THE ADOPTION OF IMPROVED AGRICULTURAL TECHNIQUES IN MOZAMBIQUE:

AN EMPIRICAL APPROACH

by

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STATEMENT BY AUTHOR

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Abstract

Studies on the adoption of improved agricultural technologies and advanced farming systems have found that the adoption of these technologies has rarely met the point of rapid diffusion because of imperfect information, capital, and income constraints. Disseminating culturally and contextually relevant agricultural extension messages to farmers have historically been problematic in less developed countries. New methods to circumvent these obstacles including farmer groups are innovative and warrant greater examination. The objective of this research is to empirically examine the factors impacting the adoption of improved agricultural practices among farmers in Mozambique, with particular attention on the role of farmer groups. Because the adoption of sustainable practices has been slow in the region, empirical results can be used to make recommendations as to how policy can influence the adoption of sustainable practices and to determine whether farmer associations play a critical role in the process.

The results indicate that disseminating improved agricultural techniques through farmer groups can play an important role in securing rural livelihoods and increasing food security in the region through increased income opportunities and increased crop production.

Chapter I: Introduction

Agriculture is an important part of the livelihoods of many poor people, and it is maintained that agricultural growth is a fundamental pre-requisite for widespread poverty reduction (Feder, Just and Zilberman 1985). Policies have sought to enhance crop yield levels and protect farmers' incomes in areas where rural poverty is most intractable, namely this includes regions of South Asia and much of sub-Saharan Africa.

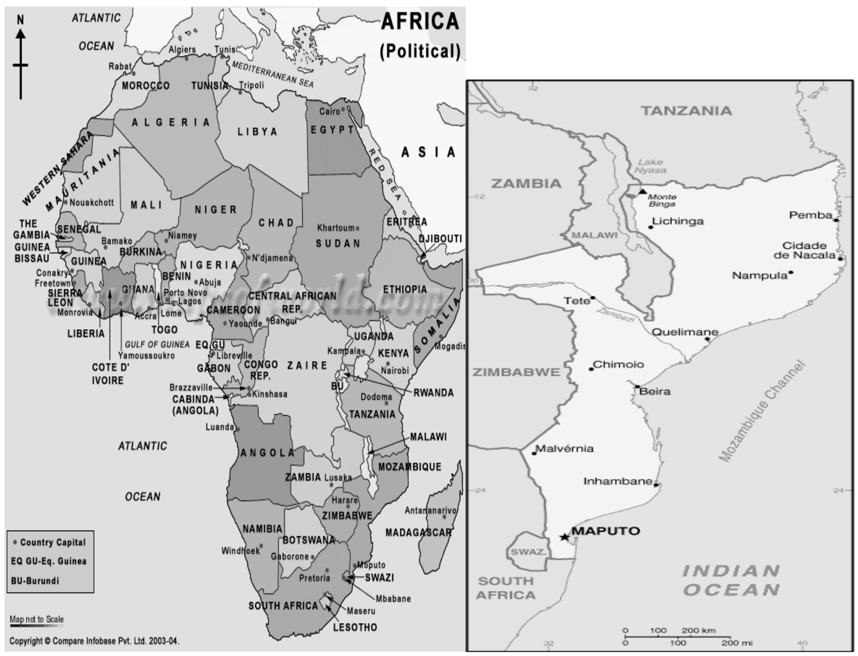
The adoption of technological innovations in agriculture has received considerable attention from development economists and practitioners as well as policy makers because of its potential to improve livelihoods in many less developed countries (Feder, Just and Zilberman 1985). Enhancing agricultural productivity in less developed countries requires approaches that promote the translation of new innovations into concrete benefits for poor farmers. However, the introduction of many new technologies, including improved agricultural methods and techniques have not been adopted to the degree expected. Lack of credit, lack of information, risk aversion and contextually inappropriate innovations within lesser developed countries are the main reasons purported.

Policy and development initiatives have sought to remove or mitigate the constraints faced by resource poor farmers by introducing better information and contextually and culturally appropriate technologies which take into consideration the lack of capital and credit available to poor farmers. These initiatives have improved the adoption of agricultural innovations in lesser developed countries but they have not been fully realized in many countries. Adoption behavior varies across different countries and time as well as by socioeconomic groups within countries (Feder, Just and Zilberman 1985).

Within the context of Africa, low production yields and poor growth performance in the agricultural sector have worsening rural poverty. Agricultural growth continues to be viewed as a critical condition for widespread poverty reduction. Policies to sharply increase crop yields have been initiated in a number of African countries. Specific policy initiatives have included the dissemination of agricultural technologies with several components such as improved seed varieties, fertilizers and corresponding land preparation practices. Improved agricultural inputs and practices complement one another and may be adopted together but often are adopted individually.

Farmer groups, is one initiative being used in different African countries, as a means to better disseminate agricultural technologies to poor farmers. Farmer groups entail both extension and marketing groups. Within farmer groups a critical component includes the use of methods to increase farmer participation in defining problems and solutions. Farmers' participation in a group is hypothesized to increase the likelihood of adoption of improved agricultural techniques. This research examines the role of farmer groups in disseminating agricultural technologies to households in Mozambique. The country provides an interesting case study given the a

Sub-Saharan Africa is faced with critical levels of malnutrition and poverty which has been attributed to civil war, corruption, and physical and geo-political factors. The colonial legacy of Mozambique led to the collapse of the economy when the Portuguese were overthrown in the 1970's. The Portuguese colonial strategy focused on the extraction of resources and minimized investment in infrastructure in the country. Civil war erupted in Mozambique devastating large areas of the country, disrupting economic activity and displacing millions of people from their homes. Although civil war ended in 1992, with the Rome Accords the country continues to be in a period of transition.



Mozambique is among the poorest countries in the world, with a per capita income of US $90. Agriculture is the major livelihood in the country and accounts for more than 60 percent of national income. More than 70 percent of the country's poor live in rural areas and over two-thirds of the rural poor are dependent on agriculture (Lukanu et al. 2004; CARE Mozambique 2004). With the end of the civil war in Mozambique, the focus of international organizations has shifted away from emergency relief to rehabilitation and development. Government officials and international organizations have given increased attention to the role of improved agriculture performance as a key step to increasing food security and income growth in Mozambique (CARE Mozambique, 2004).

Policies have been designed to increase agriculture productivity at both the macro- and micro-levels in Mozambique. Efforts to develop infrastructure and communication lines are in place to stabilize the economic environment. Developing the capacity of the Ministry of Agriculture has been a priority to target increased agricultural productivity. As people return to areas abandoned during the conflict, the Ministry of Agriculture is confronted with new challenges regarding land tenure issues, market structures, and differing production capacities between regions. At the micro-level, small farmers are also challenged with serious obstacles. Destruction of transportation infrastructures, lack of marketing channels for inputs and outputs, and lack of productive assets have seriously curtailed production in rural Mozambique (CARE Mozambique, 2004). Farmers are constrained to subsistence farming which makes it difficult to shift resources to other income-generating activities in order to strengthen their access to food.

The adoption of improved agricultural techniques promoted by governmental and non-governmental agencies has been extensive in different regions of Mozambique. Agencies have worked to develop new approaches to better disseminate agriculture extension messages and increase adoption. CARE Mozambique has created farmer groups to address farmers' priorities. CARE Mozambique's initiatives have focused on crop diversification and improving productivity levels of crops through farmer groups.

Farmer groups include both marketing and extension groups. The formation of CARE farmer groups is a process made up of two components. In the first component, a participatory appraisal to identify local traditional and improved agricultural practices used by men and women was completed. Sustainable agricultural practices were promoted by designing gender sensitive technical extension messages. An extension system was then established in conjunction with Mozambique governmental agricultural departments as well as other non-governmental organizations. The second component worked to identify gender appropriate farmer groups. To establish farmer groups CARE Mozambique coordinated with other organizations working with groups in order to determine the different ways in which actors can complement each other and identified individuals interested in experimenting with improved practices through on farm trials. Currently, 400 farmer associations have been established (CARE Mozambique, 2004).

The benefit of working through farmer groups is a more active role of farmers in adopting improved agriculture techniques. It should also be noted that the formation of farmers' associations have other objectives than simply adopting new production technologies. These associations are provided with support to develop marketing and storage strategies that can provide benefits to association members.

Government extension agents work closely with farmers participating in CARE Mozambique extension groups. Extension groups organize participatory techniques wherein farmers identify issues and techniques in which they would like to become better informed. Agents directly provide extension messages deemed important to both female and male farmers. Marketing groups work to create an awareness of market opportunities and develop the capacity of farmers to be able to access opportunities. Specifically, CARE Mozambique marketing groups work to create formal agreements between farmers and agricultural input retailers.

Little attention has been devoted to examining the impacts of farmer groups on poor farmers in Mozambique. The objective of this research is to explain the role of farmer groups in the adoption of improved agricultural practices among small-scale farmers in Nampula Districts in Mozambique using empirical analysis. It is hypothesized that membership is an important determinant of adoption of new technologies. This research examines the characteristics of households in northern Mozambique which affect the probability of adopting improved agricultural techniques. Particular attention is paid to the role of farmer groups in affecting households' adoption of agricultural techniques.

It is hypothesized that the adoption of improved techniques will be affected by the adoption costs as well as the perceived benefits of each technique. Improved agricultural techniques are divided into four categories contingent upon cash outlay requirements needed for implementing the techniques as well as amount of time needed to begin to realize benefits. The four categories have been defined in the following manner:

1. Techniques which provide immediate benefits and have a higher cash outlay, specifically the use of improved seed varieties.
2. Techniques which provide immediate benefits and have a higher cash outlay, such techniques include the use of chemical pesticides and fertilizers.

3. Techniques which have immediate benefits and do not require a high cash outlay including line and contour planting as well as proper spacing techniques.

4. Techniques which provide long term benefits and do not require a high cash outlay although labor inputs may be substantial, such as erosion control techniques and the use of cover crops.

The first categorization of techniques may constrain farmers unable to disburse a high cost outlay despite the immediate benefits provided to farmers. Techniques within the second categorization do not have high costs and also provide immediately perceived benefits however there may be information constraints as farmers may be inexperienced or untrained in using such techniques. The third categorization of techniques does not have a high cash cost but apparent benefits are not immediate or readily perceived. These techniques may be more likely to be implemented by farmers not only trained in implementing these techniques but further educated in the long term benefits of these improved agricultural techniques. Because benefits are not immediate, educational training may be necessary in order to persuade farmers to implement the techniques within the third categorization.

Some household characteristics such as education, the availability of off farm income and participation in farmers groups are hypothesized to positively influence adoption. Other characteristics such as age and female headed households are expected to negatively influence adoption.

This thesis is organized in the following manner: Chapter Two presents an overview of improved agricultural techniques and the specific role they play in less developed countries, like Mozambique, with depleted agricultural or natural resources. Historical approaches in providing agricultural extension services and disseminating agricultural techniques in different cultural contexts are examined as they relate to the context of Mozambique. In Chapter Three the theoretical and empirical frameworks are fully discussed. The theoretical framework is structured within a utility maximization framework and the empirical section defines the econometric model to be used, the estimation techniques and variable selection for the models. Specifics on data acquisition and details on the study site, Nampula, Mozambique and the agricultural conditions of the region used for this study are also discussed

The empirical results on the determinants of adoption of improved agricultural techniques are presented in Chapter Four along with the interpretation of the results. The final chapter summarizes the results, suggests policy recommendations and identifies areas for future research.

Chapter II: Literature Review

The purpose of this chapter is to provide an extensive overview of improved agricultural techniques and the approaches used to disseminate agricultural techniques to farmers. The first section details improved agricultural techniques and the specific role they play in less developed countries with depleted resources. The subsequent section examines the historical approach in providing agricultural extension services in less developed countries and the use of improved methods in agricultural extension services in providing information to resource poor farmers in different cultural contexts as it relates to the context of Mozambique.

In order to increase agricultural production, improved inputs, crop management techniques and other sustainable methods of farming have been promoted by researchers as an alternative to common unsustainable farming practices (Caviglia and Kahn 2001; Nair 1990). These improved agriculture practices benefit small-scale farmers in multiple ways. The first section of this chapter provides an overview of improved seed varieties followed by a discussion of crop management practices which directly increase soil fertility, such as cover crops, fertilizer techniques, proper plant spacing, crop rotation, intercropping and other soil fertility practices. The use of sustainable methods can also serve to lower the costs of farm management.

While numerous factors are responsible for the ultimate crop yield, the characteristics of the crop varieties used and quality of seed are critical. It is important to ensure that healthy seed of improved high yielding varieties, well-suited to local agro-ecological conditions and possessing the required characteristics of tolerance and resistance to stress are used. The use of improved seed varieties by small farmers can allow for significant increases in crop production.

Chemical fertilizer can promote vigorous growth, increased root development and improved disease and stress tolerance of crops. Fertilizers provide a mixture of critical nutrients namely, nitrogen, potassium and phosphorus in varying amounts to match the needs of a particular crop. Soil microbes fix the nutrients needed for plant growth and release them slowly as plants need them. Pesticides free crops from insect and mould damage. Pesticides further prevent damage to stored crops by preventing rats, mice, flies and other insects from contamination. These chemical inputs used in conjunction with improved seed varieties can demonstrate substantial increases in crop growth and production. The use of improved seed varieties, fertilizers, pesticides and irrigation has been a particularly important strategy of the Green Revolution for developing countries. Although these inputs were intended to as “package”, many resource poor farmers incorporate components of this package to accommodate the needs of their farm and available budget.

Resource poor farmers can incorporate low cost crop management and environmentally sustainable techniques in order to complement the use of improved seed varieties and chemical inputs. These may also provide a viable alternate for farmers unable to afford chemical inputs. Improved crop growth and production as well as the deterioration of farm land are regulated through various practices described in detail below.

Mulching is the application of a protective layer of a material spread on top of the soil. Organic mulches contain remnants such as grass clippings, straw, and bark chips providing numerous benefits including moisture conservation and improved soil conditions. Mulch slowly decomposes, providing organic matter to help retain loose soil and to further improve root growth, water infiltration, and the water-holding capacity of the soil. Because organic matter is a source of plant nutrients, it provides an ideal environment for earthworms and other beneficial soil organisms.

Cover crops are crops which are grown to protect and improve the soil, not to harvest. Cover crops have the potential to control erosion and weeds, and maintain soil organic matter. They reduce compaction and increase water infiltration which decreases the leaching of nutrients. Cover crops retain and recycle plant nutrients between crops, especially nitrogen, and provide a habitat for beneficial microorganisms (Diver and Sullivan 1991).

With the traditionally low level of farming inputs in less developed countries, the deterioration of farm land can be controlled by alternating years of cultivation with periods of fallow. Allowing for a sufficient fallow period enhances the sustainability of production through the maintenance of soil fertility. Many soils, particularly in the tropics, cannot be continuously cultivated without undergoing degradation. Such degradation is marked by a decrease in crop yields and a deterioration of soil structure. The length of the necessary rest period is dependent upon the inputs applied, soil and climate conditions, and the types of crops planted (Food and Agricultural Organization, 2006).

The use of fertilizer has a considerably beneficial impact on plant growth. Inorganic fertilizers contain a mixture of chemical compounds while organic fertilizers are composed of the byproducts of living organisms, like old leaves, peanut hulls, and animal manure. Organic materials are inexpensive and more readily available to resource poor households and add considerable quantities of organic matter to the soil as well as improve the water and nutrient holding capacity of soils (University of Minnesota, 2006).

In farmers' attempts to maximize production they may sow plants too closely to one another which leads to overcrowding of plants. Proper plant spacing and other crop management techniques allow plants to develop fully and are important keys to obtaining improved crop yields. Proper spacing prevents the invasion of weeds as well as allows enough air movement between plants to prevent diseases. Proper plant spacing is a simple technique which requires no other inputs.

If annual vegetable crops are grown in the same place year after year, there is a risk that soil borne pests and diseases will become a problem, and that plant vigor will decline. Crop rotation involves shifting crops around within the growing area. Plants which belong to the same family are grouped together when planning a rotation. Related crops are prone to the same soil-living pests and diseases and rotating them in an organized manner helps to prevent the problems in the soil. For example, some plants are better at suppressing weeds and alternating crops helps to keep weeds under control (Purdue University, 2006).

Intercropping entails growing two or more crops together in order to maximize beneficial interactions while minimizing competition among plants. For resource poor households, the beneficial interactions generated through intercropping can reduce the need for external inputs and allow farmers to decrease risk through crop diversification (King County Agricultural Extension, 2006). Sustainable farming encompasses a large number of agricultural practices, not limited to the methods described above. These practices are frequently combined to increase production and improve food security of households. Within the context of lesser developed countries both governmental and non-governmental agencies have formulated policies to address improved agriculture production. At the macro-level, this has involved investment in public agricultural research and development as well as strategic designs to disseminate enhanced knowledge. At the micro-level, this has resulted in large investments in agriculture extension services as a means of disseminating knowledge gained through research and development. Investments in developing innovative methods of providing information to farmers have been critical. Agricultural extension services have remained a critical means of providing farmer education of scientific research and new knowledge of agricultural practices. Despite such efforts, the adoption levels of improved agricultural techniques have been low.

Historically, agriculture extension services have been directed at small farmers through a top-down approach where recommendations are passed down through official channels and local extension agents are directed to convince farmers to adopt new technology designated by their superiors (Whyte 1981). Explanations given for the failure of farmers to adopt these practices include the lack of locally-based sustainable systems for inputs, technology transfers inappropriate in a given context as well as farmers' constraints due to a limited resource base (Chambers 1991). These explanations can be attributed to the top-down approach to technology which transfers technology from scientists through extension agents to farmers. The approach is faulted in its assumptions that farmers are passive recipients (Whyte 1981).

Figure 1: The Vertical Model of Agricultural Research and Development[1]

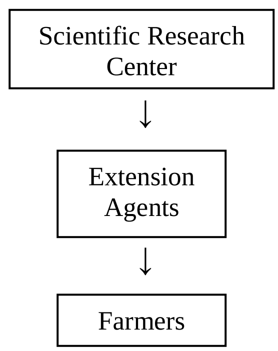
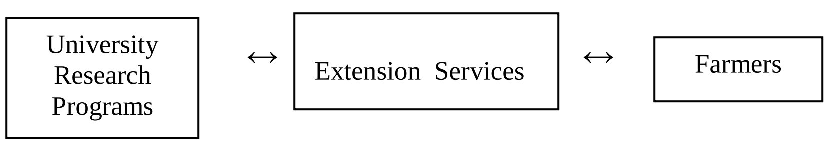


Figure 2: The Horizontal Model of Agricultural Research and Development



In more recent years, new concepts of research and development have framed farmers in a more active role. Farmers are now seen as partners in research activities and extension services. Many studies have focused on the necessity of farmers' involvement in technology development and transfer (Somda et al.2002; Gladwin 1979; Zandstra et al. 1979). Research within this field suggests a more effective organizational model based on the assumptions that poor farmers are rational actors and interested in changes that may improve their standard of living (within the limits of resources and the information available, including risks associated with the adoption of different technologies).

[1] For a further examination see Whyte, 1981

There is a significant body of research which supports these findings and highlights the major problems farmers face when dealing with a number of uncoordinated agencies in order to receive help from the state. This lack of coordination is largely due to the bureaucratic mechanisms of government in lesser developed countries (Chambers 1974; Heginbotham 1975; and Leonard 1977). This body of research asserts that a one-on-one relationship between extension agents and small farmers is not cost-effective. Policy implications suggest more effective organizational models are able to better coordinate agriculture-related agencies and connect with organized groups of farmers. Research further suggests that organizing farmers into farmer groups allows farmers to obtain greater organizational leverage to initiate action and become active participants in designing and implementing agriculture programs.

There has been an increasingly positive response to this research from government agencies and development practitioners. As a result, emphasis is shifting to focus on the means as well as the end of providing technical assistance, training and transferring information to small-scale farmers. Agricultural programs have aimed to promote improved agricultural practices through participatory approaches. This framework involves diagnosing problems and possible solutions with farmers, and emphasizes building the farmers' capacity to identify problems and to find solutions in order to create an environment for more equitable sharing of knowledge between professionals and farmers alike. Agencies have incorporated a critical component involving sensitization training and capacity-building of extension agents.

Following a participatory assessment, farmer groups are established by identifying gender-appropriate farmer groups, individuals that can serve as farmer leaders, as well as individuals interested in experimenting with improved practices on their farms (CARE Mozambique, 2004). Partnerships are created between extension agents and both newly established and existing farmer groups to better disseminate information about better practices to local farmers. The perceived benefit of working through farmer groups is a more active role of farmers in adopting improved agriculture techniques.

Research into the adoption of improved techniques attempts to gain a better understanding of the factors influencing the rate and extent of adoption. Within the context of developing countries, this research is increasingly focused on the socio-economic factors and encompasses a number of other determinants within different political and social contexts. Empirical analysis throughout Asia and Africa have found age, education or literacy rate, the role of women in the household, family size, assets, availability of off farm income, farm size and other plot characteristics to play a significant role in understanding adoption patterns (Adesina, and Zinnah 1993;Baidu-Forson 1999;Caviglia-Harris 2003;Gockowski and Ndoumbe 2004;Kebede, Gunjal and Coffin1990; Ransom, Paudyal and Adhikari 2003; Shively1997; and Doss and Morris 2001). There has also been an increasing examination of household participation in farmer organizations examined as a determinant of adoption (Herath and Takeya, 2003; Caviglia and Kahn, 2001). The following studies offer insight into the determinants (including farmer group participation) of agricultural technology adoption in different contexts.

Doss and Morris (2001) extend their analysis to include issues of gender in an analysis of the different rates of agriculture technology adoption of improved seed varieties and fertilizers among men and women in Ghana. Research within this field has enhanced understanding of key determinants of rates of agricultural technology adoption by males and females. Key determinants examined in this study include age, education, amount of land owned, the use of extension services and income. Education, extension and land owned were found to positively influence adoption however age was not found to be significant. Their research further identified relationships concerning gender and social structures. Their results indicate negative and relatively large impacts on adoption of improved seed varieties by women farmers. The authors clarified that the results do not indicate that women necessarily make different adoption decisions than men but rather suggest that there is something about the structure of female headed households that makes farmers in these households less likely to adopt improved seed varieties (i.e. gender did not affect the decision to adopt the use fertilizers).

Somda et al. (2002) examined soil fertility management in Burkina Faso and isolated several socioeconomic variables and institutional factors significant in determining the rate of compost adoption among poor households. Relevant to this study are factors such as age, gender of the farmer, the use of agro-ecological factors and the inclusion of institutional characteristics such as availability of extension workshops. Age is found to be significant and negative in affecting adoption, while participation in extension workshops and farmer gender provided ambiguous results. Gender was found to be consistent with the hypothesis that male farmers would be more likely to adopt in only one of the three models and is insignificant in the overall model used for the Burkina Faso study. Participation in extension workshops was significant and positive for two of the three models including the overall model; however, it raised concerns by the authors as to how relevant the workshops are to farmers. It was suggested by Somda et al that the content of extension workshops be considered in designing empirical analyses that account for this institutional factor.

Herath and Takeya (2003) examine the variables affecting adoption of intercropping techniques in Sri Lanka. Farmers' attitudes toward techniques, experience with new techniques, and education play a significant role in positively affecting adoption. Social participation, however, was not found to be a significant determinant in affecting farmers' adoption of intercropping techniques. This study contrasts with research by Caviglia and Kahn (2001) and Somda et al (2002). Caviglia and Kahn examine the adoption of sustainable practices by farmers in Brazil and find participation in cooperatives to greatly increase the probability of adoption.

There is still limited understanding of the role that participation in farmer groups plays in a poor household's decision to adopt new technology. Examining the role of farmer groups in the decision-making process of farmers to adopt agricultural practices will contribute to our understanding of innovative methods in disseminating scientific research in agriculture and subsequent adoption by farmers. Understanding the role of farmer groups works to better inform policy and project design aimed at influencing the adoption of sustainable practices.

The objective of this research is to explain the role of farmer groups in the adoption of improved agricultural practices among small-scale farmers in Nampula Districts in Mozambique. The hypothesis that a farmer's participation in a farmer group, holding all other variables constant, increases the likelihood of adoption of improved agricultural techniques will be tested empirically.

Chapter III: Model and Data

The purpose of this chapter is to outline the theoretical and empirical framework used for this study. The econometric model is defined and the explanatory and dependent variables selected for the econometric models are discussed. The data, study site, and the region's agricultural conditions are discussed in detail in order to provide a stong contextual understanding.

Theoretical Model

The theoretical framework of this research is founded on the neoclassical economic theory of utility. This assumes that each decision-maker is able to compare two alternatives, *a* and *b*, in the choice set using a preference-indifference operator, ≥. If $a \geq b$, the decision maker either prefers *a* to *b*, or is indifferent (Varian 1993). Preferences are defined in terms of utility and thus to say bundle *a* is preferred to bundle *b* means that bundle *a* has a higher utility than bundle *b*. The household chooses between using improved agricultural techniques or traditional agricultural techniques. Households will adopt an alternative agricultural technique if it is expected to increase utility.

For this study, the data has been divided into four different types of improved agricultural techniques. The choice that the household faces in each category is represented in this analysis as either choosing to adopt one or more improved agricultural techniques within the category or to continue to rely solely on its traditional counterpart.

The structure for the four models is similar based on the assumption that farmers maximize expected utility. It is assumed that the household chooses a set of agricultural practices based on the resources available to the household, the knowledge members possess, and the constraints that limit these activities.

The utility model utilized for this study follows the utility model employed by Caviglia, J.L. and Kahn K.R. (2001), Somda et al. (2002) and Kebede et al (1990). The utility maximization of the model is based on the unobservable utility function that ranks the preference of the *i*th household according to the technique that is chosen. The unobservable underlying utility function is represented by U ($T_1(X_i)$) or U ($T_2(X_i)$), where T represents the agricultural technique choice. T_1 denotes whether any level of improved agricultural techniques is used while T_2 denotes whether traditional practices are exclusively used. The utility is derived from the observable characteristics, X (including farm, household and physical characteristics). Although utility is unobservable, utility derived from a discrete agricultural technique is a function of the vector of the observed farm and household characteristics and included in the utility measure (Caviglia and Kahn, 2001).

Empirical Model

The decision to adopt improved agricultural techniques is treated as a pure discrete choice decision in each of the four models. The household will choose the farming techniques that maximize expected utility. A probit model is used to analyze the adoption decision of households in Mozambique.

Consider an individual household's utility of adopting an improved agricultural technique denoted by $U(T_1(X_i))$ and a household's utility of adopting the traditional technology to be given by $U(T_2(X_i))$, for a given vector of farm and household characteristics (X_i) where '*i*' denotes a specific household. The utility function is specific to each household.

The utility of adopting the distinct techniques can be defined as a linear relationship:

$$U(T_1 (X_i)) = \beta'_1 x_i + e_{i1} \qquad (2.1)$$

and

$$U(T_2 (X_i)) = \beta'_2 x_i + e_{i2} \qquad (2.2)$$

where e_{i1} and e_{i2} are disturbance terms having a mean of zero. The *i*th household will choose to use improved agricultural techniques if $U(T_1(X_i)) > U(T_2(X_i))$ or if the latent variable $Y^* = U(T_1(X_i)) - U(T_2(X_i)) > 0$, and it will choose traditional agricultural techniques when $U(T_1(X_i)) < U(T_2(X_i))$ or if the unobservable latent variable $Y^* = U(T_1(X_i)) – U(T_2(X_i)) \leq 0$.

$$Y_i = 1 \quad \text{if } Y^* > 0 \quad \text{and}$$

$$Y_i = 0 \quad \text{if } Y^* \leq 0$$

While Y^* is an unobservable latent variable that measures a household's utility of adopting the improved agricultural techniques, Y_i is observable.

The probability that the household adopts improved agriculture techniques or that Y_i equals one is a function of the explanatory variables:

$$\begin{aligned}
\Pr(Y_i=1 \mid \mathbf{x}) &= \Pr[U(T_1(X_i)) > U(T_2(X_i))], \\
&= \Pr[\beta'_1 x_i + e_{i1} - \beta'_2 x_i - e_{i2}] \\
&= \Pr[(\beta_1 - \beta_2)'x + e_{i1} - e_{i2} > 0 \mid \mathbf{x}], \\
&= \Pr[\gamma' x + \varepsilon > 0 \mid \mathbf{x}],
\end{aligned}$$

where X is an n x k matrix of explanatory variables, and γ is a k x 1 vector of coefficients to be estimated.

The probability that the *i*th household adopts improved agricultural techniques is the probability that the utility gained from traditional agricultural techniques is less than the utility gained from improved agricultural techniques. For the purposes of this analysis, the utility function evaluated at X_i is assumed to be normal, making the estimation of the probability possible using a probit model.

Farm and household characteristics, such as farm size, age of the head of the household, participation in a farmer group and education level of the head of household are included in the X matrix. It is expected that the probability of choosing improved agricultural techniques will be affected by these household characteristics and discussed later in the chapter. Further included in matrix X are variables indicating households' participation in a farmer group, specifically whether a household participates in an extension and/or marketing group organized by CARE Mozambique. It is important to determine whether factors such as education and participation in farmer groups play a significant role in the choice of adoption because these factors can directly be influenced through policy. If variables are found to be significant in this analysis then policy recommendations may be beneficial throughout other regions of Mozambique.

Dependent Variables

Improved agricultural techniques are divided into four categories contingent upon cash outlay requirements for implementing improved techniques as well as the amount of time needed to realize benefits from the improved techniques. The four categories are outlined in Table 3.1 and Table 3.2 offers descriptive statistics.

Table 3.1 Dependent Variables

Variable	Description	Specific Techniques
Category I	The use of techniques providing immediate benefits and having a high cash outlay.	Whether the household adopted the use of improved corn, bean, sesame, sunflower, ground nut or manioc seed varieties.
Category II	The use of techniques providing immediate benefits and having a high cash outlay.	Whether the household adopted the use of chemical pesticides or fertilizers
Category III	The use of techniques having immediate benefits and not requiring a high cash outlay.	Water holes used in the rainy season Turning in crop residues before sowing Line planting Proper spacing Contour planting Use of an irrigation pump Use of an “improved” barn Use of organic pesticides Use of manure and liquid manure
Category IV	The use of techniques providing long term benefits and not requiring a high cash outlay (labor inputs may be substantial).	Use of improved land clearing techniques Use of ground cover crops Use of organic compost

Category I was constructed by designating a value of ‘1’ to a household sowing any improved seed variety and ‘0’ if no improved seed varieties were sown. The varieties included were corn, bean, sesame, sunflower, ground nut and manioc. For Category II a ‘1’ was designated to a household if chemical fertilizer or pesticides were used on the farm or for storage and a ‘0’ if the household used none at all. Category III designated a ‘1’ to a household using any crop management technique and a ‘0’ to a household using none. The techniques included water holes, crop turning, line planting, proper spacing, contour planting, the use of pumps, improved barns, organic pesticides or manure. For Category IV a ‘1’ was designated to a household using any environmentally sustainable technique and ‘0’ to a household using none (e.g. cover crops or organic compost).

Table 3.2 Descriptive Statistics of the Dependent Variables

	N	Mean	Std Deviation	Minimum	Maximum
Category I	600	0.64	0.4804005	0	1
Category II	600	0.27	0.4443299	0	1
Category III	600	0.873	0.3328767	0	1
Category IV	600	0.863	0.3437817	0	1

Due to the direct and immediate economic benefits derived from the use of improved seed varieties, it is hypothesized that households are more likely to adopt improved seed varieties without extensive education about the benefits of such practices. The techniques in Category I require a high cash outlay, some farmers may be financially constrained and thus unable to adopt.

Category II includes techniques involving the use of chemical fertilizers and pesticides. These techniques provide direct and immediate economic benefits and also require a high cash outlay to buy fertilizers and pesticides. Similar to Category I farmers may be constrained financially and thus unable to adopt. These inputs are considered to be different than improved seeds for two reasons. First, the cotton industry provides chemical fertilizers and pesticides to farmers growing cotton. It is hypothesized that cotton growers will be less likely to adopt new food seed varieties because they are using their land to grow cotton but will be more likely to use chemical fertilizers and pesticides[2].Second, some of the techniques using chemical pesticides in better storing grains may be unfamiliar to farmers and thus the role of farmer groups may play a critical role in the adoption of these techniques.

Category III is comprised of crop management techniques that do not have high costs and are intended to provide immediate benefits. Techniques in Category III do not require improved seeds or chemical inputs and may be implemented with traditional seed varieties or inputs. Realized benefits include increased crop growth and reduced loss of grains during storage, regardless of seed type. Techniques in Category III comprise more labor intensive practices as compared to Category I and Category II. The techniques encompassed in Category III may largely be unfamiliar to farmers in Mozambique and thus many farmers may be inexperienced or untrained in using such techniques. It is hypothesized that there are information constraints on farmers in Mozambique and thus participation in farmer groups as well as extension services play a critical role in adoption of these specific types of improved agricultural techniques.

Category IV is comprised of environmentally sustainable practices. While this category of technique does not require high cash outlay they are generally more labor-intensive than traditional techniques. Benefits may only become apparent after a longer

[2] As seen in Table 3.5, the average farm size is a little greater than 2.2 hectares.

term providing benefits to later generations. Even if farmers are trained in the application of such techniques they may not be willing or able to invest more labor into carrying out these improved practices. It is hypothesized that these techniques are adopted to a greater extent by farmers both trained in implementation and educated in the long term benefits of these improved practices. Educational training may be necessary in persuading farmers to implement the techniques within Category IV because benefits are not immediate.

Table 3.3

Descriptive Statistics on the Percentage of Households Adopting Each Type of Technology

Category of technology	% of Households Adopting	Of those HH adopting, % that are group members
I	64%	73%
II	27%	36%
III	87%	94%
IV	86%	92%
I or II	71%	79%
(I or II) and III	65%	75%
(I or II) and III and IV	58%	72%

Explanatory Variables

The factors identified by researchers as influencing adoption of improved agriculture techniques as well as expected sign and a brief rationale for such expectations are given in Table 3.4.

Table 3.4 Description of Explanatory Variables

Variable Name	Description	Expected Sign	Rationale	Type
Edu4	Whether the head of household has completed primary school education	Positive	As education increases the head of household will be open to new techniques	Dummy
Female head	Whether the household is a Female headed household	Negative	According to previous studies female headed households tend to be resource poor and have less available labor. Thus, they may be constrained to using traditional techniques	Dummy
Participation	Whether the household participates in a CARE Mozambique marketing or extension group	Positive	Through farmer groups it is expected that farmers will have better access to information and training in techniques identified by farmers as important	Dummy
Assets	Household Assets	Positive	Availability of assets allows a household to disburse cash costs for implementing techniques	Metical (local currency)
Farm area	Farm size	Positive	As farm size increases it is expected that farmers are less resource poor and able to invest in new techniques	Hectares
Cotton	Whether a household grows cotton*	Ambiguous	If a farmer grows cotton they may be more likely to adopt some techniques and less likely to adopt other techniques.	Dummy
Coastal region dummy	If the household is located on the coast	Ambiguous	It is expected that the physical characteristics of the coastal region will play a neg. or pos. role depending on the specific category of techniques	Dummy
Middle region dummy	If the household is located on between the coast and the interior regions*	Ambiguous	It is expected that the physical characteristics of the interior region will play a neg. or pos. role depending on the specific category of techniques	Dummy
Interior region dummy	If the household is located in the interior region	Ambiguous	It is expected that the physical characteristics of the interior region will play a neg. or pos. role depending on the specific category of techniques	Dummy
Off farm income	The sum of off farm income opportunities	Positive	Cash resources will allow households to adopt new techniques	Discrete
Extension	Whether any extension services were received by the household within the last 12 months	Positive	Extension services will make households more willing to implement newly learned techniques	Dummy

Farmer groups include both marketing and extension groups. While extension groups do interact with governmental extension agents, marketing groups do not. Hence the use of extension services is not completely captured by participation in a farmer group. Furthermore, households in Mozambique do not have to participate in a farmer group in order to receive extension services. They may benefit from extension services through sources other than CARE Mozambique including governmental, non-governmental and private extension services[3].

Description of the Data

The data on the adoption of improved agricultural techniques were collected in Nampula Province, Mozambique through a survey of rural households in 2004 by CARE Mozambique. A sample of 600 households was collected in 12 districts of Nampula Province. The sample contains farmer group participants, marketing group participants and non-participants. Households were questioned at length about their agricultural production, consumption and marketing practices, and their use of improved agricultural techniques. CARE Mozambique conducted the survey in order to better inform their 'Viable Initiatives for the Development of Agriculture Project' (VIDA II Project). The VIDA II project aims to increase food security in northern Mozambique through improved availability and access to food. A key component of the project is to provide agriculture extension services through farmer's and marketing groups in order to better disseminate information.

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[3] The correlation between the use of extension services and participation in farmer groups is 0.49

At the outset of the project, CARE Mozambique conducted participatory appraisals with community members in order to identify traditional and improved agricultural practices used by both male and female farmers. CARE Mozambique created extension messages and gender sensitive technical protocols from collected information. The formation of farmer groups involved the identification of gender appropriate farmer groups, as well as individuals who could serve as farmer leaders or those interested in experimenting with improved practices through on farm trials (CARE Mozambique, 2004). The traditional agricultural practices targeted by the VIDA II for promoting improved agricultural practices are detailed in the following section.

Table 3.5 Descriptive Statistics of Explanatory Variables

Variable	Mean	Std. Dev.	Min	Max
Assets	1.666158	4.225875	0	61.88
Female headed	0.17	0.375946	0	1
Education	0.2983333	0.457908	0	1
Participation	0.45	0.497909	0	1
Farm area	2.204278	1.415437	0.1	12.5
Extension	0.595	0.491302	0	1
Coast dummy	0.1666667	0.372989	0	1
Inter dummy	0.1666667	0.372989	0	1
Off farm income	0.9266667	1.38244	0	12
Cotton	0.1716667	0.377405	0	1

Table 3.6 Characteristics of households broken down by membership in farmers' groups

Household Characteristics	Group members	Non Group Members	Overall sample
Head received at least 4 years of education	35%	25%	29%
Female headed household	17%	17%	17%
Own any assets	95%	93%	94%
Own any farm land	100%	100%	100%
Have access to off-farm income	48%	53%	51%
Has received extension services	86%	37%	59%
Grow cotton	19%	15%	17%
Live in coastal zone	12%	20%	16%
Live in middle zone	68%	65%	66%
Live in interior zone	18%	14%	16%

Study Site

Nampula Province is located in northern Mozambique and it has an area of 81,000 square kilometers. Nampula has an estimated population of three million making it the second most populated province in the country. It is located in one of Mozambique's richest agricultural regions and is considered the "breadbasket" of the country. The most important food crops produced in the region are maize, ground nuts, cassava and cowpeas, while cash crops include cashew nuts, cotton and tobacco. Farming in Nampula is largely subsistence with small-scale farmers using a system of shifting cultivation with varying fallow periods.

Food crop yields in Nampula are low compared with similar southern African countries. Typical maize yields in high potential areas in Nampula average 400-800 kg/ha, compared with between 830-3,000 kg/ha among small holder farmers in the southern African region. These low crop yields are due to three key factors: poor agricultural techniques including the lack of environmentally sustainable practices, the use of suboptimal seed varieties given the specific agro-climatic conditions of the region and low input levels used by farmers (CARE Mozambique, 2004). There are three main agro-ecological zones: the coastal zone, the intermediate zone and the interior zone. The climate is moist savannah with one wet season and one dry season. The mean annual rainfall ranges from 800-1400mm for the region, decreasing towards the coastal zone. Throughout Mozamibique almost all production is rainfed, as most farmers cannot afford to install irrigation systems. Nampula Province has more appropriate conditions for rainfed agriculture when compared to southern provinces. The probability of good harvests during the wet season is 70-95 percent in Nampula Province.

Agriculture in Nampula Province

It is expected that Nampula Province will continue to produce an abundance of food and cash crops for the market since it is one of the richest agricultural areas of the country. The region has been targeted to improve agriculture performance in order to increase food security and income growth in Mozambique (CARE Mozambique, 2004). The potential for enhanced agricultural performance exists within Nampula Province since crop growth and yields are directly affected by farming practices such as late sowing and excessively low planting densities which fail to maximize output[4].

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[4] Late sowing and low plant densities may be strategies to minimize risk due to climatic uncertainties including inadequate rainfall.

Population pressures are creating increasing demands to expand productivity and decline the use of fallow periods. Farmers are moving into more marginal land and shortening the fallow periods on land already in use. The decline in the use of fallow periods will ultimately decrease soil fertility and render agricultural land useless (Caviglia-Harris 2003). There is a tendency by small farmers to mono-crop staple crops because many farmers are constrained to subsistence farming, making it difficult to diversify the types of crops they grow. Slash and burn techniques are widespread because they do not require much labor. The use of these traditional practices greatly contributes to declining soil fertility and increased soil erosion within the region.

Current farming practices involve negligible to non-existent amounts of organic or chemical fertilizer. Pesticides are frequently misused, increasing pest problems and costs of production as well as creates environmental and health risks. Crop losses are estimated at 30 percent before the harvest can be marketed or consumed. These losses appear to be especially critical for maize and cowpeas. Traditional storage techniques are commonly used and involve the storage of grains and vegetables in woven cylindrical structures and baskets and jute bags (CARE Mozambique, 2004).

Seed stocks are low in most areas of Nampula. Most farmers use unimproved seed varieties or a mixture of different seeds, many of which are suboptimal for the agro-climatic conditions of the province. Many farmers, accustomed to receiving free seed during emergency periods associated with the war, either no longer save seed in significant amounts or are unfamiliar with the correct procedures for selecting improved seed varieties (CARE Mozambique, 2004).

<u>Characteristics of the Improved Agricultural Techniques in Nampula Province</u>

There are three inter-related components for improving household food security through improved agricultural technology: increased use of improved food seed and cash crop seed varieties, increased use of techniques intended to directly increase soil fertility through inputs, and dissemination of agricultural techniques including environmentally sustainable technique and crop management techniques (CARE Mozambique, 2004).

Improved seed varieties for corn, manioc, and a variety of legumes are the main food crops which are being targeted in Nampula. Government and non-governmental organizations hope to increase food security of households through increased opportunities for income-generating activities, and the promotion of improved seed varieties for cash crops such as sesame, sunflower, and ground nuts.

Promoting increased input use aims to improve soil fertility in the region. The main inputs include chemical fertilizer, compost and manure. Chemical fertilizer is a costly input. Compost and manure are highly labor intensive and manure further requires access to livestock.

Crop management techniques include a variety of techniques intended to improve crop growth and crop yields. The opening of holes on fields during the rainy season to capture water is being promoted within the region. Planting in rows, using proper spacing techniques, contour planting and land clearing techniques which avoid burning are being promoted to increase crop yields.

Environmentally sustainable techniques being promoted within Nampula Province include turning crop residues into the soil to improve fertility, the use of cover crops on the land during fallow periods in order to control erosion and maintain organic soil matter, and the use of organic mulches applied to top of the soil as a protective layer. This latter technique requires information on mulch content materials (grass clippings, straw, bark chips and crop residues). Crop rotation of corn, manioc, millet and sorghum with a legume and crop rotation of sunflower or sesame crops with a legume are being promoted, as well as intercropping of corn, manioc, millet and sorghum with a legume and intercropping of sunflower or sesame crops with a legume.

Not all farmers within the region have adopted all or any of these four types of improved agricultural techniques. The focus of this research is to identify the factors that motivate farmers to use or not use improved techniques. Particular emphasis is give to the role of farmer groups in the adoption of improved agricultural practices among small-scale farmers.

Chapter IV Empirical Results and Implications

The main results for the four categories of adoption techniques using a probit model are presented in Table 4.1. The Likelihood Ratio tests the null hypothesis that the natural log of the variance of assets is equal to zero. We reject the null and therefore must control for heteroskedasticity. The probit model used is controlling for heteroskedasticity with respect to the independent variable 'assets'. Those with higher assets display a different variability of adoption than those with lower assets[5]. The first column lists the explanatory variables and the following columns list the four categories reporting their estimated coefficients and corresponding standard error values in parentheses below the coefficient.

Marginal effects are nonlinear functions of the parameter estimates at a given level of the explanatory variables and demonstrate the change in predicted probability associated with changes in the explanatory variable (Greene, 2000). The magnitude of the marginal effects depend on the values of the explanatory variables and their coefficients. For the purposes of this study the marginal effects are computed at the means except for the independent variable 'extension'. Extension is held at one in Table 4.2 and at zero in Table 4.3 in order to gauge the effects of household use of extension services in relation to the remaining independent variables. The predicted probability of the probit model is given by $E[y|x]=F(\boldsymbol{\beta}'\mathbf{x})$, where F is given by Φ, the cumulative standard normal function. For continuous variables the marginal effects are given by $\partial E[y|x]/\partial x = f(\boldsymbol{\beta}'\mathbf{x})\boldsymbol{\beta}$, where f is the corresponding probability density function. For the probit model, f is the

[5] The variance of the error term in each of the four models is: $\text{Var}(u_i) = e^{\alpha_0 \text{ assets}_i}$.
The natural log is: $\ln \text{Var}(u_i) = \alpha_0 \text{ assets}_i$.

standard normal density function. The marginal effect for a dummy variable is found by taking the difference in the predicted probability with and without the specific dummy variable equal to one. This is calculated as E[y| d=1] - E[y| d=0] = $\Phi(\hat{\beta}'\bar{x} + \hat{\delta}) - \Phi(\hat{\beta}'\bar{x})$.

Table 4.1 Probit Results

Variable	Category I	Category II	Category III	Category IV
Household Assets	-0.0007 (0.0052)	0.0209 (0.1191)	0.0089 (0.1121)	0.1270 (0.1030)
Female Headed Household	0.2208* (0.1142)	-0.0719 (0.2321)	0.3978** (0.1967)	0.4378* (0.2272)
If Head has completed primary education	0.157524 (0.0996)	0.3877** (0.1881)	0.4445** (0.1640)	0.4111** (0.1790)
Participation in Farmer group	-0.0022 (0.0867)	0.3098 (0.2022)	0.2548 (0.1550)	0.4347** (0.1866)
Area of Farm	0.0366 (0.0353)	0.0509 (0.0735)	0.1101* (0.0588)	0.0162 (0.0623)
Received extension Services	0.3755** (0.1103)	0.4631** (0.2126)	0.5018** (0.1657)	0.2875* (0.1722)
Coastal dummy	-0.27047** (0.1093)	-0.9552** (0.3435)	0.3384* (0.1859)	0.2623 (0.2243)
Interior dummy	-0.2834** (0.1198)	0.6813** (0.2168)	0.5058** (0.2218)	-0.2596 (0.1994)
# off farm income sources	0.0235 (0.0283)	0.1408** (0.0630)	-0.0081 (0.0459)	0.1294* (0.0713)
Grows Cotton	-0.2834** (0.1408)	1.5483** (0.2878)	-0.0127 (0.1752)	-0.3001 (0.1956)
Intercept	0.00266 (0.0982)	-1.9620** (0.2777)	0.0319 (0.1815)	0.4636** (0.1809)
Ln σ^2 (assets)	-0.3487 (0.1560)	0.2386 (0.1164)	-0.2722 (0.1539)	0.05794 (0.0341)
Likelihood Ratio Test Ln σ^2 =0				
χ^2 (1)	11.92	3.47	-1.77	3.73
Probability > χ^2	0.0006	0.0625	0.077	0.0536
Number of observations	568	568	568	568
Wald χ^2 (10)	30.46	55.08	35.42	30.61
Probability > χ^2	0.0007	0	0.0001	0.0007
††Pseudo R^2	0.1181	0.2951	0.5235	0.4334
Log likelihood	-326.5104	-260.9771	-176.3973	-209.7564

**Significant at 5%. * Significant at 10%. Standard Errors in parentheses.

†† The Pseudo R^2 is the McFadden's $R^2=1-(L_{full}-L_0)$. Where L_{full} is the model with the explanatory variables and L_0 is the model with just the constant term

Table 4.2 Marginal Effects When ‘Extension’ Is Held Equal to 1

Variable	Category I	Category II	Category III	Category IV
Household Assets	0.0820** (0.0410)	0.0413** (0.0209)	0.0191** (0.0065)	0.0042 (0.0081)
FemaleHeaded Household	0.1076* (0.0591)	-0.0164 (0.0524)	0.0138 (0.0088)	0.0466** (0.0205)
If Head has completed primary education	0.08267** (0.0409)	0.09012** (0.0418)	0.01869* (0.0107)	0.04754** (0.0195)
Participation in Farmer group	-0.0012 (0.0479)	0.0699 (0.0450)	0.0158 (0.0130)	0.0603** (0.0284)
Area of Farm	0.0202 (0.0163	0.0117 (0.0166)	0.0057 (0.0039)	0.0021 (0.0079)
[7]Received Extension Services	0.2400526** (0.04572)	0.09983** (0.0442)	0.0978** (0.0331)	0. 0506 (0.0319)
Coastal dummy	-0.1687** (0.0615)	-0.1964** (0.0607)	0.0120 (0.0080)	0.0297 (0.0230)
Interior dummy	-0.1786** (0.0621)	0.1628** (0.0569)	0.0152 (0.0098)	-0.0366 (0.0308)
Number of off farm income sources	0.0130 (0.0143)	0.0323** (0.0152)	-0.0004 (0.0024)	0.0163* (0.0091)
Grows Cotton	-0.1774** (0.0655)	0.3703** (0.0591)	-0.0007 (0.0093)	-0.0427 (0.0315)

Table 4.3 Marginal Effects When ‘Extension’ Is Held Equal to 0

Variable	Category I	Category II	Category III	Category IV
Household Assets	0.0100 (0.0140)	0.0615** (0.0262)	0.0674** (0.0266)	0.0177 (0.0186)
FemaleHeaded Household	0.1312* (0.0772)	-0.0128 (0.0405)	0.1296** (0.0500)	0.0941** (0.0413)
If Head has completed primary education	0.09487* (0.0498)	0.07479** (0.0366)	0.1550** (0.0467)	0.09454** (0.0379)
Participation in Farmer group	-0.0014 (0.0528)	0.0608 (0.0424)	0.0896** (0.0476)	0.0942** (0.0349)
Area of Farm	0.0223 (0.0186)	0.0093 (0.0132)	0.0433** (0.0228)	0.0040 (0.0155)
[7]Received Extension Services	0.2400526** (0.04572)	0.09983** (0.0442)	0.0978** (0.0331)	0. 0506 (0.0319)
Coastal dummy	-0.1630** (0.0530)	-0.1309** (0.0337)	0.1136** (0.0512)	0.0599 (0.0465)
Interior dummy	-0.1706** (0.0547)	0.1453** (0.0523)	0.1574** (0.0490)	-0.0693 (0.0565)
Number of off farm income sources	0.0143 (0.0160)	0.0256** (0.0116)	-0.0032 (0.0181)	0.0322* (0.0177)
Grows Cotton	-0.1707** (0.0621)	0.3722** (0.0578)	-0.0050 (0.0696)	-0.0807 (0.0565)

**Significant at 5%. *Significant at 10%. Standard Errors in parentheses.

[7] This is a discrete change of the dummy variable from 0 to 1.

<u>Improved Seed Varieties</u>

Education demonstrates the expected sign and indicates that if the head of the household has completed primary school education then the probability of adopting improved seed varieties increases by 8.2% when the household uses extension services and by 9.4% when the household does not use extension services.

Whether a household grows cotton or not is found to be negatively significant, indicating that if a household grows cotton the probability of adopting improved seed varieties of corn, beans, manioc, sesame or sunflower decreases by 17% whether or not the household uses agricultural extension services. This is to be expected; if a household is already cultivating a cotton crop they may be unwilling or unable to grow another crop within the same space. The labor demands of cotton are high and cotton requires a longer cultivation period which may limit the flexibility of the household in sowing improved crops. This is further compounded by availability of seasonal work in cotton growing areas within the cotton industry further lowering the incentives of farmer in implementing improved crop varieties.

Participation in CARE Mozambique farmer groups is not found to be significant. The role of farmer groups may not play a significant role due to the widespread information on the immediate economic benefits of improved seed varieties. The willingness to adopt these techniques by farmers is great regardless of whether they participate in farmer groups. Improved seed varieties are widely available and accessible to households in the market and promoted by government agencies. Extension services are found to positively influence adoption; the role of extension services may suffice in providing the necessary skills in implementing the techniques as very little educational training is necessary in persuading farmers about the benefits of these specific improved agricultural techniques. If a household receives extension services the probability of a household adopting improved seed varieties increases by 24%.

Female headed households as an explanatory variable is found to positively influence the adoption of improved seed varieties. This is an interesting result since previous studies have found female headed households to negatively influence adoption. These households tend to be resource poor and are constrained to using traditional seed varieties because they are unable to disburse a large cash outlay for buying improved seeds. CARE Mozambique's targeting practices to include female households may play a significant role in this result.

The regional dummy variables are found to significant and are compared to the middle region. The results indicate that households on the coast have a decreased probability of 16% in adopting improved seed varieties when compared to the middle region whether or not the household used extension services. The interior region has a decreased probability of 17% in adopting improved seed varieties when compared to the middle region. These results are largely attributed to the specific agro climatic conditions of each region. The coast receives less rainfall and adoption of improved seed varieties may be considered highly risky in this region. The coast does not engage in as much agricultural activities when compared to the middle region.

Household assets are found to be significant, indicating that for every 100,000 meticals[8] worth of household assets the probability of implementing improved crop management techniques increases by 8% when the household receives extension services. The variable is not found to be significant when the household does not receive extension services. The expected result for this model was that assets would be positive because improved seed varieties are costly and a potentially risky endeavor.

The variables of farm size and available off farm income demonstrate the expected sign however they are not found to be significant in this model. These are not expected results: owning more land and availability of off farm income are believed to positively influence adoption due to the increased cash costs of adopting improved seed varieties. The available data set may have not been rich enough to significantly capture the effects of these variables.

Chemical Fertilizers and Pesticides

Category II comprises techniques involving the use of chemical fertilizers and pesticides. Education demonstrates the expected sign and indicates that if the head of the household has completed primary school education then the probability of adopting improved seed varieties increases by 9% when a household also uses extension services and increases by 7.4% when the household does not use extension services.

Participation in CARE Mozambique farmer groups is not found to be significant. The role of farmer groups may not play a significant role due to the widespread

[8] 1 US Dollar = 27,285.00 Meticals

information on the immediate economic benefits of chemical fertilizer and pesticide uses. The willingness to adopt these techniques by farmers is great regardless of whether they participate in farmer groups. Chemical inputs are widely available and accessible to households in the market and promoted by private and government agencies.

Extension services are found to positively influence adoption; the role of extension services may suffice in providing the necessary skills in implementing the techniques as very little educational training is necessary in persuading farmers about the benefits of these specific improved agricultural techniques. If a household receives extension services the probability of a household adopting improved seed varieties increases by 9.9%.

If a household grows cotton the probability of adopting techniques using chemical fertilizers and pesticides increases by 37%. Cotton companies within the Nampula Province provide their own extension services and chemical fertilizers and pesticides to farmers growing cotton. Therefore it is reasonable to expect cotton growing and extension services to be positively associated with the use of these techniques.

Off farm income is found to positively influence adoption of these techniques. The results indicate that with an increase of one or more sources of off farm income the probability of adoption increases by 3.7% when the household also uses agricultural extension services and by 2.5% when the household does not use extension services. This variable indicates a source of income enabling households to purchase chemical fertilizers and pesticides. Assets are an indicator of wealth and are also found to positively influence adoption. The probability of adoption increases by 4.1% when the household also receives extension services and by 6.1% when the household does not receive extension services.

Female headed households tend to be resource poor and unable to pay for chemical inputs. The variable demonstrates the expected sign (negative) however the variable is found to be insignificant in explaining the adoption of chemical fertilizers and pesticides. This may be because the data is not rich enough to capture this effect.

The regional dummy variables are found to significant and are compared to the middle region. The results indicate that households on the coast have a decreased probability of 19% in adopting chemical fertilizers when the household uses extension services and of 13% when the household does not use extension services. This can be attributed to the comparatively larger number of households growing cotton in the middle region when compared to the coast. The coastal region is comparatively poorer than the other two regions and households may be limited in their ability to buy chemical inputs. The interior region has an increased probability of 16% in adopting improved seed varieties when extension services are used and of 14.5% when extension services are not used these are both compared to the middle region. This is largely attributed to the different agro-climatic conditions of the region.

Farm size demonstrates the expected sign but is not found to be significant. Farm size is an indicator of a household’s wealth and ability to undertake risk. Therefore this result is unexpected. The effects of the variable may not have been captured as there is some lack of variability in this specific independent variable.

Crop Management Techniques

Category III comprises techniques which have immediate benefits but do not require a high cash outlay. These techniques are crop management techniques used namely to improve crop yields. Education demonstrates the expected sign and indicates that if the head of the household has completed his primary school education then the probability of adopting improved crop management techniques increases by 1.8% when agricultural extension services are also used and 15.5% when extension services are not employed by the household.

Female headed households are shown to have a positive influence on adoption, indicating that if the household is headed by a female the probability of implementing improved crop management techniques increases by 12.9% when agricultural extension services are not used. However when agricultural extension services are not used by the household the variable is only significant at 11%. This is a surprising result as the expected sign for this variable was negative. CARE Mozambique's efforts to target resource poor female headed households for farmer groups and to adopt techniques that are not constrained by high cash costs may play an important role in this result. The role of farmer groups may also impact the significance level of the variable when agricultural extension services are not used as extension services are a benefit of participating in farmer groups.

Participation in a farmer groups is found to be significant, indicating that if a household participates in a CARE Mozambique farmer group the probability of adoption increases by 8.9%. The positive influence of farmer group participation captures techniques tend to be taught through farmer groups. Extension services provide technical skills in implementing improved crop management techniques to farmers. The use of extension services is shown to positively influence the probability of adoption by 9.7%.

The results indicate that as the size of the farm increases by a hectare the household's probability of implementing improved seed varieties increases by 4.3% when the household does not use extension services[9]. The size of a farm is indicative of the ability of the household to undertake risk in investing in improved techniques. Because of the larger farm area available the household is able to test improved crop management practices on their farm with less risk.

Household assets are found to be significant, indicating that for every 100,000 meticals[10] worth of household assets the probability of implementing improved crop management techniques increases by 6.7% when the household does not use extension services and by 1.9% when the household does use extension services. The expected result for this model was that assets would be positive or insignificant; these particular techniques provide immediate benefits and are accessible to many farmers because they are not costly or risky.

The regional dummy variables are found to be significant and are compared to the middle region. The results indicate that households on the coast have an increased probability of 11.3% in adopting these techniques when compared to the middle region[9]. The middle region has a significantly larger number of cotton growers when compared to the coastal region. The high labor and productive demands of cotton may limit the ability

[9] The variable is not found to be significant when the household uses extension services.
[10] 1 US Dollar = 27,285.00 Meticals

of households in the middle region to implement these techniques. Coastal farmers may adopt because they are poorer and these practices are more accessible to them. The interior region has an increased probability of 15.7% in adopting improved crop management techniques when compared to the middle region[11]. This may be attributed to the lower opportunity cost of labor in the interior coupled with these techniques' visible and immediate benefits.

Off farm income and cotton are not found to be significant in this model. These are unexpected results off farm income is expected to positively influence adoption. The variable for cotton displays the expected sign however it is not found to be significant; it is expected to negatively influence adoption due to its intensive field and labor demands.

Environmentally Sustainable Techniques

Category IV comprises techniques which have long term benefits and are mainly comprised of environmentally sustainable techniques. They do not require a high cash outlay but may require extensive labor input. Education demonstrates the expected sign and indicates that if the head of the household has completed his or her primary school education then the probability of adopting improved seed varieties increases by 4.7% when a household also uses extension services and by 9.4% when the household does not use extension services.

Female headed households positively influence adoption; results indicate that if the household is headed by a female the probability of implementing environmentally

[11] The variable is not found to be significant when the household uses extension services.

sustainable techniques increases by 9.4% when extension services are not used and by 4.6% when extension services are used. This is a surprising result as the expected sign for this variable was negative. Again this may be indicative of CARE Mozambique's efforts to target resource poor female headed households to adopt techniques that are not constrained by high cash costs. This is an important finding for programs working to target poor women (policy implications are discussed in Chapter Five).

Participation in a farmer groups increases a household's probability of adopting improved agricultural techniques by 9.4% when extension services are not used and 6.3% when extension services are used. These require greater educational training in order to persuade farmers to adopt as many of these practices are unfamiliar to farmers and have substantial labor requirements. Farmer group participation works to inform farmers about benefits and develop farmers' technical abilities. Extension services reinforce the technical abilities of farmers in implementing improved crop management techniques. The use of extensive services is shown to positively influence the probability of adoption by 5%.

Off farm income is found to positively influence adoption indicating that an increase of one more source of off farm income the probability of adoption increases by 3.2% when extension services are not used and by 1.6% when extension is used by the household. The sign of this variable was expected to positively effect adoption or not play a significant role at all. It is likely that many farmers would find these techniques accessible due to low costs holding all else equal (not taking into account information or labor availability).

The regional dummy variables are not found to be significantly different and indicate that there are no regional differences when adopting environmentally sustainable practices. Farm size, assets and cotton are not found to be significant in this model. Farm size and assets were expected to be positive or insignificant; these particular techniques are accessible to many farmers because they are not costly. Owners of smaller farms have a vested interest in maintaining the fertility of their small plots and more likely to adopt environmentally sustainable techniques; however, households with larger farm sizes may be able to undertake greater risk and attempt new techniques, rendering the variable insignificant. Cotton is expected to negatively influence adoption of environmentally sustainable techniques due to its intensive field and labor demands.

Cross comparisons

A comparative analysis of the explanatory variables will offer a more complete understanding of the role, as well as the importance of, the explanatory variables. The data supports the relationship between education and adoption techniques overall as in all four models we find education to be significant and positive. This indicates the importance of improved education in increasing households’ willingness to try new techniques.

Female headed households are found to positively influence adoption of improved seed varieties (Category I), crop management techniques (Category III) and environmentally sustainable practices (Category IV). Results with respect to female headed households are interesting and differ from the literature. Female headed households are shown to be more likely to adopt improved agricultural techniques over male headed households. Participation in CARE Mozambique's farmer groups is found to positively influence adoption of crop management techniques (Category III) and environmentally sustainable practices (Category IV). The influence of CARE Mozambique in identifying female headed households and targeting them for participation in farmer groups may be play a significant role in these results. Clearly, the policy implications are noteworthy and will be discussed in the following chapter. This result indicates that farmer group participation has the potential to play an important role in the adoption of new technologies and to provide a venue for disseminating culturally and contextually relevant agricultural extension messages to farmers.

The use of extension services is found to be significant in three of the four models indicating the importance of developing the technical abilities of farmers. Project extension agents work closely with farm groups. One possibility is that the VIDA II Project impacts adoption of Categories I-III through the formation of groups and affects the adoption of Category IV through extension services.

Economic theory predicts that assets play a role in the adoption of new technologies. Overall, household assets are found to be related to a households' adoption of agricultural techniques. Assets provide a source for a cash outlay and allow households to mitigate risk.

Overall, Farm area is not strongly related to a households' adoption of agricultural techniques. This variable may be a poor gauge of a household's ability to undertake risk in attempting new technologies. The availability of off farm income was expected to play a greater role in influencing adoption by providing a source for investing in techniques involving a cash outlay as well as allowing farmers to diversify risk. Cotton growing is found to be significant in two of the four models. The variable displays the expected sign in both models. Its lack of significance in the last two models may be attributed to the stringent demands of growing cotton both in terms of labor and in the productive cycle which may limit the flexibility of farmers to experiment with new techniques. The regional variables capture the physical and economic differences between the three regions. An explanation of how regional characteristics may impact the rate of adoption was given in each of the four models in Chapter Four.

Chapter V Conclusions.

The objective of this research was to empirically examine the factors impacting the adoption of improved agricultural practices among farmers in Mozambique, with particular attention on the role of farmer groups. The results indicate that disseminating improved agricultural techniques through farmer groups can play an important role in securing rural livelihoods and increasing food security in the region through increased income opportunities and increased crop production. Obstacles in disseminating culturally and contextually relevant agricultural extension messages to farmers have historically been problematic in less developed countries. New methods to circumvent these obstacles including farmer groups are innovative and warrant greater examination.

Access to extension services significantly increases the probability of adopting improved agricultural techniques. It can be concluded that extension services are important in providing necessary information to farmers. This suggests that efforts to disseminate agricultural information should continue to employ agricultural extension services. In the case of Mozambique CARE has worked closely with government extension agents to coordinate with farmer groups in order to disseminate agriculture technology. Extension services should be used in conjunction with other forms of disseminating information including farmer groups.

Participation in CARE Mozambique's farmer groups was shown to increase households' probability of adopting improved agricultural techniques in two of the four models. Results for Category IV are interesting as group participation plays a significant role in adopting technologies with longer-term payoffs. This suggests that standard extension services are adequate to provide farmers with necessary information to adopt technologies that have immediate returns, since farmers can easily perceive the benefits of adopting these technologies. Working with groups seems to be useful to promote new technologies where the benefits are of a longer term nature. The more intensive and longer-term support that is provided to groups can help to provide information to farmers about the longer-term benefit that they can achieve by adopting environmentally sustainable practices. In other words, farmers need not only technical information about how to adopt these types of technology, but also more extensive education about the benefits of adopting these technologies. It should also be noted that the formation of farmers' associations have other objectives than simply adopting new production technologies. These associations are provided with support to develop marketing and storage strategies that can provide benefits to association members. This research does not address these other kinds of benefits of membership in associations.

These results compel researchers to ask how to best render a representative variable of participation in farmer groups or coops that work to disseminate scientific knowledge to farmers. The literature has traditionally focused on (i) whether farmers are participants or not in a group, (ii) the number of times visited to group meetings, and (iii) the number of groups to which a household belongs. Further research examining the content of group meetings as well as group dynamics may help to clarify the ambiguous impact of farmer participation on adoption of new technologies.

Results with respect to female headed households are interesting and unexpected. Female headed households are shown to be more likely to adopt improved agricultural techniques with relatively low cash costs over male headed households. This may be due to strategies by CARE Mozambique in identifying female headed households and targeting them for participation in farmer groups. This may also be an indication of tighter financial constraints as compared to male headed households. These results are encouraging and support the use of targeted programming. Policy implications include supporting the use of programs which target and identify vulnerable households, as well as support for improved methods in disseminating agricultural extension methods through farmer groups.

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