households access to a more diversified and balanced diet.

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40 According to Agriculture and Livestock Census 1999/2000, of the total number of holdings (219,541) in Gaza province, 64.5% had mango trees, papaya (50.6%), orange (35.1%), banana (31.7%), pineapple (25.8%), and mandarin (23.9%). In addition, approximately 6%, 5.0%, and 4% of the total holdings sold mango, oranges, and pineapples, respectively.

7.2.4 Health Institutions

First, from the nutritional standpoint, there is a strong relationship between the health status of a person and the bioavailability and conversion of pro-Vitamin A. Thus, food-based interventions should be complemented by the provision of health services to the rural people--particularly to young children and pregnant and lactating women, as well as improved sanitation. These health services should address reducing bacterial infections, intestinal infections, and parasitism in order to avoid negative impact of these health disorders on the bioavailability and efficacy of utilization of β-carotene provided by food-based nutritional interventions.

Second, in accordance with the Food Security and Nutritional Strategy of Mozambique, food-based interventions should be encouraged and enhanced to prevent VAD. However, since the effectiveness of food-based intervention is still uncertain, health institutions should continue to implement complementary strategies, including curative supplementation of Vitamin A and other micronutrients.

7.3 Limitations of the Study

The findings reported in this study strictly apply to the study area and should not be generalized to other regions with different agroclimatic and socio-economic characteristics.

The marketing system for sweetpotato roots was not analyzed in detail due to the existence of few traders involved in sweetpotato marketing during the survey period. This fact was partially due to the limited sweetpotato supply, as a result of flooding that devastated most lowland fields, including sweetpotato plots.

Farmers' assessment of two out of nine OFSVs was carried out and reported in Chapter V. While a few respondents assessed three other varieties, these results were not reported because they might not be representative, due to the small sample size.

Most of data gathered in this survey were based on recall information provided by the sweetpotato growers. In addition, most of the respondents were illiterate and improved OFSVs were quite new in their farming systems. All of these factors may have affected the accuracy of the data collected.

7.4 Further Research Needs

First, this study used cross-sectional data to analyze the factors influencing adoption of OFSVs in a certain point in time (2003/04 wet season). However, the technology adoption process is inherently dynamic--decisions made in one period are strongly dependent on the consequences of decisions made in previous periods. Thus, there is a need to select and periodically survey a panel of sweetpotato growers in order to monitor changing patterns in the use of nutritionally improved orange-fleshed varieties--including trends in the partial or total replacement of white-fleshed varieties, area cultivated, and the rate of adoption of new varieties by farmers over time. Additionally, these panel data could be used to assess the impact of new OFSVs on the well-being of farmers and whether or not the benefits of being an early adopter are preserved, even when many farmers have adopted the technology.

As discussed in the previous chapter, poor marketing is a major bottleneck to increasing sweetpotato production, particularly OFSVs. Therefore, post-harvesting research aimed at assessing ways to establish linkages between sweetpotato-growing farmers and sweetpotato processors[41] is vital for identifying potential markets, especially for farmers in the remote and isolated production zones that are disconnected from potential urban markets.

To address the limited demand and seasonal availability of OFSVs, studies should be carried out to investigate the present and potential demand for fresh and processed sweetpotato products. The focus of these studies should include assessing the following:

- Potential processed sweetpotato products that are highly acceptable for human consumption and are likely to be traded on a commercial basis;
- Attributes that determine product quality, as judged by consumers (i.e. consumer's tastes and preferences);
- Feasibility of utilizing sweetpotato as a raw material in existing or potential industrial[42] processes and appropriateness of available food processing technology to produce these products and;
- Assessment of the potential fresh sweetpotato supply, relative to the projected demand.

[41] For instance, the processing industry in Taiwan revealed that up to 15% of wheat flour can be replaced with sweetpotato without altering its physical properties. Thus, the development of an effective industry of sweetpotato flour to satisfy the demand was considered as a vehicle of increasing sweetpotato production and consumption (Tsou and Hang, 1992, Espinola *et al*., 1998, Hagenimana et al., 1999).

[42] It is hypothesized that the successful development of a processing industry is likely to contribute to increased utilization of sweetpotato by reducing the losses during storage and marketing. Although the relative importance of key factors conducive to achieving this goal is not well known yet, it seems that economic and cultural constraints are of the same magnitude or greater than the technical limitations towards development of successful processing industry (Bouwkamp J. 1985).

The results of these studies would provide important insights regarding the constraints to and opportunities for developing a sweetpotato-based agro-industry, which would serve to increase the consumption of orange-fleshed processed products throughout the year, increase farmers' incomes, and improve household nutrition.

APPENDIX A

PHYSIOGRAPHY AND SOCIOECONOMIC FEATURES OF MOZAMBIQUE

A.1 Geography and Agroclimatology

The Republic of Mozambique is located 10^{o} 27 N, 26 52 S, 40 51 E and 30^{o} 12 E on the eastern coast of Southern Africa, occupying an area of 799,380 square kilometers. The country shares its 4,571 Km of land borders with Tanzania to the north; Malawi, Zambia, Zimbabwe, and the South African province of Mpumalanga to the west; and Swaziland and the South African province of Kwazulu Natal to the south. Mozambique's Indian Ocean coastline stretches over approximately 2,470 Km (INE, 2002). Mozambique is divided into ten agroecological zones-- from mostly coastal lowland and uplands of 200-600 meters of altitude in the south and center regions to high plateaus and mountains more than 1,000 meters in the northwest and west. The highest point is Mount Binga (2, 436 meters) located in Manica province (MAF, 1996).

The climate of Mozambique is strongly influenced by the warm Indian Ocean currents (moving south from the Equator) and the altitude of the Mozambican plateau. The climate of Mozambique is predominantly tropical, with a cool (dry) season from May to August. However, the climate in Maputo, which lies just south of the Tropic of Capricorn, is subtropical with a substantial maritime influence. Most rainfall normally falls between November and February and the humidity is high for most of the year and n averaging 70%. Although the annual average mean temperature is 23.5^{o} C, temperatures above 43^{o} C are common (Pereira L. and Omar F., 2001).

Mozambique is very exposed to natural disaster caused by climatic irregularities, as nine of the main rivers in the Southern African region flow to the Indian Ocean through the country. However, none of the previous droughts, floods or cyclones was as rapid and severe as the heavy rains and floods that occurred across Southern Mozambique during early 2000 and caused widespread destruction.

Although the spatial and temporal precipitation patterns-- modulated by latitude, topography and coastal shape --are highly irregular, there are some identifiable homogeneous regions (e.g. semi-arid, moist, and intermediate regions. Except for Tete province, south of Zambeze River, annual precipitation averages above 1,000 mm north of parallel 20^{o} S and below 1,000 mm south of this parallel. Rainfall is highest in the coastal zone and decreases rapidly towards the interior of Gaza province-- attaining a maximum of 400 mm in Chicualacuala (Pereira L. and Omar F., 2001).

The temporal distribution of precipitation across the year is governed by the motion of two wind patterns, one coming from the south and other from the north. The former, which begins in September, reaches its peak in the second week of February as the rainfall moves from the coastal zone to the interior. This phenomenon leads to a very short cropping season in the south interior. The north wind, which is very active, persistent and extends inland to 20^{o} S. Consequently, the rainfall in the northern region of Mozambique has a more regular pattern (Pereira L. and Omar F., 2001).

A.2 Population Growth

According to the national population census of 1997, the population of Mozambique was estimated at 16.1 millions --corresponding to an average population density of approximately 20 inhabitants/km^2. Almost 44% of the Mozambican Republic's population is less than 14 years of age, and 53 % is between 15 and 64 years of age. Approximately 70% of population lives in rural areas (INE, 1999).

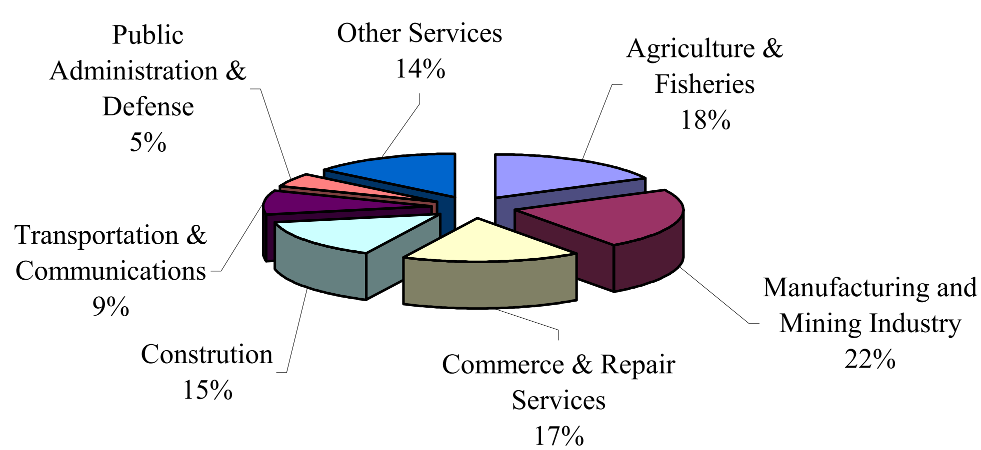
Population in Mozambique increased at an average national growth rate of 2.3 % annually during the early 1980s to late 1990s. Approximately 45% of the population is currently economically active. Of this total, approximately 75% carry out subsistence agriculture, 19% are employed as waged workers, and 5% are self-employed outside of agriculture. Internal migration from the countryside to the three major cities of southern provinces of Mozambique (Maputo, Gaza and Inhambane) was 32%, 18% and 17 % in 1997, respectively (INE, 1999). Although population growth declined to 1.9 % in the late 1990, population continued to grow to 18.8 millions in 2003 (World Bank, 2004). Unfortunately, the high rate of rural and urban population growth leads to a high demand for food and increasingly higher rates of unemployment and poverty.

A.3 Macroeconomy

According to recent macroeconomic indicators, the performance of the Mozambican economy has been satisfactory over the recent post-war years. The GDP growth rate was 12.6 % in 1998, 13.0 % in 2001 and 7.7% in 2002 compared to an annual rate of only 0.1 % from 1980-1990 and 6.9 % from 1990-2001. At constant prices of 1996, Mozambique's annual GDP growth rate averaged 11.6 % from 1996 to 2002 (INE, 2004). However, inflation is an issue of concern, as the GDP implicit price deflator averaged 4.6 % in 1998, 10.6 in 2001 and 11.2 % in 2002. Furthermore, Mozambique faces a substantial trade deficit of goods and services, estimated at 17.4 % of GDP in 1998, 13.6% in 2001, and 14.7 % in 2002 (World Bank, 2004).

Mozambique's economy is dominated by three sectors -- Manufacturing and Mining Industry, Commerce and Repair Services, and Agriculture and Fisheries. In 2002, these three largest economic sectors contributed 22.3 %, 17.2 and 17.6 % respectively, to the Mozambican GDP (Fig. 1). In contrast, from 1996-2002, the fastest growing sectors (in constant prices of 1996) were Electricity and Water (49.2%), Construction (26.8%), Public Administration and Defense (23.8%). During the same period, growth in Manufacturing and Mining Industry, Commerce and Repair Services and Agriculture and Fisheries averaged only 15.4%, 7.3%, and 5.2 %, respectively (INE, 2004).

Figure A: Major Economic Sectors and their Contribution to Mozambican GDP in 2002



Source: INE, 2004

A.4 Agriculture Sector in Mozambique

A.4.1 Agricultural Policy & Strategies

In 1995, the Government of Mozambique (GOM) developed a policy framework -- *Agricultural Policy and Strategy for Implementation*-- which identified the main agricultural development policy "the recovery of agricultural production in accord with self-sufficiency and food reserve, and the promotion of increases in the levels of commercialization of export products" (GOM, 1995). In the context of GOM agricultural policy, agricultural development is defined as the progressive transformation of subsistence agriculture into agriculture more integrated into the functions of production, distribution and processing towards provision of surplus to the market, food self-sufficiency and primary materials for national industry and its contribution to the balance of payments.

Mozambique is still one of the poorest among the group of least developed countries -- characterized by a food deficit and a huge dependency on emergency food aid while local production satisfies only 80% of minimum daily calorie requirements (MAF, 1996).

The predominance of subsistence agriculture -- characterized by traditional technology, frequent drought, diseases and pests, and the lack of inputs and improved technology-- have contributed substantially to low levels of production and productivity. However, improving the agricultural sector is vital to the country's economic development and recovery, as it is mainstay of food security, economic growth, and employment.

Consequently, the GOM has launched initiatives to improve its agricultural policies and the institutional setting which are aimed at creating an enabling environment for agricultural growth, including (GOM, 1995):

- Restructuring of commercial state farms through privatization and joint ventures;
- Implementing a balanced phasing-out of food aid in order to promote and boost domestic production;
- Promoting rural marketing through liberalization of domestic trade and improvement of access to credit and to agricultural inputs;
- Developing adequate land tenure policies and systems aimed at protecting propriety rights and to provide incentives for national and foreign investment in commercial agricultural related activities; and
- Providing timely and accurate information on input and commodity prices to support the decision-making process of producers.

These agriculture policy reforms, implemented within the broader context of the Structural Adjustment Program (SAP), have been largely completed and maintained through a broad and more comprehensive National Agriculture Development Program (PROAGRI). Implemented since the beginning of 1999, PROAGRI is envisaged to strengthen capacity within MADER to provide efficiently and effectively core public services and to develop improved institutional arrangements for the financing and delivery of agricultural services for the family sector. Agricultural input and output markets have been liberalized and prices have been decontrolled for most crops.

Since the mid 1990s, the GOM has introduced several incentives to agriculture development, including eliminating import taxes on agricultural inputs and the establishment of special fiscal and customs regions with extensive exemptions from import duties and consumption and circulation taxes on building materials and equipment deemed necessary for implementing an approved investment project. In zones endowed with minerals and high agriculture potentials, the GOM has established specialized entities to coordinate the resource development-related activities in these regions. For instance, in order to boost the harmonious development of the Zambezi valley, the GOM established the Gabinete do Plano do Zambeze (GPZ). Investors are assured security and legal protection of property and rights in connection with the investments made, export of foreign investors' profits, repatriation of capital invested upon sale, as well as freedom to import equity capital or secure loans locally.

A.4.2 Agricultural Research & Development Institutions

Increases in agricultural production and land productivity are the key components for stimulating economic growth and improving the welfare of the present population and future generations in Mozambique. This will require increasing farm-level production and productivity through the development and transfer of improved, and profitable technologies.

A.4.2.1 Agricultural Research

Under the auspicious of the Ministry of Agriculture and Rural Development, there are four research institutes[43], namely:

- National Institute for Agronomic Research (INIA)
- National Institute for Veterinary Research (INIVE)
- Institute for Animal Production (IPA) and,
- Center for Forestry Experimentation (CEF)

The overall goal of agricultural research is "to develop, test, and disseminate agricultural technology to producers that enhances national and farm level production, provides food security and self-sufficiency, maintains the natural resource base, provides a surplus for industry and export, and generates employment and income in an equitable fashion" (MAF, 1996).

The agricultural technology improvement and socio-economic research are two of the six major categories given priority in the *Agricultural Research Strategy for Mozambique*. The later should investigate problems and constraints at the farm level, improving farm management, and identify ways to increase rates of technology adoption, as well as emergent sectoral opportunities and threats for producers. Although this agricultural research strategy was elaborated and approved in 1996, little socio-economic research has been carried out, due to lack of qualified personnel and funds. It is important to point out that GOM investments in agricultural research have been decreasing over time and accounting for less than 4% of its agricultural sector budget (MAF, 1996). This

[43] Recently the GOM Council of Ministers approved the creation of the Instituto de Investigacao Agraria de Mocambique (IIAM), which amalgamates these four research institutes, Agricultural Training Center (CFA), and Agricultural Documentation Center (CDA) (GOM, 2004).

low level of investment in agricultural research—compounded by the frequent turnover of top-level scientists and research program managers, as well as year-to-year fluctuations in the budget allocated for research-- has substantially hampered the research institutes in fulfilling their mandates (MAF, 1996).

A.4.2.2 Extension Services

Due to its importance and the contribution of smallholders' agricultural production in the country's economy, public sector extension targets smallholders. Developed under the auspicious of the National Agricultural Development Program (PROAGRI), the National Extension Master Plan (1999-2003) provided for the development of an Integrated National Extension System (SINSE). The National Directorate of Rural Extension (DNER) is expected to provide public services to the priority districts and to promote the active participation of other stakeholders potentially interested in providing extension services, such as private commercial farmers, NGOs, farmers' organizations, and other private sector institutions.

Due to limited availability of financial, human, and material resources to meet the extension demand throughout the country, the National Extension Master Plan accommodates multiple financial and delivery arrangements, including outsourcing and cost sharing with private extension entities. Through outsourcing, extension services are provided to some of the targeted population by private sector extension institutions, but these services are coordinated and regulated by the public sector. Thus, in addition to being one among several extension providers, the GOM acts as regulator, evaluator, and facilitator of a more comprehensive and integrated extension service network (Gemo H. *et al*, 2001).

A.4.2.3 Market Information Systems

In recognition of the importance of timely market information organization to agricultural growth and development, the Ministry of Agriculture and Rural Development has developed the Agricultural Market Information System (SIMA), to collect, process, and disseminate weekly information on prices of basic commodities at the major markets to potential users including, producers, NGOs, traders, governmental officers, and policy makers. Since SIMA it has developed a price database and has published numerous bulletins and papers annually (Mabota A. *et al*, 2003).

Presently, the market systems for export and industrial crops are relatively better developed than those for food crops. Thus, farmers have a strong incentive to devote their scarce resources in generating marketable surpluses of these crops.

While it is imperative that farm gate prices are high enough to create incentive for farmers to increase production, there is also a need to guarantee that the urban population has access to an adequate and inexpensive food supplies. Thus, as markets are being liberalized, the GOM should address the institutional and marketing constraints in order to prevent an eventual disastrous erosion of urban purchasing power until increased supply from the rural areas contributes to price stabilization.

A.5 Trade Policy and Strategy

Improving access to output markets (for the majority of rural people engaged in subsistence agriculture) is important for increasing agricultural production and rural incomes. Key trade policy interventions that are relevant for agricultural development are as follows:

- Rehabilitation and further expansion of the commercial network, including: (i) establishment of appropriate physical market facilities and provision of fiscal incentives for investments in market infrastructure, particularly in the remote rural areas; and (ii) institutional co-ordination for rehabilitation of the road network in most populated and major agricultural production areas.
- Creation of an enabling environment for the private sector to progressively increase its contribution in developing the agro-industry sector in order to create employment opportunities and stabilize the food supply.
- Improvement of agricultural marketing systems, including (i) promotion of farmers or groups association which are based on common and shared interests; (ii) gathering, processing, and dissemination of information on major agricultural commodities in domestic and external markets on a periodical basis; (iii) promoting investments in improved handling, storage, and road/rail transportation services, and (iv) stimulating export of agricultural commodities.

These strategies are aimed at developing a market-friendly policy environment for agriculture and rural development, whilst recognizing and emphasizing the role of civil society, the private sector, and NGOs in meeting the challenging tasks of stimulating more equitable and sustainable growth in the rural areas. In addition, agriculture research can be expected to contribute substantially to economic growth and thereby to long-term poverty reduction in countries with liberalized markets and highly developed rural infrastructure. Furthermore, farmers can benefit from greater opportunities derived from diversifying their agricultural production into higher-value products, if they are properly connected to larger and efficient domestic and international markets (Hazell P. and Haddad L., 2001).

A.6 Land Use

Mozambique has 36.1 million hectares of land suitable for agriculture, of which only 5 million are presently cultivated, and 46 million hectares of forest. While Mozambique's resource-base for agriculture development includes 3.3 million hectares of irrigable land, which presently only 50,000 are exploited for irrigated agriculture (GOM, 1995). The smallholder sector is by far the largest, accounts for 97% of total cultivated area in 2000/01 (3.9 million of hectares), of which 83% were for basic food crops. The average farm size varies from one agro-ecological region to another, but 84% of all holdings have an area below two hectares (INE/MADER, 2002). Although the commercial agricultural sub-sector is expanding as a consequence of new government agricultural policies envisaged to promote private investments in agriculture sector, it is still small.

The large public state farms, which produced all of the county's cash crops (e.g. sugar cane, tea, sisal, copra and cotton) in the 1980s, have been completely privatized under the IMF and World Bank- promoted Structural Adjustment Program.

According to Agriculture and Livestock Census 1999-2000, the average cultivated are per household is 1.12 ha (Table 3). Gaza province had the highest average cultivated area per household (2.0 ha) in 2000/01 cropping season, followed by Inhambane (1.6), and Manica province (1.5 ha). However, Nampula province had the highest share of total cultivated area (19.2%), followed by Zambezia (14.1%), and Gaza (12%).

Table A: Households, Cultivated Area and Average Cultivated Area in 2000/01 Cropping Season.

Province	Households (1000)	Cultivated Area (1000 ha)	% of Total Area Cultivated	Cultivated Area per Household (ha)
Gaza	228.3	460	11.9	2.01
Inhambane	259.6	414	10.7	1.59
Manica	201.9	307	7.9	1.52
Tete	268.0	396	10.2	1.48
Niassa	189.9	234	6.1	1.23
Cabo Delgado	336.5	376	9.7	1.12
Sofala	275.8	278	7.2	1.01
Nampula	794.4	741	19.2	0.93
Zambezia	726.3	546	14.1	0.75
Maputo	174.8	115	3.0	0.66
TOTAL	**3,455.5**	**3,867**	**100**	**1.12**

Source: INE (2002)

APPENDIX B

MICRONUTRIENT DEFICIENCY AND NUTRITION POLICY IN MOZAMBIQUE

B.1 Micronutrient Deficiency

Several studies conducted in Mozambique revealed that micronutrients deficiency is a public health concern, especially among young children and woman at reproductive age (MISAU, 1999; MISAU, 2003).

The recent Demographic and Health Survey (1997) indicated that approximately 36 % of young children (less than three years of age) suffered from chronic micronutrient malnutrition. Furthermore, seven out of Mozambique's 11 provinces exhibited levels of chronic malnutrition that were greater than the average national: Cabo Delgado (57%), Niassa (55%), Tete (46%), Manica (41%), Sofala (39), Nampula (38), and Zambezia (37%). In addition, data collected through the Questionnaire on Welfare Basic Indicators (QUIBB) showed that chronic micronutrient malnutrition among children increased to 44% in 2001, and that Zambezia province had the highest level of micronutrient deficiency (INE, 2002).

Unfortunately, from the food security perspective, results of the QUIBB 2002 revealed that 38% of households felt that their economic status had deteriorated relative to previous year, 35.1% reported no changes at all, and 26% felt that had improved.

Shrimpton R. (2002), identified three main causes of malnutrition in Mozambique as follows:

- Household food insecurity[44]
- Limited availability of health care and basic sewage and

[44] "Food insecurity exists when the availability of nutritionally adequate and safe foods, or the ability to acquire acceptable foods in socially acceptable ways, is limited or uncertain."(United States of America General Accounting Office, 1999:1-2).
"Food security means access by all people at all times to the food needed for a healthy life. Sustainable food security aims to achieve this goal without compromising the productive capacity of natural resources, the integrity of biological systems, or environmental quality."(FAO and UNDP, 1994).

- Limited availability and provision of health care to infants and pregnant and lactating women.

Furthermore, a study of micronutrient deficiency carried out in 1998 indicated that there is a high probability of VAD in Maputo, Gaza, Manica, and Cabo Delgado provinces, due to a low level of consumption of both animal and vegetal enriched sources of Vitamin A (Fidalgo *et al*, 1999; MISAU, 1999).

In early 2002, a nation-wide survey was carried out in 21 randomly selected districts to determine the serum retinol levels in children 6 to 59 months and their mothers. This survey revealed that 69% of children and 11% of their mothers suffered from VAD, and approximately 14 % of children and 1% of their mothers evidenced severe VAD. In addition, this study indicated a strong relationship between VAD and the risk of *Plasmodium falciparum* infection (Odds Ratio = 3.19; CI 95%; 2.2 –4.5) (Ismael *et al*, 2003).

B.2 Nutrition Policy & Strategy

Malnutrition is a major contributor to the alarmingly high infant and child mortality in developing countries. Governments, international agencies, and research institutions have increasingly recognized that malnutrition has multiple causes and complex interrelationships with health, economic, environmental and social conditions (Austin J. *et al*, 1981, Sommer A. *et al*, 1996). Thus, there is a need for greater and more concerted nutrition intervention that channels additional resources more quickly and effectively to nutritionally at-risk groups (Austin J. *et al*, 1981).

Designing and implementing a comprehensive national nutrition plan is a complex and organizationally difficult task, since many institutions and disciplines are involved. In some countries, there are strong nutrition planning units. However, it seems more feasible to have individual governmental institutions incorporating nutritional considerations into their activities rather than establishing a totally integrated national nutrition plan with power concentrated in a single and separate nutrition planning unit (Austin J. *et al*, 1981). Seven types of nutrition programs are envisaged to mitigate malnutrition in developing countries, namely:

1) Supplementary feeding
2) Nutrition education
3) Fortification[45]
4) Formulated foods
5) Consumer food price subsidies
6) Agricultural production, Technical change and Nutritional goals
7) Integrated nutrition and Primary Health Care programs.

These nutrition programs are viewed as component of a broader and more comprehensive effort, aimed at adjusting basic socioeconomic infrastructures to remove inequities and poverty. These interrelated types of nutrition programs are directed at addressing the consequences of different causal factors at different stages, as depicted in Figure 2. The interventions, which are indicated in dotted lines in Figure 2, should be implemented simultaneously, due to their complementarities. For instance, the

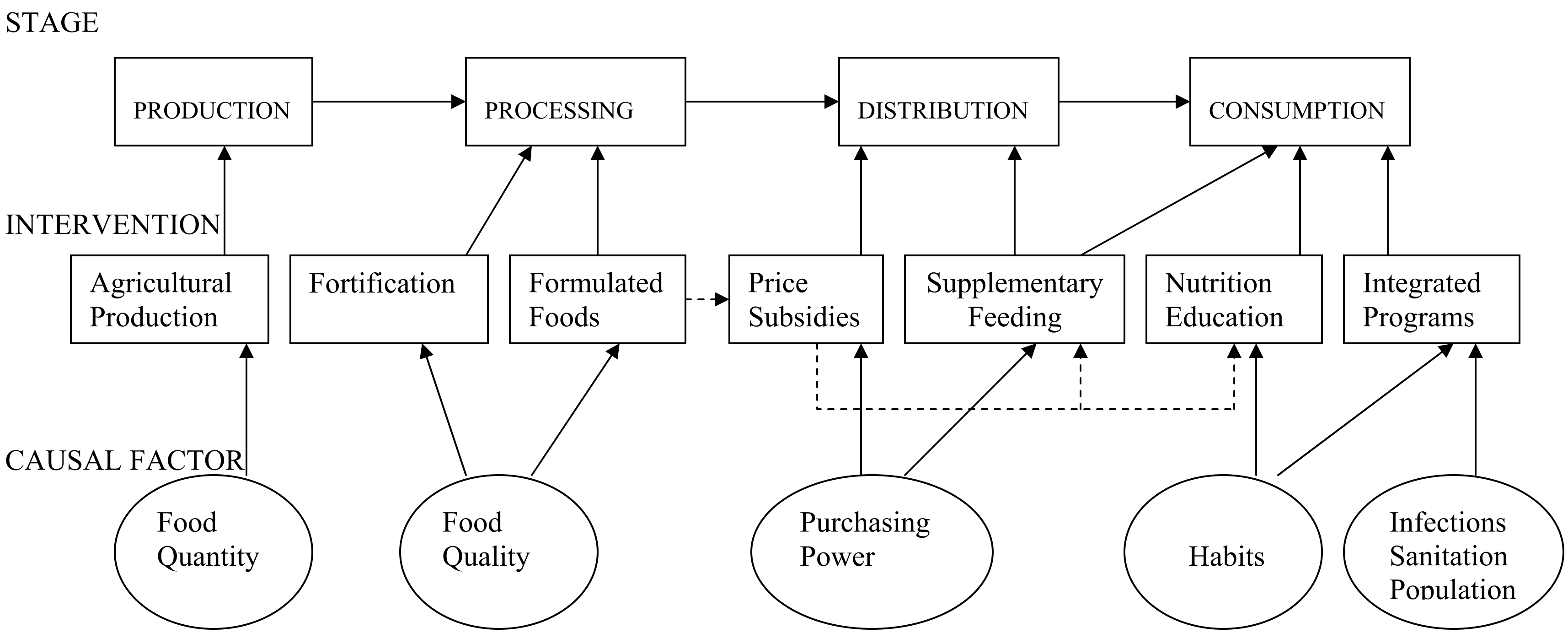
[45] Fortification is defined as being "the process whereby nutrients are added to foods to maintain or improve the quality of the diet of a group, a community or a population" (FAO/WHO, 1971).

introduction of formulated foods into the diet, requires an intervention to educate people about their importance and /or how to prepare them. By the same token, formulated foods could be used as commodities in supplementary feeding programs or they might be subsidized in order to increase their accessibility to the lower-income segments of the population (Austin J. *et al*, 1981).

The National Policy for Micronutrient Supplementation is a crucial component of the more comprehensive *National Strategy for Mitigation of Micronutrients Deficiencies*, including: (1) the promotion of production and consumption of micronutrients enriched and fortified foods; (2) the promotion of appropriate child feeding practices (provision of complementary foods to young child and duration of breastfeeding during the first two years); and (3) the control of levels of infectious and parasitic worms diseases (MISAU, 2003; Martins, H., 2004).

Based on the recommendation of the World Health Organization, International Vitamin A Consultative Group, and the United Nation Children's Fund (1988), the Ministry of Health of Mozambique adopted a Vitamin A supplementation program envisaged to prevent and cure Vitamin A deficiencies in the short and medium run, especially among young children and women.

Figure B: Relationship among Different Types of Nutrition Interventions.



Source: Austin J. *et al* 1981.

The goal of the preventive supplementation program was to distribute Vitamin A capsules through the existent health system network to all children 6 to 59 months every six months and to distribute a single dose of 200,000 IU[46] of Vitamin A to women within two months after parturition. Children 6 to 11 months of age were targeted to receive a dosage of 100,000 IU, and children over one year and under six years old, were to receive a double dosage.

The curative Vitamin A supplementation for xerophthalmia in young children and women follows the same dosage mentioned above, but it is administrated three times, with the first dose given just after the disease is diagnosed, the second on the following day, and the last dose a month later. In addition, the curative Vitamin A supplementation for controlling measles in young children follows the same pattern of three doses-- 100,000 IU to children six to eleven months and 200,000 IU to children over one year and under six years old. Finally, children suffering from acute malnutrition, persistent diarrhea, and pneumonia, are given a single Vitamin A supplement at the same dosage mentioned previously for both children's age groups (MISAU, 2002; MISAU, 2003). Vitamin A supplementation to children age 6-59 months has been carried out and achieved high coverage. However, in countries with clinical VAD, it can take up to 15-20 years to successfully replace a universal high-dose Vitamin A supplementation program with a food fortification program and/or improved dietary practices (Underwood, B. 1998). The main micronutrient deficiencies addressed through fortification are: iodine (which causes goiter, cretinism and deaf mutism), Vitamin A (causing sight impairment or blindness), iron or folic acid (which causes anemia) and B vitamins (thiamin, riboflavin and niacin). The major advantage of this nutritional intervention is that

[46] 1 International Unit (IU) = 0.30 μg Retinol Equivalent (RE) = 0.60 μg β-carotene

additional nutrients (fortificants) are incorporated into existing diets without requiring major changes in consumption behavior.

According to Underwood B., (2000), agriculture could play an important role in developing more micronutrient-dense staple crops, while not neglecting continued research to identify crops (varieties) qualitatively more balanced in their amino acid content, including vegetables and legumes or livestock.

APPENDIX C

QUESTIONNAIRE ON THE ECONOMICS OF SMALLHOLDER PRODUCTION AMD ADOPTION OF OFSVs IN GAZA PROVINCE

Respondent Number __________

NATIONAL INSTITUTE OF AGRICULTURE RESEARCH

DEPARTMENT OF AGRICULTURE ECONOMICS (MSU)

Questionnaire on the Economics of Smallholder Adoption and Production of Orange-fleshed SweetPotato Varieties in Gaza Province of Mozambique.

INSTRUCTION TO THE ENUMERATOR

First, ask who is responsible for sweetpotato production and interview this person.

Please introduce yourself before starting to interview the farmer by reading the consent of statement. If the farmer agrees to be interviewed begin the interview. Please ask each question patiently until the farmer gets the point. Please fill up the questionnaire accordingly. For open-ended questions, fill the farmer's answers and for close-ended questions, please indicate by ticking or encircling.

Respondent Number __________

District: 1- Xai-Xai 2-Chokwe **DIST:_____**

Posto Administrativo:

Localidade: **Date: / / 04**

Enumerator's Name:

I. Land and Livestock Inventory

1.1 In 2002/03 dry season, how many fields did you plant?

Field Number	Location (up/low)	Tenure	Area (house plots)	Mono/ mixed	Main crops planted (list most important crop first)
1					
2					
3					

Land tenure: 1 = Own 2 = Rent 3 = Family land 4 = Share cropping
5 = Borrowed land

1.2 In which fields did you plant sweetpotato? Field #s _____ _____

1.3 In 2003/04 wet season, how many fields did you plant?

Field Number	Location (up/low)	Tenure	Area (house plots)	Mono/ mixed	Main crops planted (list most important crop first)
1					
2					
3					

Land tenure: 1= Own 2 = Rent 3 = Family land 4 = Share cropping
5 = Borrowed land

1.4 In which fields did you plant sweetpotato? Field #s _____ _____

1.5 Do you currently have livestock? (1= Yes 0 = No) _____
IF YES: *Go to the table below.*

Type	Cows	Calves	Oxen	Donkeys	Pigs	Goats	Sheep
Number							

II. SweetPotato Production

2.1 How did you prepare the fields where you planted sweetpotato in the:

- **2002/03 wet season?** (1= manual 2= animal traction 3= tractor) _____
- **2003/04 wet season?** (1= manual 2= animal traction 3= tractor) _____

2.2 In the 2002/03 wet season, did you hire labor for any sweetpotato operation?

IF YES: **For what operations?** ____

____

2.3 In the 2002/03 dry season, did you hire labor for any sweetpotato operation?

<u>IF YES</u>: For what operations? ______________________________________

2.4 In the 2003/04 wet season, did you hire labor for any sweetpotato operation?
(0 = No 1 = Yes)______

<u>IF YES</u>: For what operations? ______________________________________

2.5.1 Which sweetpotato varieties did you grow in the 2002/03 and the 2003/04 wet seasons?

Year/ Season	Name	Type	Leaf shape	Growth habit	Location planted (up/low)	Production problems
2002/03 Wet Season						
2002/03 Dry Season						
2003/04 Wet Season						

Type:

Flesh color:	0 = White/cream flesh	1 = Orange flesh
Leaf shape:	0 = round	1 = narrow
Growth habit:	0 = prostrate	1 = erect

Respondent Number __________

2.6 In what year/season did you <u>first</u> planted OFSP vines?

Year: __________ Season ________

2.7 Did you plant OFSP varieties in the 2002/03 wet season?

(0= No = Yes) ____

<u>IF NO</u>: Why not?

____

<u>IF YES</u>:

How large of an area did you plan to sweetpotato?

(house plot comparison)______

How much area did you plant to OFSP varieties, compared to WFSP varieties?

- **More area to WFSP varieties (*circle if*) Yes Relative proportion_____%**
- **Same areas to WFSP varieties as WFSP varieties (*circle if*) Yes**
- **More area to OFSP varieties (*circle if*) Yes Relative proportion_____%**

Why did you plant this proportion?

____

2.8 Did you plant OFSP varieties in the 2002/03 dry season?

(0= No = Yes) ____

<u>IF NO</u>: Why not?

____

<u>IF YES</u>:

How large of an area did you plan to sweetpotato?

(house plot comparison)_____

How much area did you plant to OFSP varieties, compared to WFSP varieties?

- **More area to WFSP varieties (*circle if*) Yes Relative Proportion_____%**
- **Same areas to WFSP varieties as WFSP varieties (*circle if*) Yes**
- **More area to OFSP varieties (*circle if*) Yes Relative proportion_____%**

Why did you plant this proportion?

____

2.9 Did you plant OFSP varieties in the 2003/04 wet season?

(0 = No 1 = Yes)____

IF NO: Why not?

____

IF YES:

How much area did you plan to sweetpotato?

(house plot comparison)_____

How much area did you plant to OFSP varieties, compared to WFSP varieties?

- **More area to WFSP varieties (*circle if*) Yes Relative proportion_____%**
- **Same areas to WFSP varieties as WFSP varieties (*circle if*) Yes**
- **More area to OFSP varieties (*circle if*) Yes Relative proportion_____%**

Why did you plant this proportion?

____

2.10 Do you plant your sweetpotato in mounds, ridges, or on flat ground?

(1=mounds 2=ridges 3=flat land)___

IF NOT RIDGES: **Why not?**

____

____

2.11 Are there any differences in the way you plant OFSP varieties, compared to WFSP varieties? (0 = No 1 = Yes)_____

IF YES: **What are the differences?**

____

2.12a How do you evaluate OFSP varieties, compared to WFSP varieties? (Please circle)

Trait	Orange-fleshed				White-fleshed
Total yield	of OFSPV is	**lower**	**same**	**higher**	than WFSPV
Crop duration	of OFSPV is	**shorter**	**same**	***longer***	than WFSPV
DS propagation	of OFSPV is	**better**	**same**	**worse**	than WFSPV
Taste of fresh roots	of OFSPV is	**less sweet**	**same**	**sweeter**	than WFSPV
Taste of boiled roots		**less sweet**			
Your opinion	of OFSPV is	**less sweet**	**same**	**sweeter**	than WFSPV
Your spouse's opinion	of OFSPV is	**shorter**	**same**	**sweeter**	than WFSPV
Cooking time	of OFSPV is	**smaller**	**same**	**longer**	than WFSPV
Root Size	of OFSPV is	**less sweet**	**same**	**bigger**	than WFSPV
Taste of leaves	of OFSPV is	**more watery**	**same**	**sweeter**	than WFSPV
Consistency	of OFSPV is	**less**	**same**	**more mealy**	than WFSPV
Drought-tolerance	of OFSPV is	**less**	**same**	**more**	than WFSPV
Pest-resistance	of OFSPV is	**less**	**same**	**more**	than WFSPV
Disease-resistance	of OFSPV is		**same**	**more**	than WFSPV
Other (specify)					

2.12b How do you evaluate OFSP varieties, compared to WFSP varieties? (Please circle)

Trait	Orange-fleshed				White-fleshed
Total yield	of OFSPV is	**lower**	**same**	**higher**	than WFSPV
Crop duration	of OFSPV is	**shorter**	**same**	***longer***	than WFSPV
DS propagation	of OFSPV is	**better**	**same**	**worse**	than WFSPV
Taste of fresh roots	of OFSPV is	**less sweet**	**same**	**sweeter**	than WFSPV
Taste of boiled roots		**less sweet**			
Your opinion	of OFSPV is	**less sweet**	**same**	**sweeter**	than WFSPV
Your spouse's opinion	of OFSPV is	**shorter**	**same**	**sweeter**	than WFSPV
Cooking time	of OFSPV is	**smaller**	**same**	**longer**	than WFSPV
Root Size	of OFSPV is	**less sweet**	**same**	**bigger**	than WFSPV
Taste of leaves	of OFSPV is	**more watery**	**same**	**sweeter**	than WFSPV
Consistency	of OFSPV is	**less**	**same**	**more mealy**	than WFSPV
Drought-tolerance	of OFSPV is	**less**	**same**	**more**	than WFSPV
Pest-resistance	of OFSPV is	**less**	**same**	**more**	than WFSPV
Disease-resistance	of OFSPV is		**same**	**more**	than WFSPV
Other (specify)					

2.13 <u>IF THE FARMER GREW MORE THAN ONE OFSP variety</u>:

Ask which one was the best in terms of:

Name of OFSPV	**First**	**Second**
Higher total yield		
Shorter crop duration		
Preferred root size	***(Circle)***: small **or** big roots?	***(Circle)***: small **or** big roots?
More root consistency		
Better taste of fresh roots		
Better taste of boiled roots		
Shorter coming time		
Better taste of leaves		
Other (specify)		

2.14 Who decides whether or not to grow a OFSP variety? ___________

(1 = male 2 = female 3 = decide together)

Respondent Number ________________

2.15 How did you obtain your OFSP vines in each season that you planted OFSPs?

Year	Season	Variety Name	Source
2000/01	**WS**		
	DS		
2001/2002	**WS**		
	DS		
2002/03	**WS**		
	DS		
2003/04	**WS**		

WS= Wet Season **DS= Dry Season**

<u>Sources</u>

1 = Received from Agriculture Office 2 = Received from INIA/SARRNET 3 = Purchased
4 = Received from NGOs 5 = Retained from own harvest 6 = Received from relatives
7 = Received from neighbors 8 = Village multiplication plot

2.16 <u>IF THE FARMER RECEIVED VINES MORE THAN ONCE FROM A NGO</u>:

Why?

____

____

Why didn't he/she save OFSP planting material?

____

____

2.17 Did you sell any sweetpotato roots from your 2002/03 or your 2003/04 wet season crop? (0=No 1 = Yes) ______

IF YES: ***Ask***

Name of Variety	Type (OF or WF)	Amount Sold	
		Quantity	Unit

IF NO SALES: **Why not?**

____

____

2.18 If you wanted to sell sweetpotato roots, where/how would you sell them? _____

Selling Method: 1 = Take to the District market and sell to consumers
2 = Take to District market and sell to market vendors
3 = Sell to traders who come to this village
4 = Other (specify)

____

2.19 Have you ever sold or given OFSP vines to anyone? (0 = No 1= Yes) _______

IF YES: ***Go to the table below***

Year	Season	To whom	Person's village	Quantity	Given or Sold

2.20 Why did she/he/they want OFSP vines?

____

Respondent Number ________________

III. Sweet Potato Consumption

3.1 How many months during the year does your family eat/consume sweetpotato roots? ______

3.2 When sweetpotato roots are available, how many times a week do you eat them? ______

3.3 How do you prepare/eat sweetpotato roots for adults?

Most common methods:

____

____

Other ways:

____

3.4 Have you heard of preparing food from sweetpotato, such as:

Product	Have you heard of it (No/Yes)	Have you made it (No/Yes)
Juice		
Cake		
Flour		

3.5 When sweetpotato roots are available, how many times a week do you feed them to your children? ______

3.6 How do you prepare sweetpotato roots for young children to eat?

Most common methods:

____

____

Other ways:

____

3.7 What type of sweetpotato varieties do you feed your children?
(0=WF 1 = OF 2 = both) _______

3.8 Have you heard that OFSP varieties are nutritionally better for women/children, than WFSP varieties? (0 = N0 1 =Yes) _______

<u>IF YES</u>:
From whom did you hear this information?

____

Why are they nutritionally better?

____

____

3.9 Do you eat the leaves of OFSP varieties (0 = N0 1 =Yes) _______

<u>IF NO:</u> Why not?

____

IV. Institutional Factors

4.1 During the past <u>two</u> years, have you attended an agricultural field day or an on-farm demonstration (0 =No 1 =Yes) _______

<u>IF YES</u>:

Who sponsored the event	What did you learn

4.2 During the past <u>two</u> years, how many times has an extension technician assisted you? ________

IF AT LEAST ONCE, Ask:

Agency of the technician	What type of assistance did he/she provide

4.3 During the past two years, have you participated in an agricultural training course? (0 =No 1 =Yes) _______

IF YES:

Who was the sponsor	What did you learn

4.4 Are you or your spouse, a member of any association? (0= No 1 = Yes) ____
IF YES:

Name of the Association	How does the association benefit you or your spouse?

Respondent Number ________________

V. Farmer Characteristics

5.1 Respondent=s gender (0 = Male, 1= Female) ______

5.2 How old are you? ______

5.3 How many years of school have you completed? ______

5.4 How many years have lived in this village? ______

5.5 How many years have you grown sweetpotato? ______

VI. Household Members

6.1 How many people live in your household at least 9 months of the year? ______

6.2 How many adults (18 or older) live in your household? ______

6.3 How many adult members of your family live away from home? ______

6.4 How many children do you have? ______

6.5 What are the ages of your children?

Age	Age	Age	Age	Age	Age

6.6 In 2003, did you work off farm? (1 =Yes 0 = No) ___

6.7 In 2003, did your souse work off farm? (1 =Yes 0 = No) ___

VII. Comments/Suggestions

7.1 Do you have any comments/suggestions about the OFSP varieties that you have grown?

____

____

7.2 What are the main problems that limit your potato production?

____

____

7.3 Do you have any suggestion about what needs to be done to help farmers increase their sweetpotato production?

____

____

Thank you very much for your participation.

APPENDIX D

ADOPTION (%) OF OFSVs, FREQUENCY OF VINES DISTRIBUTION AND AWARENESS OF PROCESSED OFSVs PRODUCTS BY VILLAGES IN CHOKWE AND XAI-XAI DISTRICTS.

Table D-1: Adoption (%) of Orange-fleshed Sweetpotato Varieties (OFSPV) in Villages Covered by Different NGOs Operating in Chokwe and Xai-Xai Districts, Mozambique, 2002-2004.

Household Cultivated OFSPV	NGO Covered Area										Total Adoption
	LWF		CRC		WRS		WV		STC		
	Cumba	Punguine	Muzumuia	Bombofo	Macunene	Malhazene	Fidel Castro	Siaia	Voz da Frelimo	24 de Julho	
2002/03 wet season	100	100	66.7	33.3	86.7	86.7	46.7	33.3	86.7	66.7	70.7
2002/03 dry season	86.7	33.3	33.3	0	40.0	33.3	6.7	6.7	80.0	60.0	38.0
2003/04 wet season	100	93.3	60.0	20.0	40.0	40.0	6.7	6.7	80.0	60.0	50.7

LWF = Lutheran World Federation CRC = Caritas Regional Chokwe WR= World Relief Services
STC = Save the Children WV = World Vision
Source: Survey 2004

Table D-2: Frequency of OFSPV Vines Distribution, and Number of Varieties Each Household Received from 2000/01 to 2003/04 Wet Season by Village Covered by NGO, Chokwe and Xai-Xai, Mozambique.

Variable		NGO Covered Area										Total
		LWF		CRC		WRS		WV		STC		
		Cumba	Punguine	Muzumuia	Bombofo	Macunene	Malhazene	Fidel Castro	Siaia	Voz da Frelimo	24 de Julho	
Frequency of OFSPV Vines Distribution	1	NA	NA	60.0	100	100	100	100	100	33.3	100	69.3
	2	NA	NA	40.0	0	0	0	0	0	40.0	0	8.0
	3	100	100	0	0	0	0	0	0	26.7	0	22.7
Number of OFSPV Received	1	73.3	86.7	60.0	100	100	100	100	60.0	0	46.7	72.7
	2	26.7	13.3	40.0	0	0	0	0	40.0	100	53.3	27.3

LWF = Lutheran World Federation CRC = Caritas Regional Chokwe WR= World Relief Services
STC = Save the Children WV = World Vision NA= Not Applicable

Source: Survey 2004

Table D-3: Levels of Awareness and Practice of Processing Techniques of OFSP Varieties in Each Zone Covered by NGO in 2003/04 Wet Season, Chokwe and Xai-Xai Districts, Mozambique.

Variable	NGO Covered Area[a]										Total
	LWF		CRC		WRS		WV		STC		
	Cumba	Punguine	Muzumuia	Bombofo	Macunene	Malhazene	Fidel Castro	Siaia	Voz da Frelimo	24 de Julho	
Respondent is Aware of OFSPV Processed Products	100	100	53.3	40.0	100	100	13.3	46.7	86.7	60.0	70.0
Respondent Made at least one OFSPV Processed Product	6.7	13.3	0	0	6.7	0	0	0	13.3	0	4.0

LWF = Lutheran World Federation CRC = Caritas Regional Chokwe WR= World Relief Services
STC = Save the Children WV = World Vision

Source: Survey 2004

[a] Two villages covered by each NGO were selected, and 15 farmers per village were interviewed.

APPENDIX E

CORRELATION MATRIX OF VARIABLES IN THE PROBIT MODEL

Table E: Correlation Matrix of Variables in the Probit Model

	Y	Age	edu	youngd	extvis	fdemo	tbov	vinrec	varexp	offarm	female
Y	1.0000										
age	-0.0176	1.0000									
edu	-0.0299	-0.3525	1.0000								
youngd	0.0413	-0.2839	0.0395	1.0000							
extvis	-0.0402	0.1908	0.2019	-0.1421	1.0000						
fdemo	0.3597	0.0195	0.0647	0.0325	0.0134	1.0000					
tbov	0.0915	-0.0323	-0.0915	0.1041	-0.1600	0.0402	1.0000				
vinrec	0.5644	-0.0068	0.1148	0.0813	-0.1067	0.4540	0.2277	1.0000			
varexp	0.1809	0.0223	0.0104	0.0437	0.1779	0.1837	-0.0815	0.1809	1.0000		
offarm	0.0347	-0.0227	0.1290	0.0850	0.3355	0.0321	-0.0229	0.0591	-0.0306	1.0000	
female	0.0708	-0.2153	-0.1236	0.1762	-0.4593	0.0824	0.0754	0.1299	0.0489	-0.1516	1.0000
famsize	0.2360	-0.0082	0.0000	0.5083	0.0741	0.1190	0.3048	0.2164	0.1087	0.0399	0.0527
sparea	0.1946	0.0641	0.1189	-0.0584	0.0890	0.0959	0.1367	0.1718	-0.0686	0.2628	-0.2603
praware	0.3771	0.1483	-0.2198	-0.0177	-0.1845	0.2133	0.0390	0.3859	0.2234	-0.1287	0.0963
distprec	-0.2014	-0.0115	0.2981	-0.0575	0.5475	0.0235	-0.2157	-0.2923	0.3847	0.1516	-0.2500
rootcons	-0.0070	-0.0670	0.0248	0.1318	0.0077	0.0401	-0.0991	0.0623	0.0182	-0.0323	-0.0118
rsold	-0.0419	0.0360	0.0188	-0.0271	0.3819	-0.0637	-0.0541	-0.0809	0.1627	-0.0380	-0.4248
proexp	0.1334	-0.0216	0.0327	0.0036	0.0633	0.3098	0.0188	0.1949	0.0275	0.1516	0.0417
tland	0.2734	0.1245	-0.1879	0.1384	-0.1517	0.1192	0.2445	0.3358	-0.1263	-0.0470	0.0155

Table E (Cont'd).

	Famsize	sparea	praware	distprec	rootcons	rsold	proexp	tland
famsize	1.0000							
sparea	0.1647	1.0000						
praware	0.0701	0.0094	1.0000					
distprec	-0.0132	-0.0085	-0.3551	1.0000				
rootcons	0.0824	0.0610	-0.0154	0.1777	1.0000			
rsold	-0.0264	-0.0008	-0.0773	0.1395	0.0182	1.0000		
proexp	0.1010	0.2346	0.0542	-0.0278	0.0118	-0.0418	1.0000	
tland	0.2035	0.0860	0.2470	-0.3562	0.0054	0.0182	0.0044	1.0000

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