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Analysis of Adoption of Orange-Fleshed Sweetpotatoes: The Case Study of Gaza Province in Mozambique

By

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EXECUTIVE 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 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. One of the major constraints to 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 varieties is crucial to increasing crop production under rain fed growing conditions.

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.

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[1] (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 rain fed 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, 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 consumed 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

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

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).

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LIST OF ACRONYMS

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

1. INTRODUCTION

1.1. Background

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).

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 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 from the 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, Ricardo, and Gani 2002). The principal characteristics of the eight varieties are summarized in table 1.

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

Table 1. 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 INIA/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.

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

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 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 and 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, Shapiro, and Ramaswamy 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 and Research Questions

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.

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

1. 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?

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

1.4. Organization of the Paper

The remainder of the paper is divided into five principal sections. Section 2 reviews the literature on the impact of food-based interventions to mitigate VAD and adoption of new agricultural technologies. Section 3 presents the methodology used and section 4 reports descriptive results about sweetpotato production, consumption, commercialization, and producers' evaluation of OFSVs. Section 5 discusses the results on factors influencing farmer adoption of nutritionally improved OFSVs and lastly section 6 presents the policy implications and suggestions for further research.

2. LITERATURE REVIEW

This section reviews the literature related to 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.

2.1. 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, de Pee, and Darnton-Hill 1998).

Studies conducted in developing countries, such as Bangladesh and India, documented low dietary Vitamin A intakes by preschool-age children (one to three years old) and found that most of the nonbreast milk Vitamin A intake was derived from plant sources (Zeitlin 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 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[2] 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[3]) 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[4] with iron, iodine, and β-carotene significantly improved the micronutrient status of primary school children–40% of whom exhibited sub clinical VAD at the baseline assessment, due to low availability

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[2] Boiled and mashed orange-fleshed sweetpotato provided 1,031 μg of Retinol Activity Equivalent (RAE[2]) per 125 grams serving, which corresponds to 250% of Recommended Dietary Allowance (RDA) (van Jaarsveld et al. 2003).

[3] 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, it 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.

[4] 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.

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 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[5] 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[6] approaches are likely to introduce food habit changes, improve Vitamin A intakes, and eventually enhance Vitamin A status. However, McKee (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 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 have been 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 and West 1996; West 2000).

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

[6] 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 (McKee 1993).

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, it was 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.

2.2. 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, Walker, and Hijmans 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 which were widely adopted, such as improved cassava varieties in Uganda and improved coffee varieties in Kenya. Second, some technologies which 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 which were unprofitable under specific circumstances, such as animal draught-power technology for weed control when applied on farms less than 2 hectares. 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, Garcia, and Morris (2001), reported that farmers' decision to adopt hybrid maize was determined by the expected returns 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.

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 minimum 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, Just, and Zilberman 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, Crawford, and Jayne (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, Crawford, and Jayne (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.

Feder, Just, and Zilberman (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, Just, and Zilberman 1985; Mbata 2001; Rauniyar and Goode 1992).

3. 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.

3.1. Technology Adoption Decision

3.1.1. 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. These 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 the 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} farmer's 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 **t** and a vector A_{ti} ,corresponding to other attributes associated with the technology **t**. 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 **t** technology and a vector of observed farm and farmer characteristics X_i and a zero mean random disturbance term ε_i:

$$U_{it} = X_{it} + \varepsilon_i \qquad i = 1, 2, \ldots, n \text{ and } t=1,2 \qquad (1)$$

As mentioned previously, the $\mathbf{i^{th}}$ farmer adopts **t=2** if $\mathbf{U_2}$ is greater than $\mathbf{U_1}$. A qualitative variable Y can represent the farmer's adoption decision.

$$Y = 1 \text{ if } U_2 > U_1 \qquad \text{and new technology } \mathbf{t=2} \text{ is adopted replacing } \mathbf{t=1} \text{ and}$$
$$Y = 0 \text{ otherwise} \qquad (2)$$

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

$$\begin{aligned} P_i &= \Pr(Y_i = 1) = \Pr(U_{i1} < U_{i2}) \\ &\Pr(X_i\,\alpha_1 + \varepsilon_{i1} < X_i\,\alpha_2 + \varepsilon_{i2}) \\ &\Pr[\varepsilon_{i1} - \varepsilon_{i2} < X_i(\alpha_2 - \alpha_1)] \\ &\Pr(\gamma_i < X_i\,\beta) = F(X_i\beta) \qquad (3) \end{aligned}$$

Where

- Pr (.) is a probability function,
- $\gamma_i = \varepsilon_{i1} - \varepsilon_{i2}$ 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:

$$\frac{\partial P_i}{\partial X_{ij}} = f(X_i \beta).\beta_j \qquad (4)$$

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:

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

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.

1. Three alternative functional relationships are commonly used by researchers to specify G: Linear Probability (LP), Probit, and Logit models. For this study we assume a normal distribution of the disturbance term, which gives a probit model.

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 -∞ and + ∞. 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 1983). The functional form is represented as follows:

$$P = F(Z_i) = \frac{1}{\sqrt{2\pi}} \int_{\alpha}^{z} e^{-\frac{v^2}{2}} dv$$

Where $Z_i = X_i \beta + \varepsilon_i$

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 Xj as shown in equation 4.

3.1.2. 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 model for analyzing the key determinants of orange-fleshed sweetpotato variety adoption is specified as follows:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_J X_{iJ} + \varepsilon_i$$

Where:

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

i = 1, 2, 3, …, n are observations

X_{ij} = the j^{th} explanatory variable for the i^{th} observation

j = 0,1, 2, …, J

β_j = an unknown parameter

ε_i = Error term

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:

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

- X_2 - Level of education (+): This variable is measured as the number of years of formal education completed by the respondent ***(educ***).

- X_3- 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.

- X_4- 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).***

- X_5- 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.

- X_6- 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.

- X_7- 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.

- X_8 - 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.

- X_9 - 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).***

- X_{10} - 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.

- X_{11} - 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.

- X_{12}- 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.

- X_{13}- 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.

- X_{14} -Average annual precipitation (+): This variable is specified as a dummy[7], 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.

- X_{15} - 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

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[7] 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.

more dependent on sweetpotato as a food source would be more interested in growing Vitamin A-enriched OFSVs.

- X_{16} - 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.

- X_{17} - 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.

- X_{18} - 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 dependent on agriculture, and more able to assume risk, they would be more likely to adopt a new agricultural technology.

3.2. Description of Data and Sampling Approach

3.2.1. 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.

3.2.2. Sweetpotato Growers Survey[8]

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.

[8] 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 of Mazuze 2004 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. DESCRIPTIVE RESULTS OF SWEETPOTATO PRODUCERS, PRODUCTION AND FARMERS' EVALUATION OF OFSVs

4.1. Awareness and Extension Services Provided to Farmers

Taking into account the importance of technical knowledge as a key determinant of technology adoption, 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. The results are presented in Table 2.

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 2).

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 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.

Table 2. 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

In recent years, the development literature has highlighted the role of social capital in facilitating the exchange of information among farmers (Huysman and Wulf 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[9]. 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[10].

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%);
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 farmers' 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[11], including the absence of a crop marketing system and the non-availability of credit opportunities for farmers.

4.2. Sweetpotato Production

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 3.

[9] 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.

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

[11] 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).

Table 3. Four Most Frequently Grown WFSP and OFSP Varieties, Xai-Xai and Chokwe 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.

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 4), 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 4. 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.

Table 5. 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

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 5).

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.

Farmers reported several reasons for planting different proportions of their farms to white/cream versus OFSVs (Table 6). 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 6. 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 7).

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.

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. 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.

Table 7. Adoption (%) of OFSVs in Each Zone Covered by NGO, and by Season in Chokwe and Xai-Xai Districts, Mozambique

Household Cultivated OFSPV	NGO-Covered Area[a] 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.

4.3. Producers' Evaluation of OFSVs

Producers were asked their opinions regarding the OFSVs they had planted (Table 8). 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.

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%).

Table 8. 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.

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 9. 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.

Table 9. Farmers' Evaluation[12] of the Performance of OFSVs Versus "Local" Cultivated Varieties[13], 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.

[12] 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%.

[13] 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.

According to Collins and Walter (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) 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. 1985).

5. FACTORS INFLUENCING FARMER ADOPTION OF OFSVs

5.1. 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.

The summary statistics for these explanatory variables are presented in Table 10.

5.2. Results of the Probit Model

Based on the probit procedure, the maximum likelihood parameter estimates for the unrestricted (full) model were computed (Table 11). 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 12) was estimated, which excluded four variables from the full model, which had signs inconsistent

Table 10. 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: author's estimates. C = Continuous D = Dummy with adoption theory and/or were not jointly significant probably 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).

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 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.

Table 11. Maximum Likelihood Estimates of the Unrestricted Model for Factors Influencing Adoption of OFSVs in Xai-Xai and Chokwe Districts, Mozambique (N=150)

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%
[a] Excluded in restricted model
Source: Author's estimates.

Table 12. 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[14] 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: Author's estimates. NA = Not Applicable

5.3. 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.

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

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. For the study area, 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.

5.4. Goodness-of Fit

Using STATA, the estimated probability of each respondent being an adopter was computed. Using 50% as the cut-off probability[15] of being an adopter, a comparison of the observed numbers of adopters and disadopters versus the estimated numbers was made (Table 13). 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.

Table 13. 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

15 Estimated probability of adoption less than 50% is considered as being disadopter.

6. POLICY IMPLICATIONSAND FURTHER RESEARCH NEEDS

6.1. 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.

6.1.1. Agricultural Research & Development[16]

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 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[17] for farmers' rain fed 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[18] 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.

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.

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16 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 and Haddad 2001).

17 Goldman and Overholt 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.

18 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 and Walter 1995).

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.

6.1.2. 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 should disseminate those materials to sweetpotato growers. While interpersonal contacts 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. .

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[19]. 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 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[20] in the farming systems.

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[19] 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).

[20] 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.

6.1.3. 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.

6.1.4. 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.

6.2. 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.

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[21] 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[22] 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.

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.

[21] 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 Hong 1992; Espinola et al. 1999; Hagenimana and Oyunga 1999).

[22] 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 1985).

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