AN EMPIRICAL ANALYSIS OF HOUSEHOLD COPING STRATEGIES IN CEARÁ, BRAZIL

by

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STATEMENT BY THE AUTHOR

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DEDICATION

To my parents,

Rosa Lidia Barbosa Ferreira Gomes and João Batista Ferreira Gomes Neto,

and my fiancé, Rogério Cysne Araújo.

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ABSTRACT

The primary purpose of this thesis is to provide a better understanding of how families in Ceará, Brazil react immediately to avert famine and cope with lack of water during drought years. This thesis addresses three major hypotheses: do households adopt coping strategies in a sequential fashion, from reversible mechanisms (Stage 1) to the sales of assets (Stage 2); understand how household characteristics and government policies can influence families' resistance to drought; and evaluate how these same factors may influence the type and number of coping strategies taken by a household. Empirical results show that there is no sequence between Stage 1 coping strategies and the decisions to implement more reactionary strategies, in Stage 2. Families with fewer assets were more likely to implement coping strategies from Stage 1 and families with more valuable animals were more likely to use coping strategies from Stage 2. In addition, families with fewer assets adopt a larger number of coping mechanisms.

CHAPTER 1

INTRODUCTION

The main goal of farmers throughout the world is to provide for the needs of their families from their available farmland. This goal is especially elusive for rainfed farms because of unpredictability of weather. This is an even more precarious situation to farmers that live in drought prone areas. Many rural farmers in Northeast Brazil live in this uncertain and risky environment. In the last quarter century this region has faced droughts approximately every two to three years.

In developing countries, farmers must find strategies to deal with drought conditions. Many social scientists have studied and documented how farmers throughout the world cope with drought. However, no published survey has been found that utilizes econometric methodologies to understand the factors that influence coping strategy implementation.

The main goal of this thesis is to understand how rural farmers in Ceará, a state in Northeast Brazil, cope with the direct and indirect consequences of drought using econometrics methodologies. The analysis uses data from a study conducted in 2000, by the University of Arizona (UofA) and Federal University of Ceará (UFC) in two *municípios*[1] in Ceará: *Boa Viagem* and *Limoeiro do Norte*. The main objective of the UofA and UFC study was to analyze and identify the overall impact of government relief programs during drought period and how rural farmers responded and accessed to rainfall forecasts. In addition, data on use of coping strategies during were also collected which provided an opportunity to examine the coping mechanisms sequence using econometrics.

1.1 Definition and Impacts of Droughts

In many regions of the world people live in precarious conditions due to recurrent episodes of severe drought. A period where serious crop damage, depletion of water supply, and population death are due to a decrease of rainfall by more than 30 percent below the mean, for prolonged period. Many studies consider drought as a rare and random event, while others consider that drought is a normal natural hazard characterized by its variation from one region to another (Paul 1998).

Brazil has two types of natural hazards: floods in the South and droughts in the Northeast. Specifically affected by drought is the Ceará State, whose climate is characterized by high temperatures that on average exceeds 27 Celsius and has little rainfall (BrasilChannel 2003). Extensive droughts have been documented there for every century since the 1500s (Magalhães and Glantz 1992). There are only two very distinguished seasons in Ceará: a rainy season and a dry season. Typically, a normal rainfall year begins between December and January and ends in May. In a drought year, the amount of rain is insignificant and irregular and it does not come during the normal growing season (Paul 1998).

A drought's impact on the economy, environment and social aspects of life may range from mild to severe. Droughts can cause a series of effects; those that are direct

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[1] The term *município* refers to an area that closely resembles a county in the United States.

consequences of the desiccation and those that indirectly caused from the direct impacts. Direct consequences are typically biophysical; reduced crop rangeland, forest productivity, reduced water levels, increased livestock and wildlife mortality rates are such examples (NDMC 2003). As a result indirect impacts like: reduction in income for farmers, increased in food and timber prices, unemployment, increases in crime, bank loans and migration may occur (NDMC 2003). The extensive droughts throughout the centuries in Ceará have been characterized as both mild and severe and have in every case affected the region's economic development.

1.2 Background Information on Drought Coping Strategies

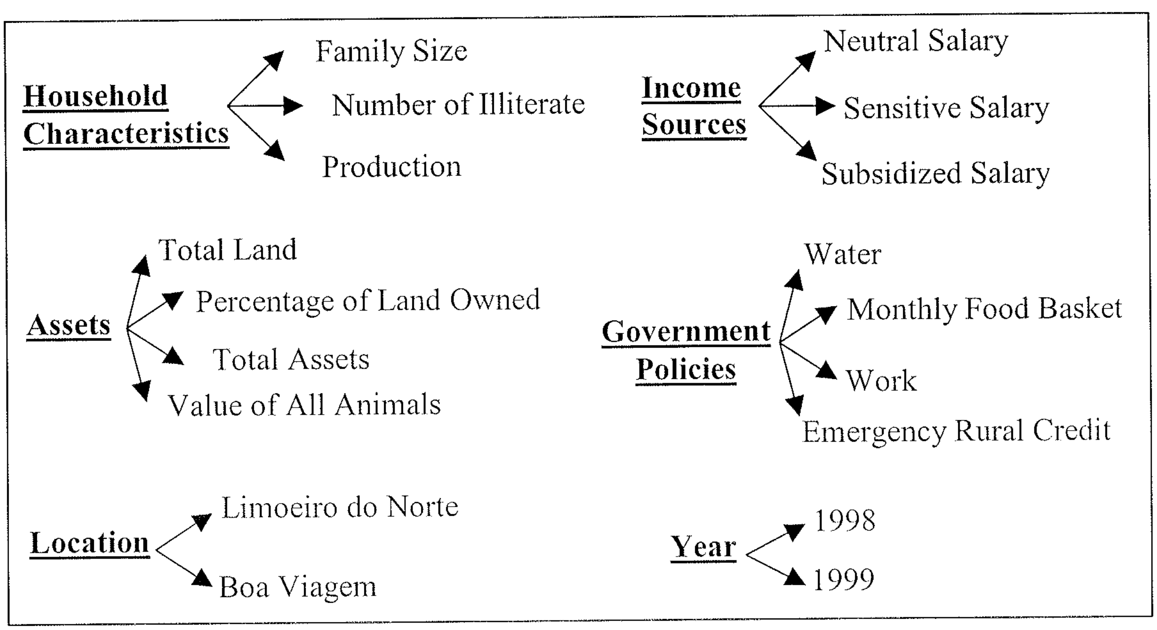
Several studies have shown that in order to deal with the harsh nature of drought families react immediately to confront famine and lack of water. Many researchers have named these reactions as "coping strategies" and/or "coping mechanisms". The most common coping strategies written about in the literature are: eating less or changing type of food eaten, consuming stored grained, receiving help from family, selling their valuable goods, such as jewelry and farmland, selling assets, and permanent migration.

Many authors identify sequences of strategies that household take in order to best protect their short-term and especially their long-term viability. Some authors classify these sequences by ranking: the most common coping mechanism with less commitment of domestic resources and the greatest degree of reversibility is ranked first, followed by those requiring greater sacrifice. (Watts 1983; Caldwell, Reddy, and Caldwell 1986; Campbell 1999; Paul 1998). Other authors decided to categorize these ranked coping mechanisms into stages (Corbett 1998; Longhurst 1986; Dunn, Kalaitzandonakes, and Valdivia 1996; Waal and Amin 1986; Cutler 1986; Adams, Cekan, and Sauerborn 1998). The coping strategies stages are defined as a sequence, which reflects decreasing the level of reversibility and increasing commitment of domestic resources (Adams, Cekan and Sauerborn 1998).

1.3 Objective of the Study

The data gathered by the UofA and UFC provides numerous variables that in previous qualitative research have been identified as important in terms of their impact on coping mechanism implementation. For this analysis, the following objectives will be examined utilizing the variable as described in Figure 1.1. The hypothesized impacts of these variables on each objective will be discussed separately in Chapters 4, 5 and 6.

Figure 1.1 Exogenous Variables



The literature assumes that the initial reaction to drought typically involves the coping mechanisms in Stage 1. As a drought becomes worse and extends over time, more coping measures are implemented to counter the drought effects on the household. Therefore, the first objective of this thesis is to verify if families in Ceará first implement Stage 1 coping strategies then implement Stage 2 coping strategies using a Bivariate Probit Model. In order to test if there is any sequence among Stage 1 and Stage 2 coping strategies, the relationship between Stage 1 and Stage 2 will be verified. Also this paper will verify if the choice of implementing Stage 2 coping strategies depends on the implementation of Stage 1 coping strategies.

The second objective of this study is to understand how different variables in Figure 1.1 influence how farmers and their families deal with drought in Ceará, Brazil. To accomplish this objective first, two univariate Probit Models will be used to evaluate how the above factors influence the implementation of Stage 1 and Stage 2 coping mechanisms. Secondly, individual coping strategies will be evaluated also using univariate Probit Models and the variables in Figure 1.1, to understand how these affect a family's choice to implement each distinct coping mechanism.

The third objective of this study is to evaluate how the variables in Figure 1.1 may influence the number of coping strategies taken by each household utilizing a Poisson Model. In other words, this objective addresses the following question: what factors influence some households to implement more coping strategies during the drought than others?

1.4 Organization of this Thesis

The thesis is organized in the following manner. Chapter 2 will discuss the background literature on the effect of drought on household's resource availability and the rank and stage categorization theories of coping strategies. Chapter 3 will address the source of the data utilized in this thesis and will discuss the region in which this study took place. Chapter 4 discusses the bivariate methodology and results from the analysis of the sequential relationship between coping strategies stages. Chapter 5 will provide the methodology and results of the univariate Probit models for Stage 1 and Stage 2 separately and for each individual coping strategy. Chapter 6 discusses the methodology and results of the Poisson model that studies the number of coping mechanisms that a household implements. Finally, Chapter 7 will discuss and conclude this thesis.

CHAPTER 2

LITERATURE REVIEW

This literature review will review recent theories of coping strategies. Furthermore, the literature review will address the efficacy of household livelihood improvement from government based drought relief programs and previous work done using the data from *municípios* in Ceará, Brazil.

2.1 Coping Strategies/Mechanisms to Resist Famine in Drought Periods

When environmental factors limit food production, rural households face problems in obtaining constant and adequate access to food. According to Sen (1981), famine is a severe shortage of food over an extended period, which can increase the death rate in areas affected by the shortage, where hunger may be sustained over long periods. Many famines across the world occur in drought prone areas. Nigeria suffered from famine as a result of severe low rainfall from 1972 to 1974 and acute shortage of food was spread throughout in the country (Mortimore and Adams 2001). Bangladesh experienced a severe drought in 1994 and 1995, which lead to a decrease in rice and wheat production and many people starved (Paul 1998). Northeast Brazil, the region of focus of this thesis, was subjected to an extended drought from 1998 to 1999, which resulted in a critical famine situation for 70% of the population in Northeast, or 1209 out of 1787 *municípios* in the region (Gomes 2001). Due to the harsh nature of drought, families must react immediately to confront impending food shortages. According to Paul

(1998), some droughts cause greater damage to crops and affect more people over a wider area than a flood or cyclone.

Many terms are used to describe what households and individuals do when faced with threat of famine. Some authors call these reactions: coping mechanisms (Paul 1998; Dunn, Kalaitzandonakes, and Valdivia 1996) and others coping strategies (Corbett 1988; Longhurst 1986; Adams, Cekan, and Sauerborn 1998; Campbell 1990; Campbell 1999; Lambert 1994; Caldwell, Reddy, and Caldwell 1986). Both terms will be used in this thesis and imply households' reactions used to avert famine during drought. They may also be referred as "responses" to drought. The most common coping strategies are: eating less or changing type of food eaten, consuming stored grained, receiving help from family, selling their valuable goods, such as jewelry and farmland, selling assets, and permanent migration.

Lambert (1994) indicates that coping strategies are undertaken only in critical years (drought years) and should be differentiated by those pursued every year as part of 'normal behavior' "livelihood strategies". Coping mechanisms employed in times of severe stress should be given particular attention because they can jeopardize the affected families' well being in the short-run or even worse, in long run. According to Adams, Cekan, and Sauerborn (1998), the aim of coping is to maintain the short-term objectives of the household, including consumption and health and also long-term objectives, such as livelihood security and status.

A number of studies show that coping mechanisms are based on a household's resource base. Coping mechanisms are mostly related to how rural households obtain access to food and income (Corbett 1988; Lambert 1994; Campbell 1990; Caldwell, Reddy, and Caldwell 1986). There are enormous differences between the options that poor and rich households have. For example, rich households are more likely to get credit, to produce more crops, to have more assets including, land and animals, as well as better income (Corbett 1998; Campbell 1990). This means that if rich households decide to sell some assets, animals, or even crops, it will not have a lesser affect on their well being. However, when poor households decide to sell their animals and assets, it can endanger their short-run and long run livelihood as they may be left with no valuable good in their household. According to Adams, Cekan, and Saueborn (1998), coping is only successful if the household has sufficient resource to overcome distress without compromising their long-term objectives. Yet, these authors say that, failing to cope with drought occurs when efforts to avoid crisis sacrificed the short and long-term objectives to survival.

2.1.1 Typical Ranking Patterns

Many authors identify sequences of coping strategies that household undertake in order to meet their short-term needs and while also protecting their long-term viability. The coping mechanism's viability with the least commitment of domestic resources and the greatest degree of reversibility are hypothesized to be utilized first, followed by those requiring greater sacrifice. (Watts 1983; Caldwell, Reddy, and Caldwell 1986; Campbell 1999; Paul 1998). Four studies utilizing this ranking methodology are presented below.

A study by Campbell (1999), in Southern Kajiado District in Kenya, is unique from the other studies in that it divided the investigation in two different periods: from 1972 to 1976 and from 1994 to 1995. It focused on the difference between herders, most dependent on livestock, and farmers, primarily dependent on crop harvest. According to this study, farmers in Kenya, appear to choose consuming stored grained as one of their first responses in both 1972 through 1976 and 1994 to 1995. Kenyan herders in 1972 chose to first to sell livestock but in 1994-1995 choose famine relief or buying food as their first response. Although, the first coping strategies are different among farmers and herders the final strategies used are similar in both time periods. Selling labor, hunting animals, and selling livestock are examples of final strategies in this study. According to this author, the drought from 1972 to 1976 was stronger and longer, also over the 20 years changes on the socioeconomic systems in the area led to an alter of the basis of their coping strategies in the two studied periods.

In Bangladesh, Paul (1998) found that, like farmers in Kenya, the consumption of stored grain was one of the first coping mechanisms utilized in the droughts of 1994 and 1995. While this mechanism is prominent, the author recognized that the vast majority of the households also sold some kind of belonging, typically livestock (55%) and/or land (37%). Selling livestock and/or land was the focus of the study and more costly responses like out migration were uncommon. Paul (1998) stated that, for many rural families, it was difficult to consider out-migration as a possible strategy.

Studies in South India (Caldwell, Reddy, and Caldwell 1986), and Northern Nigeria (Watts 1983) showed similar responses, eating less or changing type of food eaten, and help from relatives as first choices for coping with shocks. Also, selling of valuables, such as jewelry and farmland, was equally important in these two studies, and were ranked as the final coping strategy (Caldwell, Reddy, and Caldwell 1986; Watts 1983).

The sale of jewelry, land or assets appeared universally in these studies but they differed in their ranking position. For example, according to Watts (1983), the sale of livestock is ranked fifth and sale of farmland ranked ninth among the ten coping strategies. In South India, the sale of livestock ranked fourth, the sale of valuable goods, such as jewelry and land, ranked five and six, respectively, among the six coping mechanism (Caldwell, Reddy, and Caldwell 1986).

It is pertinent to this thesis to note that, Watts (1983) was the only author to distinguish between temporary migration and permanent migration. For him temporary migration was ranked 4th out of 10 and permanent migration was the last option for the family.

The ranking of coping strategy patterns or sequences is not the only theory of response categorization. Other authors categorize these ranked strategies into the three stages (Corbett 1998; Longhurst 1986; Dunn, Kalaitzandonakes, and Valdivia 1996; Waal and Amin 1986; Cutler 1986; Adams, Cekan, and Sauerborn 1998).

2.1.2 Common Stages in Coping Strategies

A key argument in coping mechanism literature is the sequence in which households take certain strategies according to levels of distress. Adams, Cekan and

Sauerborn (1998) stated that, coping mechanisms are implemented when there is decreasing reversibility and increasing commitment of domestic resources. For example, selling land or valuable assets can be irreversible but changing or decreasing household's diet can be reversible after the drought period. Many authors have categorized coping strategies according to how often the strategies are practiced and by their level of irreversibility, and have typically characterized coping mechanisms into three main stages.

The first stage is variously defined as reversible mechanisms (Dunn, Kalaitzandonakes, Valdivia 1996), or insurance mechanisms (Corbett 1988), or adaptive strategies (Cutler 1986), or even as an alternative source of income, which does not reduce the subsistence base of the household (Waal and Amin 1986). According to Dunn, Kalaitzandonakes, and Valdivia (1996), these coping strategies are characterized by their reversibility and their relatively low impact on the future income-earning capacity of the household. Three out of four studies characterized reducing or changing diet or borrowing money with low interest rates from relatives or family into stage one (Dunn, Kalaitzandonakes, and Valdivia 1996; Corbett 1988; Waal and Amin 1986). Waal and Amin considered taking herds to pasture or drink far from their land as stage one response. One of the factors which causes household to move between stage one to two is when famine sets in and all of the renewable resources are depleted (Corbett 1988).

The second stage is defined as: less reversible strategies which affect the future economic welfare of the household into risk (Dunn, Kalaitzandonakes, Valdivia 1996), or disposal of productive assets (Corbett 1988), sale of key productive assets (Cuttler 1986), or use of an alternative font of income or food which reduce the subsistence base of the household (Waal and Amin 1986). This stage includes strategies of selling profitable resources preceding failure of family's economic status after the crisis period. All four studies found the sale of land, livestock, jewelry, agricultural tools and equipment common in this stage (Dunn, Kalaitzandonakes, Valdivia 1996; Corbett 1988; Waal de and Amin 1986; Cutler 1986). Also working as a day laborer or migrating to seek work in other towns are also considered part of this stage because farmers are leaving their farmland which leads to a decrease in a household's own field production (Waal Amin 1986).

The third stage is identical as: destitution (Dunn, Kalaitzandonakes, Valdivia 1996; Corbett 1988), mass migration (Cutler 1986), or when the subsistence base is severely exhausted or no longer exists (Waal and Amin 1986). In other words, households move to stage three only after the complete depletion of household resources. This is the terminal stage because households have no assets and there is a failure to generate current and future income (Corbett 1988). All four studies studied mentioned that this stage is characterized by the migration of the whole household. Complete reliance on charity given from relatives is mentioned by two studies as part of the terminal stage (Dunn, Kalaitzandonakes, Valdivia 1996; Wails de and Amin 1986).

2.2 Significance of Government's Drought Relief Programs

In recent times, most poor households have relied on the government for help when drought affects their livelihoods. Provision of effective government relief programs are pivotal in the way farmers respond to the threat of famine and the success of their coping strategies. Therefore, it is imperative to analyze the effectiveness of household coping strategies and drought relief programs together (Caldwell, Reddy, and Caldwell 1986).

According to Torry (1986), government relief programs can be important in protecting human life, minimizing loss of property and developing economic infrastructure. These programs should complement farmers' coping mechanism by focusing on the way rural households are try to adjust to drought (Jodha 1975). This can protect both the ownership of households' assets and maintenance of good harvest. An evaluation of emergency relief programs in Kenya and Brazil from 1997 to 1999 stated that government should become concerned when inhabitants are unable to adapt to climate change either because it happens too fast, or because they are poor (Lone 2000). Governments should initiate relief programs when households affected by drought start to decrease their intake of food. According to Sen (1993), Bangladeshi government responses to famine during the drought of 1974 was delayed because of the false sense of high figures of food supply. This government only began work fronts when food prices peaked and death rates were very high. Good program timing can prevent households from selling all of their assets and also help avert the last stage of coping mechanisms (Torry 1986; Jodha 1975; Caldwell, Reddy, and Caldwell 1986; Sen 1993).

There are many types of drought relief programs to prevent famine around the world, such as water distribution schemes, food aid, work fronts, credit relief, and others. However, the majority of the studies on the subject emphasize work fronts and low interest credit relief programs. Most authors believe that these two relief programs are important because they are the main source of aid for households' livelihood during drought periods (Torry 1986; and Caldwell, Reddy, and Caldwell 1986).

2.2.1 Work Fronts

Work front programs have existed throughout the world for decades. In the 1960s the structure and focus of many of these programs changed. Prior to that time, work fronts were primarily concerned with protecting lives and property. Work fronts functioned by giving food or money to farmers that produced food on their land. Money was also given to them to buy food and general needs. These relief wages also contributed greatly to household livelihood. Torry (1986) illustrates that through these work fronts, households have a better chance to reduce starvation levels. Furthermore, Torry (1986) states that the absence of the third stage coping strategies, like mass migration and starvation, illustrate the sustaining power provided by the work fronts.

After the 1960s, the focus of work front changed to work on regional infrastructure programs, such as constructing dam and canal, land recovery due to deforestation and soil erosion, and other development projects. These work fronts give the benefits mentioned above, as well as giving farmers the opportunity to work in a large organized project (Torry 1983). Building roads and wells, in a severe drought from 1972 to 1973, in the Indian State of Maharashtra saved the affected workers from having nothing to eat (Sen 1993). Comparing the reactions of Maharashtra State with some Sahel countries; Sen (1993) found that there were few people who starved in Maharashtra. This is because in Sahel countries the food shortage was not distributed equally and work fronts were not implemented in those countries so that competition could be applied between families.

Despite their effectiveness in providing short-run relief, there are still many problems with work front programs. First, the income provided is often not enough to ensure long-term livelihood security for farmers. Second, many needy families are excluded from these fronts because the spaces for the relief work are constrained due to limited funds. Third, many workers do not receive the potential maximum salary because they lack the strength to work full capacity due to low calories intakes. In addition, dishonest politicians underreport workers' wages and keep the difference, or they create "ghost" workers and pocket the extra funds (Torry 1986).

According to Caldwell, Reddy, and Caldwell (1986), work fronts have a high opportunity cost because farmers cannot cultivate their own land. Farmers are taken from their fields to work on dams or roads that are not seen to have any relevant purpose in the problems of their daily lives and most of the time these projects are done poorly and become dilapidated (Caldwell, Reddy, and Caldwell 1986; Basu 1996). The main idea of these projects is to generate employment for a better access of food to poor families, even though the projects are not durable (Basu 1996). Another problem stated by Shipton (1990) is that the displacement, voluntary or involuntary, frequently involves redefinition of group identities and association, and relief camps often attract disproportionate numbers of old and young workers. Also, Sen (1993) mentions that African governments often send people to camps away from home, disrupting their own cultivation and animal husbandry, which, in turn, interrupt future production and upset family life. Another problem analyzed by this author is that infectious diseases are very common in the camps. Basu (1996) writes that the worst problem is when families are considered to be above the poverty line and are left out of the program. This can cause deterioration in the families' well being because food prices will rise due to an increase for demand of food. Hence, these families are be pushed below the poverty line and are unable to sign up for the work fronts (Basu 1996).

2.2.2 Credit Relief Programs

Credit relief for drought-affected households can come from various lending services. Some lending services are flexible on the due date of loan payments, others have low interest rates, and others give loans only after the drought period to help farmers with their production. Government credit relief typically carries low interest rates and repayment periods of up to ten years (Torry 1986).

The objective of credit relief is to ensure that households maintain their minimum living conditions. Caldwell, Reddy, and Caldwell (1986) state that almost half of the families in India took loans during the drought of 1980 to 1983, and most felt that the loan helped maintain their minimum living conditions. Most of the credit requested is for personal consumption. According to Torry (1986), 80% of the loans are taken for personal consumption.

However, one major problem with credit relief is that it is generally given to farmers who initially have better living conditions and want to use relief money to buy agricultural tools or repair their homes and/or fields (Torry 1986; Caldwell, Reddy, and Caldwell 1986). Specifically, in India, Torry (1986) found three major problems surrounding credit relief programs. According to this author, these problems are that loans take several weeks to be given to the farmers. Moreover, there are many demand for credit relief but not enough supply and there is an emphasis on agricultural production and land ownership as a security for repayment, which discriminates in favor of impoverished households in need of consumption credit.

2.3 Previous Work Done Using the Data from *Municípios* in Ceará, Brazil

The survey undertaken from 1997 to 1999, in the six *municípios* of Ceará State, Brazil allowed researchers to study households' socioeconomic and policy impacts on farmers and Brazilian government. This project had four objectives: 1) to identify the process in which climatic information is incorporated into government programs that are designed to prevent drought impacts; 2) to assess how Ceará State and local levels of power in the use of climate forecast data; 3) to describe the use of Ceará Foundation for Meteorology and Water Resources' (FUNCEME) climate forecast information distributed to rural stakeholders who faced different levels of vulnerability to drought; 4) to specify rural families coping strategies in drought years (Lemos et al. 2001). Since then, this research made it possible for consultants, staff members, and professors to analyze many other aspects related to the topics mentioned above. The major findings of these researches are summarized in this section.

According to Finan and Nelson (2001), drought in Northeast Brazil is observed as a climatic phenomenon rather than a socioeconomic problem. These authors suggest that government should plan for short-term and long-term policies by accepting drought as a normal phenomenon in the semi-arid regions of Ceará. In this case, short-term policies are to minimize the impacts during the next drought seasons and long-term policies are to reduce vulnerability of all droughts by strengthening the socioeconomic well being of the family. The local *municípios*' governments should organize these policies because they are more aware of the needs of the population in those regions.

Lemos et al. (2002) explain how the improvement of the Ceará Foundation for Meteorology and Water Resources' (FUNCEME) climate forecasts are fundamental in a socioeconomic and political context. According to this study, FUNCEME, a forecast provider in Ceará State, can alleviate the negative impacts of drought on rural families (a better detailed discussion on FUNCEME's function is presented in Chapter 3).

Some lessons are drawn from this study. When highly vulnerable families to began to notice that FUNCEME's climate forecasts were often incorrect, this created a disharmony between science and local knowledge and belief systems and many farmers said that FUNCEME was the cause of drought rather than a science messenger (Lemos et al. 2002).

The second lesson of this paper is that government used these climate forecasts as a tool to manage agriculture in their relief programs. For example, the *Hora de Plantar* program (Time to Plant Program) is a seed distribution program provided by the Brazilian government since 1989. This program has the objective to provide farmers with high quality seeds (corn, beans, rice, and cotton), however the seeds are distributed only when planting conditions were appropriate. The goal of this program is to use scientific information to familiarize farmers with regard to the true onset of the rainy season so that farmers do not loose their yield when it is a drought year. This program took from farmers the task of deciding to plant crops, and put it in the hands of politicians instead. Most vulnerable farmers cannot access alternative crops, technologies, or diversify their income. Their only alternative for income diversification is to join government work fronts or migrate to other cities. For this reason, they cannot respond to climate predictions even if FUNCEME's climate forecast is precise (Lemos et al. 2002).

The project study draws two technical conclusions. First, forecasts have to be better adapted to semi-arid regions in order to reduce negative drought effects to rural farmers. In Ceará, forecasts are generally announced for micro-regions within the state. However, in a semi-arid environment, rainfall can be located only in certain parts of the region leaving the driest areas without any rain. Farmers are interested only in their individual field and not the entire micro-region, and they are aware that their fields can remain dry even when the whole region received 'nomal' (between 400mm to 600mm) precipitation levels. Second, advance forecast timing is critical for water management in Ceará State. The Water Resources Management Company (COGERH) which is the operational agency for water management, uses forecast to determine how much water should be release from large reservoirs in Fortaleza, Ceará's capital city, to far and vulnerable *municípios*. The decision of how much water should be released has to be made by August but climate forecasts are only released in December. By this time period, critical decisions have been already made. (Lemos et al. 2002).

The paper written by Santana et al. (1999) examined the participation level of rural farmers and analyzed why many of them did not choose to continue participating in the *Hora de Plantar* Program. The study found that there was decrease of nearly 45 percent of the rural families registered for the *Hora de Plantar* Program between the years 1987 and 1999; these authors verify that this statistic consists of few new people registering, and also farmers leaving the program.

These authors analyzed in depth why fewer farmers registered for the *Hora de Plantar* Program. Fifty percent of the farmers interviewed stated that there were too many delays in receiving seeds, and the access to them was very hard. Other reasons were given for the decrease of registration to the program, such as some farmers preferred to used their own seed, or the program did not appeal to them. Others mentioned that they did not have enough information about the project (Santana et al. 1999).

The study also found that only 14.4 percent trusted these climate forecasts, even though the distribution of seed from *Hora de Plantar* depends on FUNCEME's climate forecast. This is the main reason why these farmers were not registered for seeds from the Time to Plant Program (Santana et al. 1999).

Mayorga and Mayorga (1999a) found that families who were most vulnerable to drought have had knowledge on FUNCEME's forecast but little faith in them (Santana et al. 1999, Lemos et al. 2001). This paper also proves that there is no relationship between the Time to Plant Program and the Rural Credit Program. This means that the most vulnerable farmers have access to the Time to Plant Program but not to the Rural Credit Program.

The analysis done by Mayorga and Mayorga (1999b), in Limoeiro do Norte in the State of Ceará, determined that there is a positive relationship between the level of technology and the Rural Credit Program, between cultivated irrigated land and technology levels, and between the educational level and technology level. This means that farmers with a low technology level did not have access to rural credit. Also, out of the 75 farmers with irrigated cultivated land 52 had rented tractors to work on their land. Moreover, 55 percent of the farmers who know how to read and write used tractors to work on their lands; also manual technology was practiced by only illiterate farmers. No relationship was found between cultivated irrigated land and the Rural Credit Program.

2.4 Summary

Rural families suffering from famine in drought seasons use wide range of coping strategies/mechanisms as means of survival. When faced with stress to their livelihoods, some studies categorize the coping mechanims that are most commonly implemented by a household in response to drought. These coping strategies are then ranked according to level of commitment of domestic resources and degree of reversibility after the drought. Some authors have categorized coping strategies by how often the strategies are also practiced and by their level of irreversibility. Coping mechanisms are typically divided into three main stages. The first stage, families alter their lifestyles in short-term ways that will not affect their future livelihood. The second stage, families must sell assets (i.e.

agricultural tools) and/or livestock in order to simply subsist. Finally, when all else has failed, families have to go to another city, hoping to find better lives.

The study in Southern Kajiado District in Kenya was unique from other studies because it divided the population of the study into two: herders, most dependent on livestock; and farmers, primarily dependent on agriculture. The herders were more likely to sell their animals and buy food as their first response while farmers only implemented these coping strategies as their last choice. This particular study indicated that if farmers have more assets, such as livestock, they are more likely to sell them in order to not change their diet (Campbell 1999). Other studies also stated that families with more assets and income are more likely to sell their animals to not suffer from hunger (Corbett 1998; Campbell 1990).

Government relief programs are also studied in this chapter because they can affect the way farmers respond to the threat of famine and their choice of coping strategies. Work fronts and credit relief programs are the most mentioned drought relief programs in the studies done in this subject. According to the literature, work fronts after the 1960s had many advantages, but the main disadvantage was the high opportunity cost for farmers to attend work at distribution centers rather than cultivating their own land. The main idea of the work front's projects was to generate employment for a better access of food to poor families even though these projects were not durable. The credit relief programs were identified by the studies to be mostly given to rural families that were not so vulnerable to drought effect. The reason for this was because the lending institution wanted to have a guarantee that they would get their money back someday.

Past studies in Ceará, Brazil, have emphasized the importance of improvement in FUNCEME's climate forecast timing and precision for rural families' livelihoods and also for better development programs. Accurate and advance timing of information may also improve farmer's water access and credits relief during drought seasons. Rural credit is usually extended to farmers facing drought conditions with the capability to pay back any kind of loan whereas seeds are distributed among the poor farmers in case of "normal' rainfall year. Both these operations by government require correct forecast of rainfall (weather). Some authors believe that government should take drought as a normal phenomenon and devise the relief programs accordingly. The assumption of drought as a normal phenomenon would remove government's excessive reliance on the climate forecast. With no reliance on climate forecast, the Brazilian government would implement short and long term development programs to minimize drought effects to rural farmers and improve their livelihood in all the years.

CHAPTER 3

DATA SOURCE AND STUDY REGION

3.1 Overview of Brazil and Northeast Brazil

3.1.1 Brazil

Brazil, the only country colonized by Portugal in the Americas, has an area of more than 8.5 millions square kilometers, where 7491 kilometers is coastline. Brazil is the 5th largest country in the world and it is the biggest in South America. The country is surround by Venezuela, Guyana, Suriname, and French Guyana to the North; Colombia to the Northwest; Argentina, Paraguay, Bolivia and Peru to the West; and Uruguay to the South. Its total land boundary is 14,691 km and only two South American countries, Ecuador and Chile, do not share border with Brazil (BrasilChannel 2003).

According to the Brazilian Ministry of Agriculture, Livestock and Food, Brazil is a main exporter of coffee, oranges, soybeans, beans, corn, and sugar from sugarcane. According to the Brazilian Ministry of Foreign Relations (MRE 2001), this country has the largest economy in Latin American and ranks eighth in the world, with a gross domestic product of 700 billion US dollars per year.

The Brazilian population lives in twenty-six states that form five national regions: North, Northeast, Center-West, South, and Southeast. According to the Brazilian Institute of Geography and Statistics (IBGE 1996), approximately 81.25% of the population, 138 million people, live in urban areas and 18.75%, or 31 million live in rural areas. These regions are diverse in many aspects; one in particular is climate. There are six different climates in Brazil: Tropical, Equatorial, Atlantic Tropical, Altitude Tropical, Subtropical, and Semi-arid.

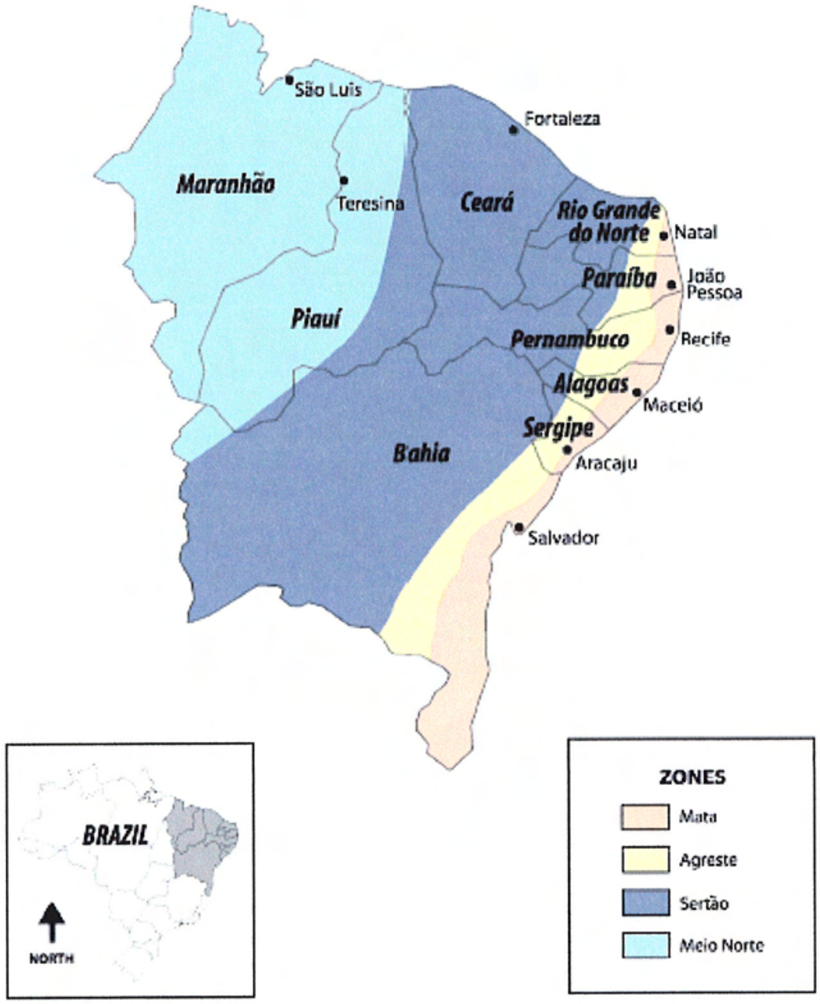
The tropical climate reaches the Northeast, Southeast, and a small portion of North region. This climate has two distinct seasons: rainy summer and the dry winter. The average temperature exceeds 20 Celsius throughout the year. The equatorial climate is mostly found in the north region of Brazil, in the Amazonian Plain and Plateaus and is characterized by a great amount of rain during the year and an average yearly temperature of 25 Celsius. The Atlantic tropical climate is mostly found in the Brazilian coast. This climate has two distinct seasons; intensified rain in the fall and winter season is dry in the rest of the year, and the raised temperature between 18 and 26 Celsius. The Altitude Tropic reaches part of the Southeast of Brazil with two distinct seasons: rainy summer and dry winter, with average temperatures between 18 and 22 Celsius. The South region is generally distinguished by a subtropical climate, with average temperatures below 18 Celsius. Furthermore, it rains regularly during the whole year and at high altitudes there can be snow. Finally, the Northeast is one of the most problematic regions of Brazil due to its semi-arid climate. This climate is characterized by high temperatures that on average exceeds 27 Celsius and has little rainfall, which, can lead to long drought periods (BrasilChannel 2003). These extensive droughts have affected the region's economic development.

3.1.2 Northeast Brazil

The Northeast consists of nine states (*Maranhão, Piauí, Ceará, Rio Grande do Norte, Pernambuco, Alagoas, Sergipe,* and *Bahia*) and comprises 18% of the national territory, or 1,516,177 square kilometers, and holds nearly 30% of Brazil's population (Portal Brasil 2003). This region is extremely diverse geographically and culturally and has suffered from chronic droughts since the colonial period (1500-1800).

The Northeast region can be described by four different geographical zones: *Meio Norte, Mata, Agreste,* and *Sertão* (see Figure 3.1). *Meio Norte* Zone is only present in 422.911 square kilometers of the Brazilian Northeast. This zone is not as affected by drought as the other three zones, due to permanent rivers, but it suffers from floods, which creates problems for agricultural production. *Mata* Zone holds 29% of the *nordestinos*, or people from the Northeast, but it only occupies 18.2% of the Northeast. This zone is the most economically developed part of the Northeast and where is found the greatest concentration of industries, tourism, and six out of nine state capitals. *Agreste* and *Sertão*, together are the largest regions in the Brazilian Northeast, and these regions are where rain is scarce and a lot of drought occurs. The *Agreste* Zone is slightly smaller than the *Mata* Zone. It is the transition zone between *Mata* Zone and *Sertão* Zone and is characterized by a diversified soil in a short distance a person can find very dry land, as the *Sertão* Zone, or very wet land, as the *Mata* Zone. The *Agreste* Zone does not receive as much rainfall during the year and it is very concentrated during the months of March to June. The lack of water exists in this zone, but is not as dry as the *Sertão* Zone (Ceara.com.br 2003).

Figure 3.1 Geographical Zones of Northeast Brazil



Source: Adapted from Andrade (1998)

The *Sertão* Zone, also known as the area of drought polygon, occupies 49% of the Northeast region. This zone is the focal area of this thesis and it is important to note that the state of *Ceará* lies 94.8% within this extremely dry zone. In the *Sertão* Zone, there are only two very distinct seasons: a rainy season and a dry season, in which no rain falls. A normal rainfall year in this zone is about 750mm of rain and usually begins between December and January and finishes in May, with most rain falling between February and April. In a drought year, the amount of rain is insignificant and irregular; it after does not come during the normal growing season (Paul 1998). According to Lemos et al. (2001), a drought can be declared even when the annual precipitation level is normal (referred as "green drought" by the local population). Even when there is no drought, the peasant farmers save food from the rainy season to be consumed in the dry season. This means that even when the year is not considered a drought year, the farmers suffer from a shortage of food resources as the dry season progresses. In a year considered to be a drought year, the food is even scarcer and many starve. Studies have shown that extreme droughts are very common in the state of *Ceará* for years, such as: 1614, 1723-24, 1790-94, 1816-25, 1877-79, 1900, 1915, 1958, 1983, 1987, 1992, 1993, 1997-99, 2001 (Magalhães and Glantz 1992).

3.2 Background *Ceará* State and the Two Studied *Municípios*

3.2.1 *Ceará*

Ceará State is located in the northern coast of Brazil and has an area of more than 148 square kilometers. Its population in 2000 was 7,414,402 inhabitants, with a little over two million inhabitants live in the capital city, Fortaleza. Approximately, 71% of the state population, or 5,300,000 inhabitants, live in rural areas. The state of *Ceará* is comprised of 184 *municípios* and its population density is 50.91 habitants per square kilometers. (IPLANCE 2002).

In *Ceará*, the main substance crops are beans, rice, corn, and manioc, and the principal cash crops are cotton, cashew, cashew nuts, lobsters, and carnauba wax. In some parts of the state, fruits like, bananas, oranges, limes, mangos, and papayas are produced as major cash crop (MRE 2001). Most of the soils are fertile but many are also stony, shallow, impermeable, non-porous and lacking in water.

Caatinga is the predominant vegetation in this state. It is as a bush aspect, with small leaves or thorns. These bushes are widespread in many *municípios* in *Ceará*. They have adapted well to arid conditions, which causes some plant species to have a loss of leaves in the dry season and some to store water (BrazilNature 2003).

The state of *Ceará* stands out as the part of Brazil most severely affected by droughts. According to Mayorga et al., 95% of the territory of *Ceará* is characterized by semi-arid with predominantly crystalline soils and has a limited availability of subterranean water. Almost all of its territory lies in drought prone areas, including 171 of its 184 *municípios* (Tendler 1997). Most of the rural households in this state are still based on rainfed agriculture and livestock, which both extremely dependent on rain.

There are three types of droughts in the State of Ceará: hydrological drought, agricultural drought, and effective drought. The hydrological drought is defined by low rainfall, but it is well distributed in time. The agricultural drought, also know as *seca* *verde* (green drought), is characterized by enough rainfall, although rainfall is not well distributed in time and space. The effective drought is the worst type of drought due to low rainfall, affecting subsistence crop production, animals, and drinking water (SUDENE 2003).

In general, *Ceará* is considered to have three types of climates: hot and humid with an average temperature between 27°C on the coast; cold and humid with an average temperature of 22°C on the mountains; and semi-arid with an average temperature of 33°C in the interior of the State (IPLANCE 2002). The overall *Ceará* average rainfall in a normal year from January to May is approximately 775 millimeters; however the coastal and mountains areas receive more or less 1200millimeters and the interior of the state only between 400 to 800 millimeters (Lemos et al. 2001). People living in *Ceará* also call the interior region as Sertão (sertões in plural form). Due to the variability in rainfall, other water sources are paramount to residents of *Ceará*.

According to Lemos et al. (2001), most of the water in *Ceará* comes from the eight main rivers (*Jaguaribe, Acaraú, Curu, Poti, Coreaú, Pirangi, Choro,* and *Pacoti*). These rivers are very important for agriculture and consumption because ground water is not found in many parts of the state, and can disappear during drought seasons (Lemos et al. 2001). However, the *Jaguaribe* is the most important river in *Ceará* State because watershed occupies 50% of *Ceará*'s territory (Ceará.com.br). Also there no permanent river in this state and *Jaguaribe* is the only present perennial river (BrazilNature 2003).

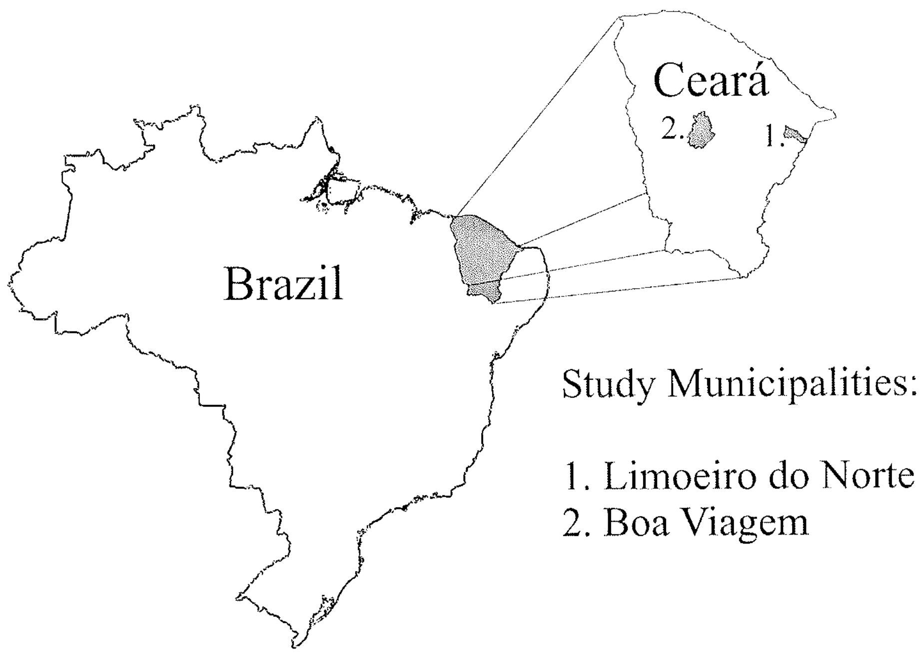
3.2.2 The Two *Municípios* Studied: *Limoeiro do Norte* and *Boa Viagem*

The two *municípios*, *Limoeiro do Norte* and *Boa Viagem*, chosen for this study, are located in different areas in the *Ceará* State (see Figure 3.2). They were elected for the study due to their differences in rainfall variations and the access to irrigation. Both *municípios* are affected by droughts in some extent but more severely in *Boa Viagem*. These drought strike especially livestock and subsistent and cash crops, which are the main reason for deterioration of household livelihood.

Limoeiro do Norte is located in the Littoral East, in the *Jaguaribe* Valley, with intensive agricultural production due to the perennial *Jaguaribe* River. This *município* has an area of 771 square kilometers and its population is 47,233, of which urban is 28,186 and rural is 19,047 (IPLANCE 2000b). In *Limoeiro do Norte* there are three types of ecosystem: *Apodi* Mountain, Cultivated Plain, and *Sequeiro* (Dry Land). Bixopa is the only district in *Limoeiro do Norte*. This district is mostly affected by drought because it is where the *Sequeiro* ecosystem is present. Most of the *município*'s population lives in the Cultivated Plain, where is not likely to be stricken by drought. (Lemos et al. 2001)

Boa Viagem, one of the driest and poorest *municípios* in *Ceará,* is located in the Central *Sertão* (IPLANCE 2000a). This *município* has an area of 2,737.5 square kilometers and its population is 47,645 (19,037 urban and 28,608 rural). Three ecosystems are present in this *município* but they are not so distinct. *Boa Viagem* has five districts (*Boa Viagem*, *Jacampari*, *Ibuaçu*, *Domingos da Costa*, and *Guia*), where they are mostly affected by periodic drought. (Lemos et al. 2001)

Figure 3.2 Map of Study Area



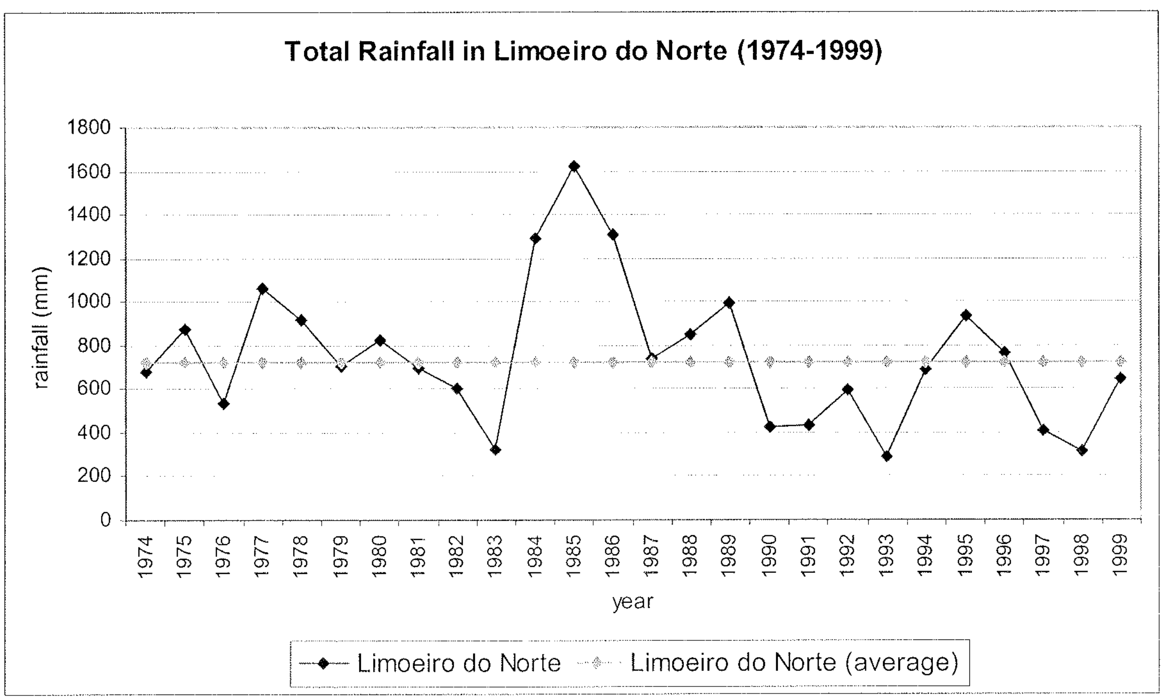
Source: Lemos et al. (2001)

The average temperatures, rainfall, and the water resource are very distinct between the two *municípios*. In *Boa Viagem* the maximum average temperature is 35 Celsius and the minimum average temperature is 25 Celsius, where in *Limoeiro do Norte* the minimum average temperature is 20 Celsius and the maximum average temperature is only 26 Celsius. In *Boa Viagem*, Figures 3.3 and 3.4 depict that 13 out of 25 years the annual rainfall is below the average rainfall (703.8mm) and *Limoeiro do Norte* 10 out of 25 years the annual rainfall is below the average rainfall (720.5mm). Figure 3.5 shows that in 15 out 25 years; *Limoeiro do Norte* received more rainfall than *Boa Viagem*, especially in 1984 where *Limoeiro do Norte*'s rainfall was 378.5mm higher than *Boa*

Viagem. Also, the years identified as drought by FUNCEME (identified by square points in Figure 3.5), *Limoeiro do Norte*'s annual rainfall is higher in seven out of eleven years, sometimes reaching as much as 280.9mm more rainfall than *Boa Viagem*. (Lemos et al. 2001, IPLANCE 2000a, IPLANCE 2000b)

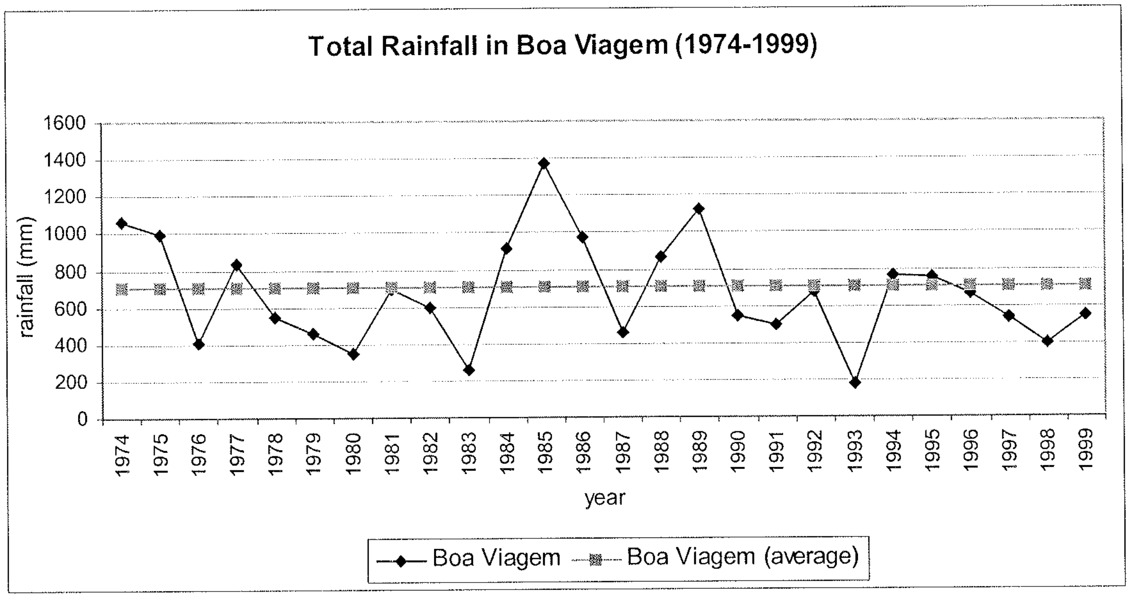
Water is more abundant in *Limoeiro do Norte* compared to *Boa Viagem*. In *Limoeiro do Norte*, water comes from the *Jaguaribe* River, the biggest river in *Ceará* and 26 wells, while in *Boa Viagem*, two dams (São José and Vieirão) and 47 wells had to be constructed due to the lack of water. (Lemos et al. 2001) According to Lemos et al. (2001), most of *Boa Viagem*'s land is dry but in *Limoeiro do Norte* 70% of the land is irrigated.

Figure 3.3 Total Annual Rainfall in *Limoeiro do Norte* from 1974 to 1999



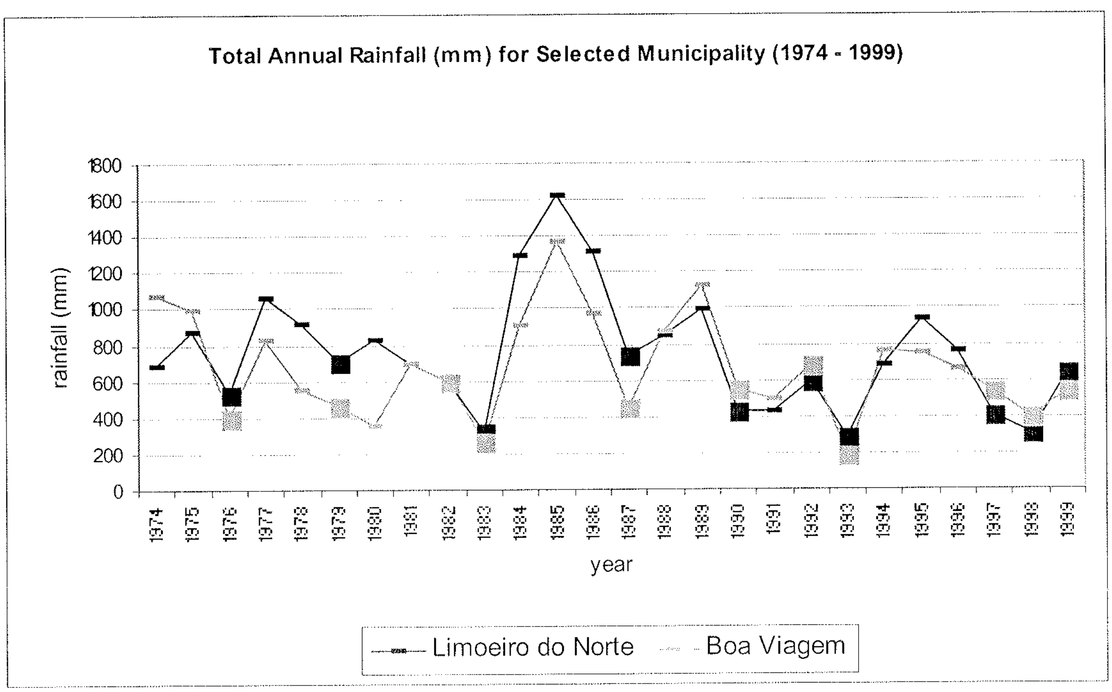
Source: Lemos et al. (2001)

Figure 3.4 Total Annual Rainfall in *Boa Viagem* from 1974 to 1999



Source: Lemos et al. (2001)

Figure 3.5 Total Annual Rainfall in *Limoeiro do Norte* and *Boa Viagem* from 1974 to 1999



Source: Lemos et al. 2001

3.3 Background of the Survey

The National Oceanic and Atmospheric Administration (NOAA) funded the University of Arizona (UofA) and the Federal University of Ceará (UFC) to conduct a survey for the Ceará Foundation for Meteorology and Water Resources (FUNCEME), the State of *Ceará* forecast provider. This survey had four objectives: 1) to identify the process in which climatic information is incorporated into government programs that are designed to prevent drought impacts; 2) to assess how Ceará State and local levels of power in the use of climate forecast data; 3) to describe the use of FUNCEME climate forecast information distributed to rural stakeholders who faced different levels of vulnerability to drought; 4) to specify rural families coping strategies in drought years (Lemos et al. 2001). This survey conducted in the two *municípios* in *Ceará*, had two time periods of interview: one interview was done in August of 1998 and another in spring of 2000.

The survey gives background information on different levels of household vulnerability, coping strategies and individual's perception of climate forecast done by FUNCEME versus the traditional methods of drought forecasting. Also it focused on local perception of government drought relief and agricultural support programs.

These surveys utilize both quantitative and qualitative data collection and analysis. The quantitative analysis provides information about household demographics, income, assets, and land holdings. The qualitative information includes impacts of drought, coping strategies, credit histories, and climate information access and use. The project objective was to use these data to identify how the population had access and responsed to forecast information and the overall impact of government relief programs. (Lemos et al. 2001). This had a better understanding about the interaction between scientist, public policymakers, and farmers (Lemos et al. 2001).

In the 1998 interview, the project team interviewed 484 households in six different *municípios* (*Limoeiro do Norte, Boa Viagem, Parambu, Guaraciaba do Norte,* and *Itarema*); each *município* is from different macroclimate regions in *Ceará*. In each *município*, around 80 urban or rural household were interviewed. Some of these households owned, leased or worked in the farmland that they cultivated. These households were chosen randomly from a list, which contained the farmer's name, association, and the sub-region that they lived in. (Lemos et al. 2001)

In the 2000 interview, 120 households were interviewed, of which 54 were previously interviewed in 1998. In 2000, interviewees were asked the situation of the household in the years of 1998 and 1999. These interviews were conducted only in *Boa Viagem* and *Limoeiro do Norte* because these *municípios* represented the best range of agricultural, climatic, and socio-economic indicators. Only the later survey is used in this thesis, because in the 1998 interview, coping strategies were not well identified as in the 2000 interviews.

3.4 Household Characteristics in the Studied *Municípios*

There are two ways in which families cultivate their land in *Limoeiro do Norte* and *Boa Viagem* (see Table 3.1). Rainfed agriculture is practiced in without access to groundwater or surface water for irrigation. Irrigated agriculture is much more limited because lack of water resources, or households' lack of money to make the necessary investment. In *Boa Viagem*, only one household has irrigated land. As mentioned before, this *município* is very dry and water is very scarce. Also only 18.3% of the households in this *município* have piped water and 15% have cisterns (see Table 3.2). The households in *Limoeiro do Norte* benefit from the proximity to the Jaguaribe River so it is expected that irrigation should be more widespread in this *município*. Also in this *município*, 43.3% of the households have cisterns and 36.7% pipe water making it easier to irrigate.

Table 3.1 Cultivated Land

	Limoeiro do Norte	Boa Viagem
Household with Rainfed land	34	59
Household with Irrigated land	32	1
Total Household	60	60

Source: Lemos et al. 2001

Table 3.2 Some Important Household Assets

	Limoeiro do Norte		Boa Viagem	
	Number of Household	%	Number of Household	%
Masonry House	47	78.3	49	81.7
Television	42	68.3	35	58.3
Radio	49	81.7	59	98.3
Stereo	28	46.7	17	28.3
Energy in the house	42	70	39	65
Pipe water	22	36.7	11	18.3
Cistern	26	43.3	9	15
Parabolic Antenna	18	30	15	25
Refrigerator	35	58.3	21	35
Sewing machine	29	48.3	9	15
Gas Stove	52	86.7	37	61.7
Bike	53	88.3	35	58.3
Motorbike	24	40	12	20
Car	4	6.7	0	0
Pickup truck	4	6.7	1	1.7

Source: Lemos et al. 2001

As seen in Table 3.3, the family size and the age of the household head are quite similar between *Limoeiro do Norte* and *Boa Viagem*. Fifty-seven out of sixty households, or 95%, of the sample household in each *município* are headed by men. The literacy rates for the household head however, are much lower than the national level of 83% (IBGE 2003). As seen in Table 3.4, only 6.7% in *Limoeiro do Norte* and 5% in *Boa Viagem* the head of the household finished 4th grade and only one household head in each *município* has a university degree. Also, 48.3% of the households in each *municípios* have at least one member illiterate that is older than 15 years old. According to Lemos et al. (2001), the focus on education in these *municípios* is very low and this is the reason why these rates are so low.

Table 3.3 Demographic Information

	Family Size	Age of the Household Head
Limoeiro do Norte	4.9	51
Boa Viagem	4.7	47

Source: Lemos et al. 2001

Table 3.4 Household Head Education Level

	Limoeiro do Norte		Boa Viagem	
	Number of household	**%**	**Number of household**	**%**
Illiterate	22	36.7	22	36.7
Literate	13	21.7	18	30
4th grade completed	4	6.7	3	5
8th grade completed	1	1.7	1	1.7
11th grade completed	2	3.3	1	1.7
University degree	1	1.7	1	1.7

Source: Lemos et al. 2001

3.5 Emergency Drought Relief Programs

When State government detects an effective drought, as the worst type of drought described earlier in the chapter, it declares a state of emergency in order to receive funds from the Federal government to help the affected *nordestinos* (Pessoa 1987). The Brazilian Ministry of Agriculture, Livestock and Food, a Federal government agency, then plans and executes emergency relief programs and delegates to many state government agencies. (Mayorga et al. 2001). The Brazilian Government has provided significant amount of federal resources in crisis-based emergency relief programs (Lemos et al. 2002). In the State of Ceará, various emergency relief programs have been implemented as a part of government policy, for example providing: income for unemployed rural farmer with work fronts, water consumption through water trucks, food supply through monthly food basket, and offering credit assistance to the affected population (Mayorga et al. 2001). These emergency drought relief programs, detailed below, help to minimize the effect of drought in vulnerable households in the State of Ceará.

Table 3.5 provides the total number of households in the two *municípios* that have benefited from each of the emergency drought relief programs.

Table 3.5 Number of Households with Government Drought Relief Programs

	Limoeiro do Norte		**Boa Viagem**	
	98	**99**	**98**	**99**
Water truck	19	19	20	23
Work front	21	19	21	23
Monthly food basket	26	30	48	48
Emergency rural credit	17	10	10	7

Source: Lemos et al. 2001

3.5.1 Monthly Food Basket

The Monthly Food Basket Program is given to rural households that have lost some or all their harvest. This program's main objective is to meet the households' food minimum consumption requirement (Albuquerque, Tomasin, and Pagotto 1988; Mayorga et al. 2001). In 1998 and 1999, the monthly food basket cost was 14 reais (around 15 dollars), which contained on average 20 kilograms of food, including: rice, beans, noodles, corn starch, sugar, manioc flour, cooking oil, and sugarcane bars "rapaduras" (Mayorga et al. 2001). In the *município* of *Limoeiro do Norte*, 5875 food baskets were distributed in 1998 and 6000 in 1999 and in *Boa Viagem*, vulnerable families received 7393 food baskets in 1998 and 1999 (Lemos et al. 2001).

3.5.2 Work Fronts

The Work Front Program's objective is to reduce migration to urban centers, to improve quality of life, and to increase income. Work Fronts help employ heads of households who lose their main source of income as a result of drought (Lemos et al. 2001).

The State Civil Defense Council decides the eligibility for the work fronts programs. Households are eligible if: they are not receiving retirement pension or do not benefit from any retiree pension, unless there are more than 5 in the household; the spouse or the person is not a public servant, unless he/she is a rural resident who receives half of the minimum salary and has more than five household members; they are not receiving emergency credit; they are not rural employees, such as: farm managers, foremen, herdsmen, or any permanently salaried farm position; if they do not own automobile; if they have less than 20 cows or 60 goats; and if they are not a merchant, with or without permanent store (warehouse, small grocery store, canteen, bar, and others) (Lemos et al. 2001).

During 1998 and 1999, the 4170 work front workers in *Boa Viagem* produced bricks and repaired dams and were compensated 130 reais per month in both years. In *Limoeiro do Norte*, 3000 workers were engaged in the same activities. However, the workers there received 130 reais per month, in the beginning of 1998, but by July the salary decreased to 90 reais and remained at this level in 2000.

3.5.3 Water Delivery

Water trucks are commonly sent to rural families as a way to solve water depletion during prolonged drought. These water trucks are used in drought seasons because the existing reservoirs and dams are not well administered to send to all the affected *municípios* (Mayorga et al. 2001).

In 1998 and 1999, *Limoeiro do Norte* utilized five and *Boa Viagem* used three water trucks to combat the drought, respectively. The Federal government funded 80% of the water transportation costs and the rest was covered by the State of *Ceará* government. *Boa Viagem* experienced many problems with the transported water. For example, salty water affected 8000 people in the *Guia* district and the village of *Massape dos Paes*. Also, many people had diarrhea due to the inadequate quality of water (Lemos et al. 2001).

3.5.4 Emergency Rural Credit

In 1996, the Federal government, with help of *Banco do Nordeste* (BNB – the Northeastern Bank), created the National Program to Strengthen Family Agriculture (PRONAF). This program gives emergency rural credits in order to support family-based agriculture, reduce regional inequalities and to strengthen needy families (Mayorga et al. 2001).

The *Banco do Nordeste* eligibility requirements for the Emergency Rural Credit Program are that rural farmers: own or are leasing the land; permanently employ at least two farm workers; do not have an area over four fiscal models; receives 80% of their income from rural activities; live on their farm or in a proximal towns (Banco do Nordeste 2003).

In *Limoeiro do Norte* and *Boa Viagem*, the rural emergency credit was introduced on June 15th, 1998 due to the pressure from farmers so that they could build wells or buy fodder. The Federal Government subsidized 50% of this credit and a 6% yearly interest rate 12 years pay back period (Lemos et al. 2001). However, the *Banco do Nordeste* (2003) states that the loan period is only 8 years, not 12, with a 2 years grace period.

3.6 Coping Strategies

Even with these government relief programs, it is very important to understand the attitude of the rural farmers when drought is announced. Many coping strategies are important approach to deal with the survival of the household during a drought. Table 3.6

classified the most common coping strategies undertaken by households in *Limoeiro do Norte* and *Boa Viagem*.

Table 3.6 Most Common Coping Strategies

	Limoeiro do Norte		Boa Viagem	
	1998	**1999**	**1998**	**1999**
Changed diet	24	26	32	31
Walked far to get water	20	13	29	27
Received help from family or friends	19	24	27	27
Take animal out of the property to eat	9	9	12	14
Sold animals	22	28	15	19
Worked in non-agricultural job*	15	9	5	5
Sold land or assets	1	4	0	1
Temporary migration	8	6	3	1
* these non-agricultural jobs do not include work fronts				

Source: Lemos et al. 2001

In both *municípios*, eight different coping strategies were found. The most common in the two *municípios* was the change in diet, which is more intensified in *Boa Viagem*. Also in both *municípios*, many families had to walk far to get water, which decreased a little in 1999 and they received help from family or friends. These helps were received by family members or friends, who migrated to bigger and non-drought. Most of the help comes in money form but in some cases they also come as food and clothes. These different coping strategies are the main topic of this thesis, which will be discussed in more detail in the further chapters.

CHAPTER 4

ESTIMATION TECHNIQUES AND RESULTS FOR THE BIVARIATE PROBIT MODEL

This chapter addresses the first research topic of this thesis, which is the verification of the sequence adoption of coping strategies stage use, as documented in anthropological literature. It aims to model the sequence of coping strategy stage implementation, from adoption of reversible mechanisms (Stage 1) to the sale of assets (Stage 2), utilizing a Bivariate Probit model. Prior to the full estimation of a Bivariate Probit model, the relationship between the stages will be examined. In addition an estimation of dependence of Stage 2 on Stage 1 will be investigated.

4.1 Categorization of Coping Strategy Stages

Binary decision-making can be explained by using qualitative choice models like the Probit formulation of the regression model. The coping stages theory groups the full range of coping mechanisms into progressively more severe categories: the reversible mechanisms (Stage 1), the disposal of productive assets (Stage 2), and the distress migration (Stage 3). This study only examines the decision processes utilized in Stage 1 and Stage 2 because there were no observed incidences of distress migration in this data set. The categorization of Stage 1 and Stage 2 coping strategies can be seen in Table 4.1. The literature on coping strategies argues that initial reactions to drought typically involve the mechanisms in Stage 1. As the hardship caused by the drought increases and extends over time, more coping measures are employed to fight the effects of drought on the household.

Table 4.1 Coping Strategies in Each Stage

	Stage 1	Stage 2
Household Coping Strategies	Changed Diet	Sold animals
	Walked far to get water	Sold assets or land
	Received help from immigrants or friends	Worked in a non-agricultural job
	Took animals out of the property to graze and drink	Temporary migration

4.2 Data Overview

Surveyed households cope with droughts using mechanisms from both Stage 1 and/or Stage 2. From the 240 households in the survey, 183 implemented Stage 1 coping mechanisms and 120 put Stage 2 mechanisms into practice. Table 4.2 demonstrates the cross-utilization of the two stages.

Table 4.2 Stage 1 and 2 Contingency Table

		Stage 1		Total
		Yes	No	
Stage 2	Yes	93	27	*120*
	No	90	30	*120*
Total		*183*	*57*	*240*

This data set shows that households may decide to utilize a Stage 1, Stage 2, a combination of both, or neither of the stages during a drought. However, in order to have sequence among the two stages, it was expected that household would only implement Stage 2 if they already have adopted Stage 1 coping strategies. Table 4.2 shows that 27 households did not implement Stage 1 coping mechanisms and instead immediately adopted ones in Stage 2. A Bivariate Probit model is to examine if there is any more complex statistical relationship between the two stages. In addition, a univariate Probit model will be estimated, where Stage 2 depends on Stage 1. In this model a relationship between the two stages will be analyzed in order to verify if families who chose to implement Stage 2 were more likely to implement Stage 1. In presence of any relationship, the Bivariate model will be estimated.

4.3 Bivariate Probit Model

The Bivariate Probit model is used to analyze the variables affecting the choice of a coping mechanism during Stage 1 and Stage 2. A household may choose to use or not to use a Stage 1 mechanism and/or utilize or not utilize Stage 2. A better illustration of this model is presented in Equations 4.1 and 4.2. Figure 4.1 is a visual explanation of this model, where a black circle (Y) denotes the use of a household coping strategy(s) and a white circle (N) depicts no use of coping strategy.

The household coping strategies stages (HCSS) model are described as follows:

(4.1) Stage 1 Model

$$\text{Stage } 1^* = x_1\beta_1 + u_1 \qquad \text{Stage } 1 = \begin{cases} 1 \text{ if Stage } 1^* > 0 \\ 0 \text{ otherwise} \end{cases}$$

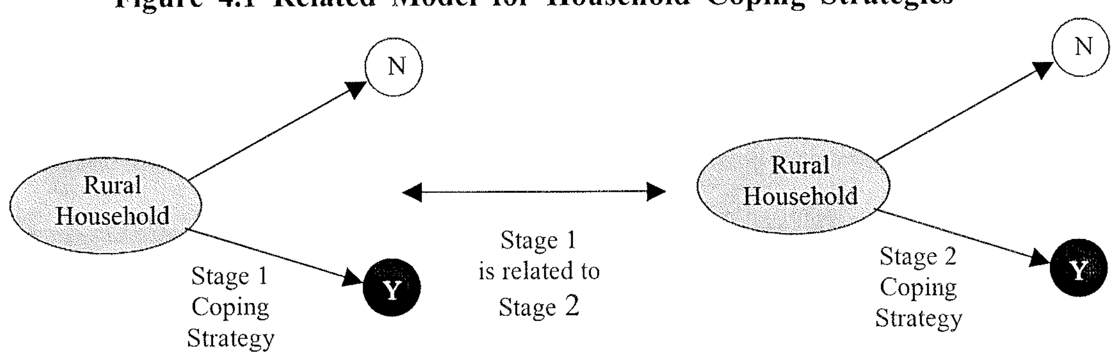
(4.2) Stage 2 Model

$$\text{Stage } 2^* = x_2\beta_2 + u_2 \qquad \text{Stage } 2 = \begin{cases} 1 \text{ if Stage } 2^* > 0 \\ 0 \text{ otherwise} \end{cases}$$

where, $\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \sim N\left[0, \begin{pmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{12} & \sigma_{22} \end{pmatrix}\right]$

Stage 1* and Stage 2* are the unobserved latent variable; x_1 and x_2 are vectors of exogenous variables; and β_1 and β_2 are the vectors of the unknown parameters. All the parameters are estimated using the maximum likelihood thus providing consistent estimators. This model describes the relationship between the error terms of the two stages. In the variance-covariance matrix the diagonal elements (σ_{11} and σ_{22}) are equal to one and off-diagonal elements (σ_{12}) are equal to ρ, in which the correlation coefficient between stage 1 and stage 2.

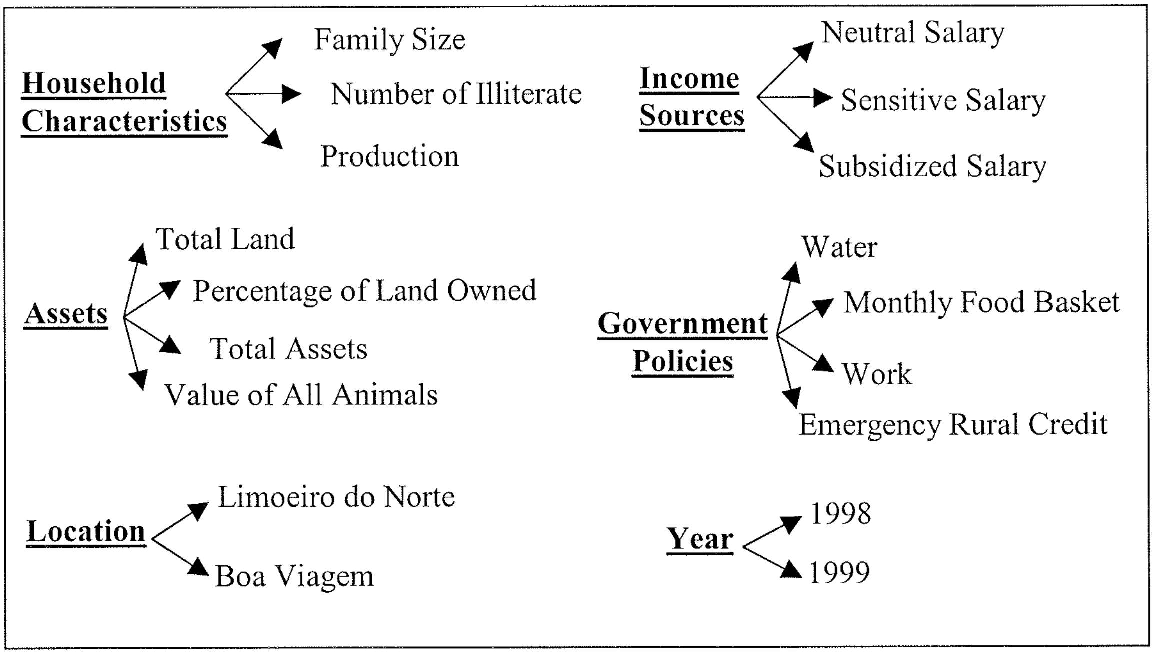
Figure 4.1 Related Model for Household Coping Strategies



4.3.1 Exogenous Variables for the Bivariate Model

The exogenous variables used to estimate the Bivariate Model is shown in Figure 4.2. However, detail of these variables will be presented in depth in Chapter 5.

Figure 4.2 Exogenous Variables



4.3.2 Test for the Correlation between the Error Terms in Stage 1 and Stage 2

The correlation between the two error terms in Stage 1 and Stage 2 are important in determining if the Bivariate Probit model is appropriate for this data set. Two tests, the Wald Test and the Likelihood Ratio Test, will be used, where the null hypothesis is $\rho = 0$. Rho (ρ) is the correlation coefficient between the two error terms. In other words, these two tests are important to verify the hypothesis that the decision made in the two coping strategy stages are related. Both tests have a chi-square distribution, where the degrees of freedom correspond to the number of restrictions (Greene 2000; Taylor 1974).

The Wald Test is the corresponding ρ divided by the standard error from the full model as seen below (Greene 2000; Taylor 1974):

(4.3) $$\text{Wald} = \left(\frac{\rho}{\text{std.error}}\right)^2 \sim \chi_1^2$$

The Likelihood Ratio (LR) Test is the comparison between the log likelihood of a full model (L_f) and a reduced model (L_r), as shown below (Greene 2000; Taylor 1974):

(4.4) $$\text{LR} = 2 \bullet (L_f - L_r) \sim \chi_1^2$$

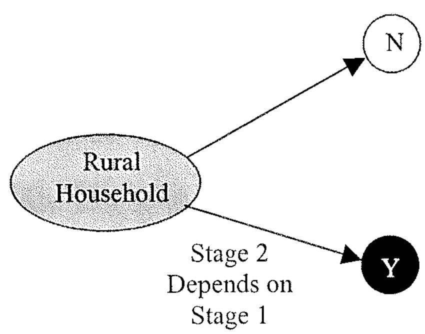
4.3.2.1 Results of the Wald and Likelihood Ratio Tests

The result of the Wald Test (χ^2 = 1.74, df 1) and the Likelihood Ratio Test (χ^2 = 2.53, df 1) show that ρ is equal to zero at the 95% confidence level. This indicates that Stage 1 and Stage 2 coping mechanism choices are independent and no relation is present between them. More specifically, the related model for household coping strategies stages, which states that households follow a sequential pattern of coping mechanisms choices is rejected. This indicates that two separate Probit models should be estimated. However, to verify also if there is any kind of dependency among the two stages a Probit model where Stage 1 is an exogenous variable of Stage 2 will be estimated. In this case if Stage 1 is significant then we can say that the two models are related and some sequence can be observed between Stage 1 and Stage 2 models.

4.4 Probit Model for Stage 2 Model (Dependency of Stage 2 on Stage 1)

The Stage 2 model, where Stage 1 is treated as an exogenous variable, is to analyze if choosing to implement Stage 2 coping strategies depends on the decision to utilize Stage 1. A better illustration of this model is presented in Figure 4.2 and Equation 4.5. The exogenous variables used for this model are the same as those presented in Table 4.3. The endogenous variable, Stage 2, and the exogenous variable, Stage 1, use the same coping strategies, as denoted in Table 4.1.

Figure 4.3 Stage 2 Model (Dependency of Stage 2 on Stage 1)



The Stage 2 model (when Stage 2 depends on Stage 1) is described as follow:

(4.5) $\text{Stage } 2^* = x_2\beta_2 + \text{Stage1}\delta_1 + u_2 \qquad \text{Stage } 2 = \begin{cases} 1 \text{ if Stage } 2^* > 0 \\ 0 \text{ otherwise} \end{cases}$

where $u_2 \sim N(0, \sigma_2^2)$

Stage 2* is the unobserved latent variable; x_1 and Stage1 are vectors of exogenous variables; and β_1 and δ_1 are the vectors of the unknown parameters. All the parameters are estimated using the maximum likelihood so that the model will have consistent estimators. The variance (σ_2^2) is normalized to one.

4.4.1 Test for Heteroscedasticity for the Stage 2 Model (When Stage 2 Depends on Stage 1)

Heteroscedasticity is very common in cross-sectional data. Stage 2 model is estimated for cross-sectional data thus it is important to test for heteroscedasticity. If heteroscedasticity is present in the model and if it is not accounted for, it can lead to inconsistent estimators. In typical Probit models the error variance is constant and normalized to equal to one (Var (u) = $\sigma^2 = 1$) so that the parameters in Equation 4.5 (β and δ) can be estimated. Otherwise, it is impossible to estimate consistent parameters (β and δ) (Godfrey 1988; Maddala 1983).

In order to test for heteroscedasticity, consider the alternative in which Equation 4.5 is replaced by Equation 4.6, below:

$$(4.6) \quad y_i^* = g(x_i'\beta, z_i'\alpha) + u_i$$

where, z_i is a q-dimensional vector of exogenous variables and α is a q-dimensional vector of unknown parameters. The Lagrange Multiplier (LM_2) test will be used to check for heteroscedasticity (see Equation 4.7).

(4.7) $$LM_2 = [-(x_i'\hat{\beta})z_i', x_i']f_i(\hat{\theta})/[F_i(\hat{\theta})(1-F_i(\hat{\theta}))]^{1/2}$$

where, $F_i(\hat{\theta}) = 1-\Phi(x_i'\hat{\beta})$ and $f_i(\hat{\theta}) = \phi(x_i'\hat{\beta})$

The LM_2 test has a chi square distribution with 2q + 1 degrees of freedom, where q is the number of explanatory variable in the Probit model. The null hypothesis to be tested is that there is no heteroscedasticity. (Godfrey 1998).

4.4.2 Results from the Heteroscedasticity Test

The result of the LM_2 Test (χ^2 = 24.90313, df 31) showed that there is no heteroscedasticity in this model at a 95% confidence level. Therefore we fail to reject the null hypothesis: there is no heteroscedasticity Consequently the log-likelihood does not have to be re-written in this models.

4.4.3 Calculation of Marginal Effects for the Stage 2 Model (Where Stage 2 Depends on Stage 1)

When no heteroscedasticity is found, marginal effects for exogenous variables in each coping strategy models are calculated as:

(4.8) $$\frac{\partial E(Stage2 \mid Stage1)}{\partial x_2} = \beta_2 \bullet \phi(x_2 \bullet \beta_2 + Stage1 \bullet \delta_1)$$

(4.9) $$\frac{\partial E(Stage2 \mid x)}{\partial Stage1} = \delta_1 \bullet \phi(x_2 \bullet \beta_2 + Stage1 \bullet \delta_1)$$

where, ϕ is the probability density function for the coping Stage 2 model. The marginal effect for a dummy explanatory variable is calculated using:

(4.10) Marginal Effect for Coping Strategy$_k$ of x_j =

$$E(Stage2 \mid x_j = 1) - E(Stage2 \mid x_j = 0) = \Phi(x_2\beta_2 \mid x_j = 1) - \Phi(x_2\beta_2 \mid x_j = 0)$$

where, Φ is the cumulative density function for Stage 2 model.

4.4.4 Calculate Goodness of Fit (R^2)

The R^2_{count} is going to be used to calculate the goodness to fit for each coping strategy model also, as follows:

(4.10) $$R^2 = \frac{1}{N}\sum_i n_{ii}$$

where n_{ii} are the number of correct predictions for outcome i and N is the total number of observation in the model (Long 1997).

4.4.5 The Estimation of When Dependency of Stage 2 on Stage 1

The results for the coefficient parameters, p-values, and marginal effects in the Stage 2 model, when Stage 1 is an exogenous variable for the model, are presented in Table 4.3. Stage 1 is not significant in this variable. Therefore, Stage 2 is not dependent on Stage 1 decision.

Table 4.3 Estimation Results from Stage 2 Model (Stage 1 is an Exogenous Variable)

Variable	Constant	P-value	Marginal Effects	P-value
Constant	- 0.851262	0.072*		
Stage 1	0.346588	0.140	0.137871	0.141
Family size	0.311867E-02	0.954	0.124126E-02	0.954
Percentage of Land Owned	0.324159E-02	0.116	0.128943E-02	0.116
Value of all Animals	0.763127E-04	0.044**	0.303547E-04	0.044
Total Assets	0.026760	0.457	0.010646	0.458
Number of illiterate	- 0.140189	0.140	- 0.055764	0.141
Production	- 0.60395E-06	0.939	- 0.240066E-06	0.939
Neutral Salary	- 0.18562E-04	0.680	- 0.738286E-05	0.681
Sensitive Salary	0.109212E-03	0.696	0.434451E-04	0.696
Subsidized Salary	- 0.10823E-03	0.100*	- 0.430483E-04	0.107
Work Front	- 0.302891	0.127	- 0.117308	0.127
Monthly Food Basket	0.172709	0.463	0.068810	0.462
Emergency Rural Credit	- 0.128443	0.608	- 0.050707	0.609
Limoeiro do Norte	0.810018	0.000***	0.298885	0.000
1998	- 0.175383	0.309	- 0.068945	0.307

* significant at 0.1 ** significant at 0.05 ***significant at 0.01
N = 240
$R^2_{count} = 0.658$
Log likelihood = - 145.360

Table 4.4 shows the overall accuracy of the predictions. The Stage 1 has a R^2_{count} of 0.783. For comparison a nascent model would correctly predict 50% of the cases.

Table 4.4 R^2 count for Stage 2 (Stage 1 is an Exogenous Variable)

Stage 1		**Actual**	
		0	**1**
Predicted	**0**	81	39
	1	43	77

4.5 Summary

The Wald and the Likelihood Ratio test showed use of Stage 1 strategy is not related to the use of Stage 2 mechanisms. Furthermore, Stage 2 is not dependent on Stage 1 utilization, as shown in Table 4.2. The model results do not support the hypothesis that households adopt coping strategies sequentially. Consequently, the choice of coping strategies should be estimated independently using a Probit model for each stage. These estimations will be presented in Chapter 5 in order to identify which household factors influence the choice of coping strategies stages.

CHAPTER 5

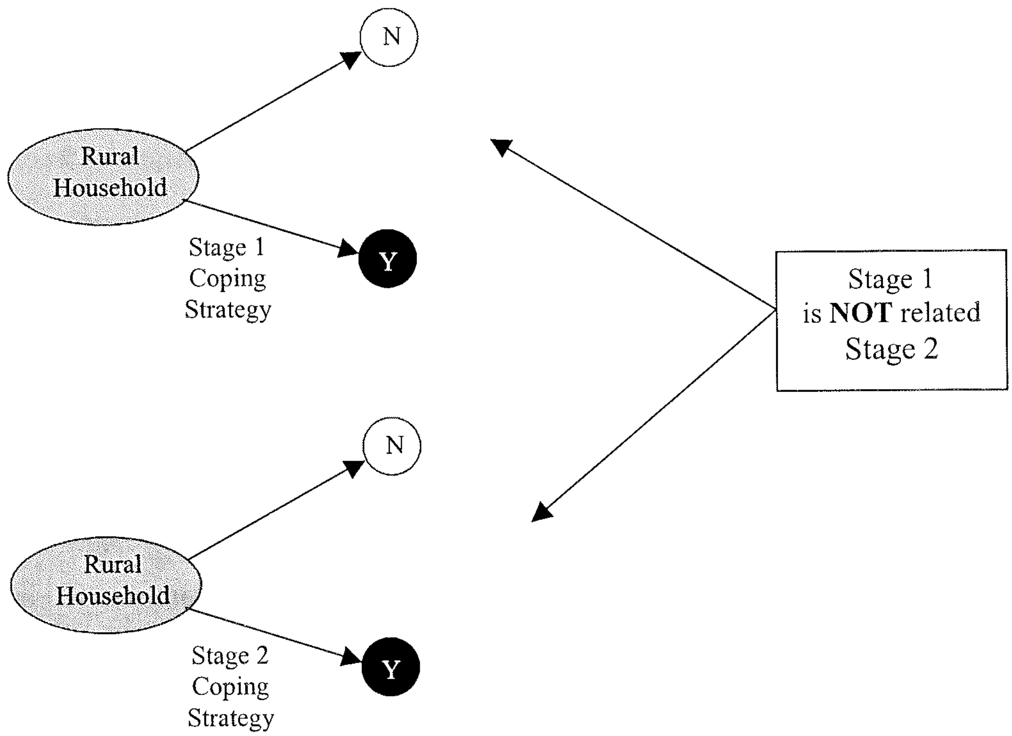
ESTIMATION TECHNIQUES AND RESULTS FOR THE PROBIT MODELS

The results of the bivariate Probit model presented in the previous chapter do not support the hypothesis that the use of coping strategies stages are related. In other words, this data indicates that the choice to use mild coping mechanisms, in Stage 1, and the decisions to implement more reactionary strategies, in Stage 2, are independent. In order to analyze the factors that influence household's choices of coping strategies stages, individual dichotomous models are warranted. This chapter presents the findings of these univariate Probit models. In addition the results from univariate Probit models, for each individual coping strategy, are given.

5.1 Two Separate Probit Models for the Stage Models

Two separate Probit models one for adoption of Stage 1 mechanisms and the other for Stage 2 mechanisms have been estimated. An illustration of these models, when $\rho = 0$, can be seen in Figure 5.1 and Equations 5.1 and 5.2. The two Stages use the same coping strategies, as denoted in Chapter 4 (Table 4.1).

Figure 5.1 Non-Related Model for Household Coping Strategies



The household coping strategies stages decision are described as follows:

(5.1) Stage 1 Model

$$\text{Stage } 1^* = x_1\beta_1 + u_1 \qquad \text{Stage } 1 = \begin{cases} 1 \text{ if Stage } 1^* > 0 \\ 0 \text{ otherwise} \end{cases}$$

where $u_1 \sim N(0, \sigma_1^2)$

(5.2) Stage 2 Model

$$\text{Stage } 2^* = x_2\beta_2 + u_2 \qquad \text{Stage } 2 = \begin{cases} 1 \text{ if Stage } 2^* > 0 \\ 0 \text{ otherwise} \end{cases}$$

where $u_2 \sim N(0, \sigma_2^2)$

Stage 1* and Stage 2* are the unobserved latent variable; x_1 and x_2 are vectors of exogenous variables; and β_1 and β_2 are the vectors of the unknown parameters. All the parameters are estimated using the maximum likelihood so that the model will consist of consistent estimators. The variances (σ_1^2 and σ_2^2) are equal to one.

5.1.1 Exogenous Variables for Stage 1 and Stage 2 Models

The exogenous variables were chosen from development economics and anthropological studies. The variables include geographical and economic aspects of a household as well as, government emergency relief programs during droughts (see Tables 5.1 and 5.2). Some of the exogenous variables in Stage 1 differ from those in Stage 2 due to high correlation between certain variables. These include two 'Government Policies', 'Total Land', and the 'Value of All Animals'.

The government policies are treated as exogenous variables. Although farmers apply for these relief programs, it is the government agencies which chooses the eligible farmers. However, the 'water delivery' program and 'work fronts' are highly correlated with each other (Pearson correlation coefficient = 0.64). Therefore these two government relief programs could not be used in the same model. Water delivery programs are included in the variables for the Stage 1 portion of the model because it is a less intensive government program. Furthermore, walking far to get water and taking animals out of the property to eat and drink are Stage 1 coping mechanism. The water delivery programs mitigate this strategy. The work front variable is placed in the Stage 2 portion of the model because it is related to the coping strategies in this stage. This includes such as getting non-agricultural jobs and temporary migration.

The variables for 'Total Land' and 'Value of All Animals' are correlated with each other (Pearson correlation coefficient = 0.569). Total Land was used in Stage 1 portion of the model because the coping strategies in this stage, such as 'changed diet', are mostly related to the household's land size. The 'Value of all animals' was placed in Stage 2 portion of the model because it is related to the coping mechanism in this stage, such as 'sold animals' and 'sold assets or land'.

Table 5.1 Stage 1 Exogenous Variables

	Variable Name	Description
Household Characteristics	Family size	Number of people in the household
	Number of illiterate	Number of people in the household that are illiterate
	Production	Total amount of production of subsistence crops (beans, rice, manioc, and corn) measured in kg^2
Assets	Total Land	Total irrigated and rainfed cultivated land in km^2
	Percentage of Owned Land	Total amount of owned land in km^2 divided by the total amount of irrigated and rainfed cultivated land in km^2
	Total Assets	Total number of assets in the household
Income Sources	Neutral Salary	Total amount salary – unskilled work, skilled work, business, employee, workmanship, help from family, and leased land
	Sensitive Salary	Total amount salary – agricultural labor
	Subsidized Salary	Total amount salary – work fronts and retiree pension
Government Policies	Water Delivery	Water delivery, a government emergency relief program, dummy variable where water delivery = 1
	Monthly Food Basket	Monthly food basket, a government emergency relief program, dummy variable where monthly food basket = 1
	Emergency Rural Credit	Emergency rural credit, a government emergency relief program, dummy variable where emergency rural credit = 1
Location	Limoeiro do Norte	*Município* of Limoeiro do Norte, dummy variable where Limoeiro do Norte = 1
Year	1998	Year of 1998, dummy variable where year of 1998 = 1

Table 5.2 Stage 2 Exogenous Variables

	Variable Name	Description
Household Characteristics	Family size	Number of people in the household
	Number of illiterate	Number of people in the household that are illiterate
	Production	Total amount of production of subsistence crops (beans, rice, manioc, and corn) measured in kg^2
Assets	Percentage of Owned Land	Total amount of owned land in km^2 divided by the total amount of irrigated and rainfed cultivated land in km^2
	Total Assets	Total number of assets in the household
	Value of all animals	Total value of cows, goats, donkey, and chicken in reais
Income Sources	Neutral Salary	Total amount salary – unskilled work, skilled work, business, employee, workmanship, help from family, and leased land
	Sensitive Salary	Total amount salary – agricultural labor
	Subsidized Salary	Total amount salary – work fronts and retiree pension
Government Policies	Work Fronts	Work fronts, a government emergency relief program, dummy variable where work fronts =1
	Monthly Food Basket	Monthly food basket, a government emergency relief program, dummy variable where monthly food basket = 1
	Emergency Rural Credit	Emergency rural credit, a government emergency relief program, dummy variable where emergency rural credit = 1
Location	Limoeiro do Norte	*Município* of Limoeiro do Norte, dummy variable where Limoeiro do Norte = 1
Year	1998	Year of 1998, dummy variable where year of 1998 = 1

5.1.2 Expected Signs for Stage 1 and Stage 2 Models

Table 5.3 presents the exogenous variables included in the Stage 1 and Stage 2 prediction models. The expected signs in Stage 1 and Stage 2 are very similar, except for 'Limoeiro do Norte', 'Total Assets', and 'Percentage of Land Owned' variables. As mentioned in Chapter 3, the *município* of Boa Viagem is drier than Limoeiro do Norte. Therefore, it is expected that the farmers living in Limoeiro do Norte are more likely to implement Stage 2 strategies (selling animals, looking for non-agricultural jobs, selling assets or land, and/or temporary migration) because they are more likely to have more assets and animals to sell. Consequently, this variable is expected to be positive for Stage 2 and negative for Stage 1. The variable for 'total assets' is expected to be negative in Stage 1 because those with less assets, have less to sell, thus they will use other resources to cope with drought, such as decreasing food intake and receiving help from family or friends. However, if households have many assets, especially valuable assets, it is more likely for household to sell them so the sign for 'total assets' is expected to be positive in Stage 2 model. The variable for 'percentage of land owned' is expected to be negative in Stage 1 because families with more possessed land are more likely to cultivate more crops and build wells in their property. Therefore, these families will implement less of Stage 1 strategies, such as change their diet and walk far to get water. However, the expected sign for this variable is positive in Stage 2 because if families have more owned land they are more likely to sell them in order to not have to change their diet and receive help from family.

The signs of the other exogenous variables are the same in both models. The variable for family size is important because if there are more members, the more likely family is to be more sensitive to drought since assets and income will be less per household member. Therefore large households are more apt to adopt Stage 1 and Stage 2 mechanisms. Hence, the sign for this coefficient is expected to be positive. The number of illiterate people in a family can influence the amount and quality of resources a household has due to the opportunity of getting better or more diversify jobs. Consequently, if a household member is illiterate, he/she is more likely to work in agriculture, which makes them more vulnerable to drought effects. Therefore, if a household has many illiterate members the less resources that family will likely have, thus forcing them to implement both Stage 1 and Stage 2. Consequently, the sign for 'number of illiterate' is expected to be positive. Families, which depend on agricultural production, face serious problems during drought periods. Production can plummet, forcing the family to adopt both Stage 1 and Stage 2 coping mechanisms. Therefore, the sign for production is expected to be negative.

In contrast to 'Percentage of Land Owned' variable, the expected sign for 'Total Land' is positive because this variable includes crop shared land, leased in, community farmed, and other types of land. Therefore, the more total land a family has the more cultivation and animal husbandry may take place and these livelihoods are susceptible to drought. The variable for 'Value of All Animals' is expected to be positive because households may sell animals for money to buy needed goods or sell them in order to remove the burden of feeding the animals.

The sign for the 'Neutral Salary' variable is expected to be negative because these salaries are not affected by droughts, whereas the sign of the 'Sensitive Salary' variable is expected to be positive because these salaries are based on agricultural jobs and thus related to drought effects. The 'Subsidized Salary' variable consists of work front salary and/or retiree pension. Both are provided by the Brazilian government, however work fronts are only available during drought years while retiree pensions are given to rural farmers after the age of fifty, proving that they only worked in agricultural jobs their entire active life. Households receiving these subsidies therefore have greater monetary resources to deal with drought thus this variable is expected to have a negative sign.

The dummies for government relief programs have negative expected signs because if a household has access to a government relief program, the less household that will need to use coping strategies. The dummy for the year of 1998 is expected to be positive because the drought was more severe than in 1999.

Table 5.3 Expected Signs for the Exogenous Variables in Stage 1 and Stage 2 Models

Variables	Expected Signs for Stage 1	Expected Signs for Stage 2
Family size	+	+
Number of illiterate	+	+
Production	-	-
Total Land	+	
Percentage of Land Owned	-	+
Total Assets	-	+
Value of all animals		+
Neutral Salary	-	-
Sensitive Salary	+	+
Subsidized Salary	-	-
Water Delivery	-	
Work Fronts		-
Monthly Food Basket	-	-
Emergency Rural Credit	-	-
Limoeiro do Norte	-	+
1998	+	+

when the independent variable is not present in the model.

5.1.3 Univariate Statistics for the Exogenous Variables in Stage 1 and Stage 2 Models

Table 5.4 presents the means, standard deviation and variance for all the exogenous variables used in the models.

Table 5.4 Mean, Standard Deviation, and Variance for Exogenous Variables

Variables	Mean	Standard Deviation	Variance
Family Size	4.79167	1.81069	3.27859
Number of Illiterate	0.81667	1.01852	1.03738
Production	4092.45500	12411.55900	1.54047D+08
Total Land	4.88146	6.04357	36.52478
Percentage of Owned Land	62.08217	47.22412	2230.11759
Total Assets	6.88333	3.16144	9.99470
Value of All Animals	1944.02917	2731.18626	7459378.37990
Neutral Salary	1074.95417	2118.17114	4486648.96442
Sensitive Salary	98.81667	332.78919	110748.64407
Subsidized Salary	1246.53750	1505.42028	2266290.20779
Water Delivery	0.33750	0.47385	0.22453
Work Fronts	0.35000	0.47797	0.22845
Monthly Food Basket	0.63333	0.48290	0.23319
Emergency Rural Credit	0.18333	0.38775	0.15035
Limoeiro do Norte	0.50000	0.50104	0.25105
1998	0.50000	0.50104	0.25105

5.1.4 Test for Heteroscedasticity for Stage 1 and Stage 2 Models

As mentioned in Chapter 4, heteroscedasticity is very common in cross-sectional data. Both Stage 1 and Stage 2 models are estimated for cross-sectional data thus it is important to test for heteroscedasticity. If heteroscedasticity is present in the model it can lead to inconsistent estimators. In Probit models the error variance is constant and restricted to equal to one (Var (u) = $\sigma^2 = 1$) so that the parameters (β) can be estimated. Otherwise, it is impossible to estimate consistent parameters (β) (Godfrey 1988 and Maddala 1983).

In order to test for heteroscedasticity, consider the alternative in which Equations 5.1 and 5.2 is replaced by Equation 5.3, below:

(5.3) $$y_i^* = g(x_i'\beta, z_i'\alpha) + u_i$$

where, z_i is a q-dimensional vector of exogenous variables and α is a q-dimensional vector of unknown parameters. The Lagrange Multiplier (LM_2) test will be used to check for heteroscedasticity (see Equation 5.4).

$$(5.4) \quad LM_2 = [-(x_i'\hat{\beta})z_i', x_i']f_i(\hat{\theta})/[F_i(\hat{\theta})(1-F_i(\hat{\theta}))]^{1/2}$$

where, $F_i(\hat{\theta}) = 1 - \Phi(x_i'\hat{\beta})$ and $f_i(\hat{\theta}) = \phi(x_i'\hat{\beta})$

The LM_2 test has a chi square distribution with 2q + 1 degrees of freedom, where q is the number of explanatory variable in the Probit model. The null hypothesis to be tested is that there is no heteroscedasticity. (Godfrey 1998).

5.1.5 Results of the Heteroscedasticity in Stage 1 and Stage 2 Models

The results from the LM_2 Test (see Table 5.5) showed that one should fail to reject the null hypothesis, in other words, there was no heteroscedasticity in either of the two models.

Table 5.5 LM_2 Test for Heteroscedasticity

	χ^2	**Degrees of Freedom**
Stage 1	33.42871	29
Stage 2	25.64037	29

5.1.6 Calculation of the Marginal Effects for Stage 1 and Stage 2 Models

As referenced in Chapter 4, in a Probit model the coefficients measure the change of the unobserved Stage 1* or Stage 2* associated with the change of each endogenous variable. However, a more useful measure to interpret the coefficient (β) is to calculate the marginal effects using Stage 1 and Stage 2. The marginal effects for the continuous exogenous variables, when no heteroscedasticity is present, are calculated by using:

$$(5.5)\ \frac{\partial E(\text{Stage1} \mid x)}{\partial x_1} = \beta_1 \bullet \phi_1(x_1\beta_1)$$

$$(5.6)\ \frac{\partial E(\text{Stage2} \mid x)}{\partial x_2} = \beta_2 \bullet \phi_2(x_2\beta_2)$$

where ϕ_1 is the probability density function for the Stage 1 model and ϕ_2 is for Stage 2. The marginal effects for dummy variables are calculated by using:

(5.7) Marginal Effects for Stage 1 of x_j =

$$E(\text{Stage1} \mid x_1 = 1) - E(\text{Stage1} \mid x_1 = 0) = \Phi_1(x_1\beta_1 \mid x_1 = 1) \bullet (x_1\beta_1 \mid x_1 = 1) - \Phi_1(x_1\beta_1 \mid x_1 = 0) \bullet (x_1\beta_1 \mid x_1 = 0)$$

(5.8) Marginal Effects for Stage 2 of x_j =

$$E(\text{Stage2} \mid x_2 = 1) - E(\text{Stage2} \mid x_2 = 0) = \Phi_2(x_2\beta_2 \mid x_2 = 1) \bullet (x_2\beta_2 \mid x_2 = 1) - \Phi_2(x_2\beta_2 \mid x_2 = 0) \bullet (x_2\beta_2 \mid x_2 = 0)$$

where, Φ_1 and Φ_2 are the cumulative density function for Stage 1 and Stage 2 models, respectively.

5.1.7 Calculation of the Goodness of Fit (R^2) for Stage 1 and Stage 2 Models

As mentioned in Chapter 4, the goodness of fit chosen for this analysis measures the categorical outcomes from the observed values and the expected counts for correct predicted values, defined as R^2_{count}:

(5.9) $$R^2 = \frac{1}{N}\sum_i n_{ii}$$

where n_{ii} are the number of correct predictions for outcome i and N is the total number of observation in the model (Long 1997).

5.1.8 Estimation Result for Stage 1 Model

The results for the coefficient parameters, p-values, and marginal effects in the Stage 1 model are presented in Table 5.6. Six variables were significant: Family Size, Number of Illiterate, Production, Total Land, Total Assets, and Neutral Salary. Most of the coefficient signs for the significant variables were expected as mentioned above, except for 'Number of Illiterate' in the household. This is a confusing result. The negative sign on this variable may be because these households already have a poor diet and therefore do not have little to change or they may have few animals to actually take off land to graze and drink.

Table 5.6 Estimation of the Stage 1 Probit Model

Variable	Coefficient	P-value	Marginal Effects	P-value
Constant	0.942832	0.060*		
Family size	0.219914	0.002***	0.059880	0.034
Number of illiterate	- 0.322028	0.004***	- 0.087685	0.029
Production	- 0.27582E-04	0.022**	- 0.751018E-05	0.046
Total Land	0.044261	0.079*	0.012052	0.122
Percentage of Land Owned	- 0.35228E-03	0.890	- 0.959212E-04	0.890
Total Assets	- 0.128342	0.004***	- 0.034946	0.021
Neutral Salary	- 0.11775E-03	0.026**	- 0.320613E-04	0.096
Sensitive Salary	0.78445E-04	0.815	0.213598E-04	0.815
Subsidized Salary	0.20793E-04	0.764	0.566179E-05	0.762
Water Delivery	- 0.179823	0.466	- 0.045077	0.478
Monthly Food Basket	0.365846	0.162	0.114613	0.182
Emergency Rural Credit	- 0.029181	0.922	- 0.784411E-02	0.923
Limoeiro do Norte	- 0.088806	0.712	- 0.023236	0.714
1998	- 0.032614	0.875	- 0.875368E-02	0.875

* significant at 0.1 ** significant at 0.05 ***significant at 0.01
N = 240
$R^2_{count} = 0.783$
Log likelihood = - 97.9621

Table 5.7 shows the overall accuracy of the predictions so that the R^2_{count} can be calculated. The Stage 1 model correctly predicts 78.3% of the cases. For comparison a nascent model would correctly predict 50% of the cases.

Table 5.7 R^2 count for Stage 1

Stage 1		**Actual** 0	**Actual** 1
Predicted	**0**	20	15
	1	37	168

5.1.9 Results for Stage 2 Model

The results for the coefficient parameters, p-values, and marginal effects in the Stage 2 model are presented in Table 5.8. Four variables were significant: Number of Illiterate, Value of All Animals, Subsidized Salary, and Limoeiro do Norte. Most of the coefficient signs for the significant variables were expected as mentioned above, except for 'number of illiterate' in the household. Again, this is a confusing result. The sign may be negative because these households may have fewer animals and assets to sell.

Table 5.8 Estimation of the Stage 2 Probit Model

Variable	Coefficient	P-value	Marginal Effects	P-value
Constant	- 0.572389	0.185		
Family size	0.016598	0.754	.659256E-02	0.754
Number of illiterate	- 0.159370	0.090*	-.063289	0.091
Production	- 0.2991E-05	0.695	-.118764E-05	0.694
Percentage of Owned Land	0.30797E-02	0.134	.122298E-02	0.134
Total Assets	0.016179	0.646	.642772E-02	0.646
Value of all animals	0.82596E-04	0.029**	.327989E-04	0.029
Neutral Salary	- 0.2911E-04	0.512	-.115593E-04	0.513
Sensitive Salary	0.11122E-03	0.689	.441452E-04	0.689
Subsidized Salary	- 0.1087E-03	0.100*	-.431620E-04	0.104
Work Fronts	- 0.301501	0.128	-.116263	0.129
Monthly Food Basket	0.217707	0.350	.086674	0.348
Emergency Rural Credit	- 0.124156	0.619	-.048886	0.621
Limoeiro do Norte	0.807405	0.000***	.299801	0.000
1998	- 0.175696	0.307	-.068833	0.305

* significant at 0.1 ** significant at 0.05 ***significant at 0.01
N = 240
$R^2_{count} = 0.638$
Log likelihood = - 146.455

Table 5.9 shows that the overall R^2_{count} of this model is 0.646, meaning that the Stage 2 model correctly predicts 64.6% of the cases.

Table 5.9 R^2count for Stage 2

Stage 2		Actual	
		0	**1**
Predicted	**0**	77	44
	1	43	76

5.2 The Eight Household Coping Strategies Decision Models

The rural households cope with droughts using one of the eight coping mechanisms shown in Table 5.10. The most common used coping mechanism in this study is change of diet, following by received help from immigrants or friends, and walked far to get water. Few households sold assets or land, only 6 (2.5%) households decided implement this strategy.

Table 5.10 Number of Families from the Study that Chose Each Coping Strategy

Coping Strategies Models	k	Yes	No
Changed Diet	1	112	128
Received Help from Family or Friends	2	97	151
Walked Far to Get Water	3	89	151
Took Animals Out of the Property to Graze and Drink	4	44	196
Sold Animals	5	84	156
Worked in a Non-Agricultural Job	6	34	206
Temporary Migration	7	18	222
Sold Assets or Land	8	6	234

Separate Probit models were estimated for each of the eight individual coping strategies. These eight Probit models are estimated to identify the factors, which play in the choice of a household to use a particular coping mechanism. The exogenous variables chosen for these eight coping strategies models include geographical and economic aspects of a household as well as, government emergency relief programs during droughts (see Table 5.11). A better explanation of the model can be seen in Table 5.12, Figure 5.2, and Equation 5.10.

Table 5.11 Exogenous Variables for the Eight Coping Strategy Models

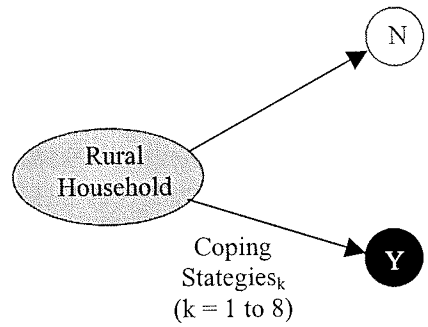
Endogenous / Exogenous	Changed of diet	Walked far to get water	Received help from immigrants or friends	Took animals out of the property to eat and drink	Sold animals	Sold assets or land	Worked in a non-agricultural job	Temporary migration
Family Size	✓	✓	✓			✓	✓	
Number of Illiterate	✓	✓	✓		✓	✓	✓	✓
Production	✓	✓	✓		✓	✓	✓	✓
Total Land	✓	✓	✓			✓		
Percentage of Land Owned	✓	✓	✓	✓	✓	✓	✓	✓
Total Assets	✓	✓	✓	✓		✓	✓	✓
Value of All Animals				✓	✓		✓	✓
Neutral Salary	✓	✓	✓	✓	✓	✓	✓	✓
Sensitive Salary	✓	✓	✓	✓	✓	✓	✓	✓
Subsidized Salary	✓	✓	✓	✓	✓	✓	✓	✓
Water Truck	✓	✓	✓	✓		✓		
Work Fronts					✓		✓	✓
Monthly Food Basket	✓	✓	✓	✓	✓	✓	✓	✓
Emergency Rural Credit	✓	✓	✓	✓	✓		✓	✓
Limoeiro do Norte	✓	✓	✓	✓	✓	✓	✓	✓
1998	✓	✓	✓	✓	✓	✓	✓	✓

✓ = exogenous variables included in each equation

Table 5.12 List of Coping Strategies

	Coping Strategies
K = 1	Changed Diet
K = 2	Walked Far to Get Water
K = 3	Received Help from Family or Friends
k = 4	Took Animals Out of the Property to Graze and Drink
k = 5	Sold Animals
k = 6	Sold Assets or Land
k = 7	Worked in a Non-Agricultural Job
k = 8	Temporary Migration

Figure 5.2 The Household Coping Strategies Decision



The household coping strategies decision are described as follows:

(5.10) Coping Strategy Models

$$\text{Coping Strategy}_k^* = x_k\beta_k + u_k \qquad \text{Coping Strategy}_k \begin{cases} 1 \text{ if Coping Strategy}_k^* > 0 \\ 0 \text{ otherwise} \end{cases}$$

where k = 1 to 8 and $u_k \sim N(0, \sigma_k^2)$

Coping Strategy$_k$* are the unobserved latent variable; x_k are vectors of exogenous variables; and β_k are the vectors of the unknown parameters. All the parameters are estimated using the maximum likelihood so that the model will consist of consistent estimators. All variances (σ_k^2) are equal to one.

5.2.1 Expected Signs for the Coping Strategy Models

The expected coefficient signs for the 'Change Diet', 'Receive Help from Family or Friends', 'Walked Far to Get Water', and 'Took Animals Out of the Property to Graze and Drink' coping mechanisms models comprise the overall Stage 1 strategy, the sign of the coefficients are expected to be the same as in the Stage 1 model. Similarly, the 'Sold

Animals', 'Worked in a Non-Agricultural Job', 'Temporary Migration', and 'Sold Assets or Land' coping mechanisms models are expected to have coefficients signs comparable to that of the Stage 2 model. Table 5.13 presents the signs for each coping mechanism model.

Table 5.13 Expected Signs for the Exogenous Variables in the Coping Strategy Models

Exogenous Variables	Coping Strategy Models (k)							
	1	2	3	4	5	6	7	8
Family size	+	+	+			+		+
Number of illiterate	+	+	+		+	+	+	+
Production	-	-	-	-	-	-	-	-
Total Land	+	+	+					+
Percentage of Land Owned	-	-	-	-	+	+	+	+
Total Assets	-	-	-	-		+	+	+
Value of all animals				+	+	+	+	
Neutral Salary	-	-	-	-	-	-	-	-
Sensitive Salary	+	+	+	+	+	+	+	+
Subsidized Salary	-	-	-	-	-	-	-	-
Water Delivery			-	-				
Work Fronts					-	-	-	
Monthly Food Basket	-	-			-	-	-	-
Emergency Rural Credit	-	-			-	-	-	
Limoeiro do Norte	-	-	-	-	+	+	+	+
1998	+	+	+	+	+	+	+	+

k=1 for Changed Diet, k = 2 for Received Help from Family or Friends, k =3 for Walked Far to Get Water, k = 4 for Took Animals Out of the Property to Graze and Drink, k = 5 for Sold Animals, k = 6 for Worked in a Non-Agricultural Job, k = 7 for Temporary Migration, k = 8 for Sold Assets or Land

When the independent variable is not present in the model.

5.2.2 Test and Results for the Heteroscedasticy for Coping Strategies Models

All eight Coping Strategy Models are cross-sectional therefore the Lagrange Multiplier (LM_2) test will be used to check for heteroscedasticity (see Equation 5.4).

Table 5.14 shows that there was no heteroscedasticity in any of the Coping Strategy Models.

Table 5.14 LM_2 Test for Heteroscedasticity

Coping Strategy Models	χ^2	Degrees of freedom
Changed Diet	24.3368	27
Received help from immigrants or friends	14.18108	27
Walked far to get water	14.60076	25
Took animals out of the property to eat and drink	22.68339	21
Sold animals	22.12990	25
Worked in a non-agricultural job	12.05437	29
Temporary migration	6.667809	27
Sold assets or land	7.090634	25

5.2.3 Calculation of the Marginal Effects for the Coping Strategies Models

Since no heteroscedasticity was found, marginal effects for exogenous variables in each Coping Strategy Models are going to be calculated as:

$$(5.11)\quad \frac{\partial E(\text{Coping Strategy}_k \mid x)}{\partial x_j} = \beta_j \bullet \phi_k(x_k\beta_k)$$

where ϕ_k is the probability density function for the coping strategy$_k$ model. The marginal effect for a dummy explanatory variable is calculated using:

(5.12) Marginal Effect for Coping Strategy$_k$ of x_j =

$$E(\text{Coping Strategy}_k \mid x_k = 1) - E(\text{Coping Strategy}_k \mid x_k = 0) = \Phi_k(x_k\beta_k \mid x_k = 1) \bullet (x_k\beta_k \mid x_k = 1) - \Phi_k(x_k\beta_k \mid x_k = 0) \bullet (x_k\beta_k \mid x_k = 0)$$

where, Φ_k are the cumulative density function for each coping strategy$_k$ models.

5.2.4 The Estimation of the Coping Strategies Models

The results for the eight Coping Strategies models are shown in Tables 5.15 to 5.22. They are present in the form of Model 1 to 8. The results of the Coping Strategy Models are discussed below by exogenous variables in bulleted format, where only significant variables are presented.

- Family Size

Family size is also positive correlated, as expected, and significant in the models: 'Changed Diet' and 'Receive Help from Immigrants or Friends'.

- Number of Illiterate

The coefficient for 'Number of Illiterate' was significant and negative correlated to 'Receive Help from Immigrants or Friends' and 'Sold Animals' models. This negative sign is not expected in either of the models. Once again, this sign may be negative in the 'Sold Animals' model because these households may not have many animals to sell. And immigrants and friends still give money if members are not illiterate specially if there is a drought.

- Production

The Production coefficient is significant in four models: 'Changed Diet', 'Walked Far to Get Water', 'Took Animals Out of the Property to Graze and Drink', and 'Sold Animals'. This coefficient is negative correlated to all four models, as expected.

- Total Land

The coefficient for 'Total Land' was significant and positive correlated, as expected, to 'Sold Assets or Land' model.

- Percentage of Land Owned

The Percentage of Land Owned coefficient is significant in two models: 'Changed Diet' and 'Sold Animals' models. This coefficient had expected signs in both models, where it is negative correlated to 'Changed Diet' model and positive correlated to 'Sold Animals' model.

- Total Assets

Total Assets coefficient are significant correlated in four models: 'Changed Diet', 'Received help from immigrants or friends', 'Walked far to get water', and 'Sold Assets or Land'. This coefficient had expected signs in all four models, where it is positive correlated to 'Sold Assets or Land' model and negatively correlated to 'Changed Diet', 'Received help from immigrants or friends', and 'Walked far to get water' models.

- Value of all Animals

The coefficient for 'Value of all animals' is significant in 'Took animals out of the property to eat and drink' and 'Sold animals' models. The sign for this variable is expected in both models, where it is positive correlated to 'Took animals out of the property to eat and drink' to the 'Sold Animals' model.

- Neutral Salary

Neutral Salary coefficient was significant and negative in the Changed Diet Model. The sign for this coefficient was expected.

- Sensitive Salary

The Sensitive Salary coefficient is significant in the Received Help from Immigrants and Friends Model. The sign is positive in this model, as expected.

- Subsidized Salary

The Subsidized Salary coefficient is significant and negative correlated to the 'Changed Diet' and 'Worked for a Non-Agricultural Job' models. This sign is as expected in both models.

- Water Delivery

The Water Delivery coefficient was not significant in any of the coping strategy models.

- Work Fronts

This variable is significant in two coping strategy models: 'Worked in a Non-Agricultural Job' and 'Temporary Migration'. The sign in both models is negative, as expected.

- Monthly Food Basket

The 'Monthly Food Basket' coefficient was significant in one model: 'Sold Assets or Land'. However, the sign for this coefficient turned out to be positive in all three models, instead of negative, as expected. The reason is not clear. The amount of food in this basket may not be enough so households may decide to sell their assets and land in order to buy more food.

- Emergency Rural Credit

The emergency rural credit was not significant in any of the coping strategy models.

- Limoeiro do Norte

The dummy variable for the *município* of *Limoeiro do Norte* was significant in three coping strategy models: 'Sold Animals', 'Worked in a Non-Agricultural Job', and 'Temporary Migration'. The sign for this coefficient was positive as expected.

- 1998

This dummy variable was only significant in the 'Sold Assets or Land' model. However, the sign for this coefficient is negative, although expected to be positive. This opposing sign may be because of the compounding effect of double drought years. Therefore households in 1999 likely felt a more profound drought effect thus forcing households to cope by selling land or assets.

Table 5.15 Estimation Results from Model 1

Variable	**Coefficient**	**P-value**	**Marginal Effects**	**P-value**
Dependent Variable: Changed Diet				
Constant	1.00842	0.046**		
Family Size	0.188808	0.002***	.063425	0.004
Number of Illiterate	- 0.174371	0.106	-.058644	0.116
Production	- 0.87118E-04	0.006***	-.293071E-04	0.010
Total Land	0.022902	0.373	.764833E-02	0.382
Percentage of Owned Land	- 0.71729E-02	0.002***	-.240777E-02	0.008
Total Assets	- 0.109451	0.005***	-.036779	0.018
Neutral Salary	- 0.36813E-03	0.000***	-.123805E-03	0.000
Sensitive Salary	- 0.26820E-03	0.460	-.907329E-04	0.456
Subsidized Salary	- 0.23288E-03	0.005***	-.782709E-04	0.007
Monthly Food Basket	- 0.033909	0.898	-.011866	0.895
Emergency Rural Credit	- 0.383798	0.191	-.141066	0.167
Limoeiro do Norte	0.194536	0.378	.061683	0.387
1998	0.022439	0.911	.747446E-02	0.911

* **significant at 0.1** ** **significant at 0.05** *****significant at 0.01**
N = 240
$R^2_{count} = 0.825$
Log likelihood = - 103.060

Table 5.16 Estimation Results from Model 2

Variable	Coefficient	P-value	Marginal Effects	P-value
Depedent Variable: Receive Help from Immigrants or Friends				
Constant	0.739069	0.079*		
Family size	0.088777	0.087*	0.033554	0.051
Number of illiterate	- 0.318620	0.002***	- 0.108035	0.005
Production	- 0.39250E-05	0.680	- 0.150741E-05	0.637
Total Land	- 0.019116	0.294	- 0.576532E-02	0.343
Percentage of Owned Land	- 0.20322E-02	0.312	- 0.505413E-03	0.454
Total Assets	- 0.087392	0.011***	- 0.035216	0.009
Neutral Salary	- 0.46889E-04	0.333	- 0.180843E-04	0.255
Sensitive Salary	0.57861E-03	0.039**	0.180819E-03	0.071
Subsidized Salary	0.18044E-04	0.787	0.631561E-05	0.776
Monthly Food Basket	- 0.377010	0.102	- 0.120783	0.151
Emergency Rural Credit	0.267428	0.291	0.054068	0.511
Limoeiro do Norte	- 0.183476	0.342	- 0.050965	0.448
1998	- 0.169570	0.325	- 0.163179	0.023

* significant at 0.1 ** significant at 0.05 *** significant at 0.01
N = 240
$R^2_{count} = 0.675$
Log likelihood = - 146.102

Table 5.17 Estimation Results from Model 3

Variable	Coefficient	P-value	Marginal Effects	P-value
Dependent Variable: Walked Far to Get Water				
Constant	0.259842	0.489		
Family size	0.044617	0.395	0.015439	0.392
Number of illiterate	- 0.174145	0.084*	- 0.060262	0.086
Production	- 0.73619E-04	0.029**	- 0.254717E-04	0.023
Total Land	0.037232	0.036**	0.012886	0.040
Percentage of Owned Land	- 0.45464E-02	0.023**	- 0.157318E-02	0.029
Total Assets	- 0.064879	0.062**	- 0.022451	0.067
Neutral Salary	- 0.15943E-04	0.759	- 0.551054E-05	0.758
Sensitive Salary	0.20841E-03	0.426	0.721205E-04	0.427
Subsidized Salary	0.88236E-05	0.899	0.305529E-05	0.899
Water Delivery	- 0.046005	0.814	- 0.016101	0.813
Limoeiro do Norte	- 0.244603	0.208	- 0.089500	0.213
1998	0.259581	0.144	0.082980	0.148

* significant at 0.1 ** significant at 0.05 *** significant at 0.01
N = 240
$R^2_{count} = 0.666$
Log likelihood = 158.830

Table 5.18 Estimation Result from Model 4

Variable	Coefficient	P-value	Marginal Effects	P-value
Dependent Variable: Took Animals Out of the Property to Graze and Drink				
Constant	- 0.541199	0.069*		
Production	- 0.60229E-04	0.050**	- 0.118987E-04	0.056
Percentage of Owned Land	- 0.13464E-02	0.554	- 0.265929E-03	0.557
Total Assets	- 0.044946	0.259	- 0.888084E-02	0.276
Value of all animals	0.15303E-03	0.001***	0.302353E-04	0.007
Neutral Salary	- 0.10729E-04	0.850	- 0.212557E-05	0.849
Sensitive Salary	- 0.40837E-03	0.237	- 0.806929E-04	0.256
Subsidized Salary	- 0.41172E-04	0.597	- 0.813628E-05	0.601
Water Delivery	- 0.233139	0.286	- 0.052552	0.281
Limoeiro do Norte	0.060549	0.781	0.011536	0.779
1998	- 0.026568	0.893	- 0.533253E-02	0.893

* significant at 0.1 ** significant at 0.05 ***significant at 0.01

N = 240

$R^2_{count} = 0.821$

Log likelihood = -104.765

Table 5.19 Estimation Results from Model 5

Variable	Coefficient	P-value	Marginal Effects	P-value
Dependent Variable: Sold Animal				
Constant	- 1.36022	0.000***		
Number of illiterate	- 0.181573	0.071**	-.071839	0.071
Production	- 0.18069E-04	0.121	-.717181E-05	0.123
Percentage of Owned Land	0.76277E-02	0.001***	.301949E-02	0.001
Value of animals	0.13412E-03	0.000***	.530947E-04	0.000
Neutral Salary	- 0.78313E-05	0.857	-.310639E-05	0.857
Sensitive Salary	0.71384E-04	0.788	.282477E-04	0.788
Subsidized Salary	0.63563E-05	0.922	.250219E-05	0.922
Work Fronts	0.038646	0.849	.015252	0.849
Monthly Food Basket	0.287809	0.225	.110335	0.221
Emergency Rural Credit	0.079556	0.752	.031272	0.753
Limoeiro do Norte	0.552907	0.005**	.201342	0.006
1998	- 0.242724	0.180	-.096568	0.178

* significant at 0.1 ** significant at 0.05 ***significant at 0.01

N = 240

$R^2_{count} = 0.433$

Log likelihood = - 131.504

Table 5.20 Estimation Results from Model 6

Variable	Coefficient	P-value	Marginal Effects	P-value
Dependent Variable: Worked in a Non-Agricultural Job				
Constant	- 0.904421	0.116		
Family size	0.085158	0.202	0.015724	0.253
Number of illiterate	- 0.073068	0.521	- 0.013483	0.544
Production	0.16841E-05	0.860	0.311506E-06	0.857
Percentage of Owned Land	- 0.39163E-02	0.143	- 0.723126E-03	0.319
Total Assets	- 0.024540	0.582	- 0.452963E-02	0.605
Value of all animals	- 0.54266E-04	0.377	- 0.100281E-04	0.399
Neutral Salary	- 0.25504E-04	0.692	- 0.471341E-05	0.683
Sensitive Salary	- 0.12983E-04	0.970	- 0.238978E-05	0.970
Subsidized Salary	- 0.24526E-03	0.024**	- 0.452788E-04	0.116
Work Fronts	- 0.528621	0.045**	- 0.100737	0.125
Monthly Food Basket	- 0.191270	0.521	- 0.029118	0.548
Emergency Rural Credit	- 0.367668	0.297	- 0.063238	0.249
Limoeiro do Norte	0.712783	0.006***	0.054851	0.203
1998	0.291626	0.192	0.030990	0.299

* significant at 0.1 ** significant at 0.05 ***significant at 0.01
N = 240
R^2_{count} = 0.854
Log likelihood = - 83.9398

Table 5.21 Estimation Results from Model 7

Variable	Coefficient	P-value	Marginal Effects	P-value
Dependent Variable: Temporary Migration				
Constant	- 1.85712	0.003***		
Number of illiterate	- 0.057595	0.658	-.236978E-02	0.707
Production	- 0.4662E-05	0.679	-.191924E-06	0.730
Percentage of Owned Land	- 0.5533E-02	0.103	-.227855E-03	0.516
Total Assets	0.071968	0.223	.296333E-02	0.536
Value of all animals	0.19173E-04	0.778	.789344E-06	0.793
Neutral Salary	- 0.1876E-03	0.133	-.772195E-05	0.486
Sensitive Salary	- 0.3417E-02	0.451	-.140668E-03	0.387
Subsidized Salary	- 0.6176E-04	0.575	-.254327E-05	0.634
Work Fronts	- 0.791523	0.042**	-.073623	0.384
Monthly Food Basket	0.144833	0.695	.511435E-02	0.731
Emergency Rural Credit	- 0.304511	0.463	-.017325	0.503
Limoeiro do Norte	0.774078	0.025**	.014700	0.547
1998	0.396086	0.166	.010787	0.546

* significant at 0.1 ** significant at 0.05 ***significant at 0.01
N = 240
R^2_{count} = 0.925
Log likelihood = - 52.7203

5.22 Estimation Results from Model 8

Variable	Coefficient	P-value	Marginal Effects	P-value
Dependent Variable: Sold Assets or Land				
Constant	- 6.72428	0.005***		
Family size	0.172361	0.313	0.133590E-02	0.585
Number of illiterate	0.096841	0.670	0.852169E-03	0.729
Production	- 0.3069E-04	0.532	- 0.254277E-06	0.672
Total Land	0.071469	0.083*	0.557063E-03	0.586
Percentage of Owed Land	0.11415E-02	0.857	0.128260E-04	0.828
Total Assets	0.322824	0.030**	0.259560E-02	0.552
Neutral Salary	- 0.2278E-03	0.173	- 0.172801E-05	0.591
Sensitive Salary	0.67478E-03	0.268	0.495120E-05	0.627
Subsidized Salary	- 0.1637E-03	0.264	- 0.132157E-05	0.622
Monthly Food Basket	1.28261	0.091*	0.269786E-02	0.641
Limoeiro do Norte	0.602980	0.291	0.234733E-02	0.645
1998	- 1.00077	0.094*	- 0.034687	0.283

* significant at 0.1 ** significant at 0.05 ***significant at 0.01
N = 240
$R^2_{count} = 0.975$
Log likelihood = -18.0770

5.2.5 The Calculation of R^2_{count} for the Coping Strategy Models

The R^2_{count} is also going to be used to calculate the goodness to fit for each coping strategy model also, as follows:

$$(5.13)\quad R_k^2 = \frac{1}{N}\sum_i n_{ii}$$

where, n_{ii} are the number of correct predictions for outcome i and N is the total number of observation in the model (Long 1997).

5.2.6 The Results of the R^2_{count} for the Coping Strategy Models

Table 5.23 shows the overall accuracy of the prediction so that R^2_{count} can be calculated for all eight models. Most models are correctly predicted, except for the 'Sold

Animals' model, where the R^2_{count} equals to 0.454. However, there are four significant variables in this model. All other models predict at least 67% of all the cases and most models predicts more than 80% of the cases.

Table 5.23 Separate Coping Strategy Model R^2_{count}

		Predicted	
		$Utilized_i = 0$	**$Utilized_i = 1$**
Changed Diet (CD)			
Actual	$Utilized_{CD} = 0$	105	23
	$Utilized_{CD} = 1$	19	93
Received Help from Immigrants or Friends (RHI)			
Actual	$Utilized_{RHI} = 0$	118	25
	$Utilized_{RHI} = 1$	53	44
Walked Far to Get Water (WFG)			
Actual	$Utilized_{WFG} = 0$	119	32
	$Utilized_{WFG} = 1$	48	41
Took Animals Out of the Property (TAO)			
Actual	$Utilized_{TAO} = 0$	194	2
	$Utilized_{TAO} = 1$	41	3
Sold Animals (SA)			
Actual	$Utilized_{SA} = 0$	68	88
	$Utilized_{SA} = 1$	48	36
Worked in a Non-Agricultural Job (WNA)			
Actual	$Utilized_{WNA} = 0$	204	2
	$Utilized_{WNA} = 1$	33	1
Temporary Migration (TP)			
Actual	$Utilized_{TP} = 0$	222	0
	$Utilized_{TP} = 1$	18	0
Sold Assets or Land (SAL)			
Actual	$Utilized_{SAL} = 0$	234	0
	$Utilized_{SAL} = 1$	6	0

5.3 Summary

Previous literature on coping strategies stated that families with more access to assets, such as valuable animals, can have more opportunity to sell animals in order to not change families diet (Corbett 1998; Campbell 1990; Campbell 1999). The estimation results for Stage 1 and Stage 2 Coping Strategies Models confirm this theory because families with less assets were more likely to implement coping strategies from Stage 1 and families with more valuable animals were more likely to use coping strategies from Stage 2.

Another interesting result was that none of the government policies affected the coping strategies in either Stage 1 or Stage 2. It was expected that emergency rural credit would reduce household's reliance on Stage 2 mechanisms, such as selling animals, assets, or land. Also it was expected that work fronts would be negative in Stage 2 Model, since access to work fronts should reduce the need to look for a non-agricultural job or migrate, a Stage 2 coping mechanisms. Water Delivery was expected to be also negative significant for coping strategies in Stage 1 model because walking far to get water and taking animals out of the property to drink are mechanisms of this stage. However, it was known later that some families who do not have wells in their homes still have to walk far to get water from nearby wells, where water is deposit by the this program. The Monthly Food Basket program also was expected to be negative significant in order for families to not change their diet, sell their animals, or ask for help from families or friends.

The variables characterized as household characteristics, such as family size, was significant in Stage 1 coping strategies. Meaning that the more members in a family the less per capita income, assets, and animals they will have. Therefore, it is more likely for large families to change their diet in order to have enough food for all the members in the household. Another important factor was that location was significant in the Stage 2 Model. It was expected that families living in *Limoeiro do Norte* would be more likely to implement the coping mechanisms from Stage 2 (sell their animals, land or assets) because this city is less dry than *Boa Viagem*. Consequently, it is more likely for families living in this *Limoeiro do Norte* to have more assets.

The Eight Coping Strategy Decision Models also had similar results as the Stage 1 and Stage 2 models. For example, the variables characterized as assets, such as 'Total Assets' and 'Percentage of Land Owned', showed again that if families have less assets they are more likely to change their diet and receive help from family or friends. Moreover, families who have more assets are more likely to sell animals, assets and/or land. Again families that live in *Limoeiro do Norte* sold more their animals, worked in non-agricultural jobs, and migrated temporarily. Still some government policies ('Emergency Rural Credit' and 'Water Delivery') were not significant in any of the Eight Coping Strategy Models. However, 'Work Fronts' and 'Monthly Food Basket' were significant in some of the coping strategies models.

The 'Work Fronts' program was negative significant in the two models expected: Worked in a Non-Agricultural Job and Temporary Migration. This means that if families benefit from working in the work fronts they are more likely to not work in a non-agricultural job and temporary migrate in search for jobs. According to Waal and Amin (1986), farmers leave their farms in order to look for non-skilled labor when there is no work fronts during a drought, which can lead to a decrease in a household's own field production. The 'Monthly Food Basket' program was expected to be negative significant in 'Change Diet' and 'Received Help from Family and Friends' models however it was only significant in the 'Sold Assets or Land' model. In this model the 'Monthly Food Basket' was positive significant which means that the more food basket a family receives the more they will sell their assets or land. As said before this is probably due to few food in the basket which induces family to sell their assets or land in order to not suffer from hunger.

CHAPTER 6

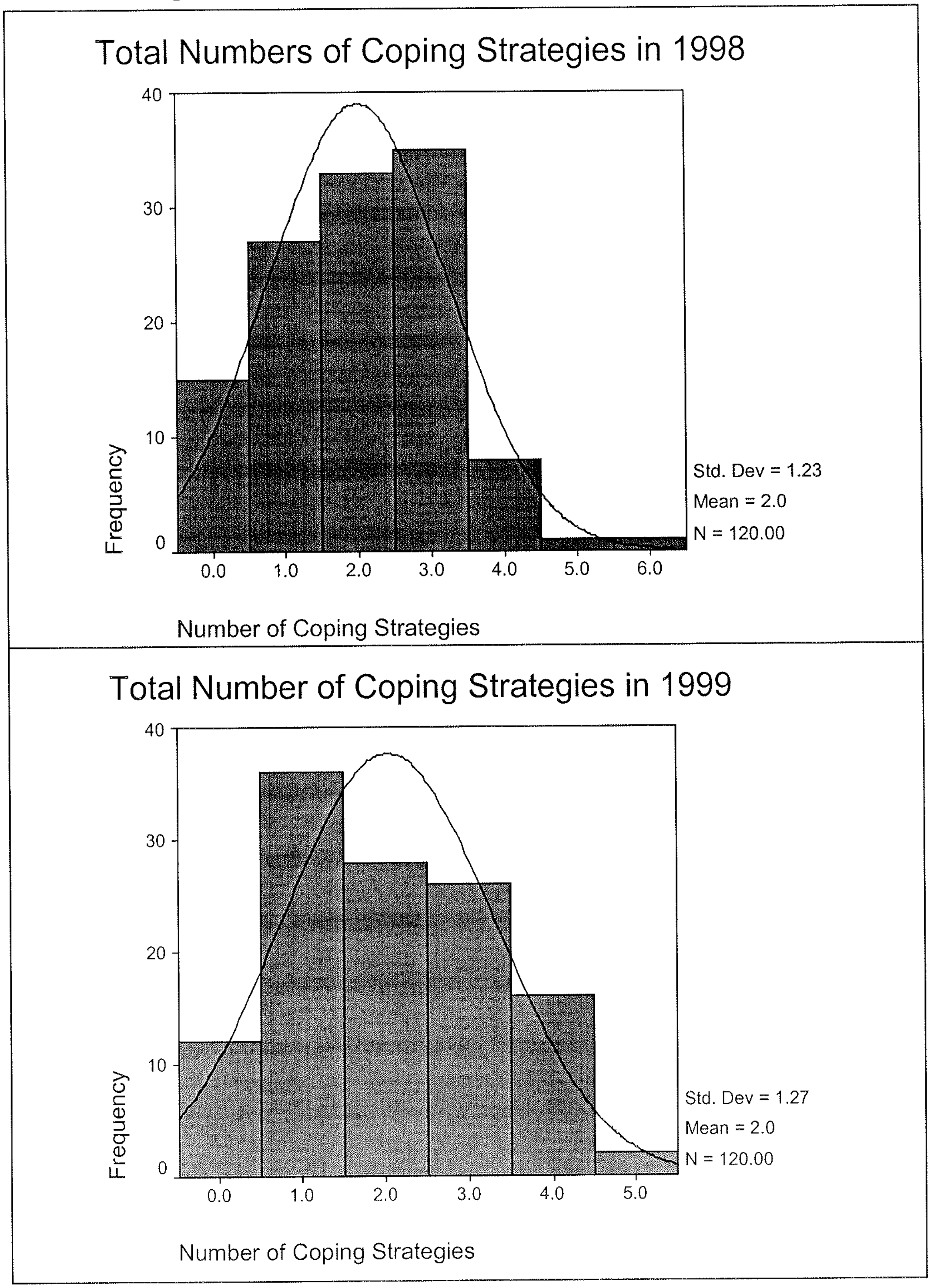
ESTIMATION TECHNIQUES AND RESULTS FOR THE COUNT MODEL

This chapter presents the analysis and results from techniques used to examine the factors, which affect the number of coping strategies that a household adopt. The Poisson model or Negative Binomial model is used to conduct this analysis of why certain households implement more coping mechanisms than others during a drought. This chapter also observes the role of household characteristics, government policies, different sources of income and any other factors in influencing the number of coping strategies adopted by household.

6.1 Data Overview on Number of Coping Strategies

The number of strategies pursued by a household may be considered as an of this severity of the stress they are experiencing from the drought. In the case of the data utilized in this thesis, there is evidence of multiple coping mechanisms use as seen in Figure 6.1. In both 1998 and 1999, the mean number of strategies used was two with a maximum of six strategies in 1998 and five in 1999. Further, approximately fifteen households in 1998 and twelve in 1999 did not implement any strategies to combat drought.

Figure 6.1 Histogram for Number of Coping Strategies



Source: Lemos et al. 2001

6.2 Poisson and Negative Binomial Models

To study the effect of different factors on the number of coping strategies used by a household either the Poisson model (see Equation 6.1) or the Negative Binomial model (see Equation 6.2) can be used. The difference between the two models is that the Poisson's mean and conditional variance are equal, whereas in case of the Negative Binomial model the conditional variance is larger than the mean. Further explanation of these two models can be seen in Equations 6.1 and 6.2 and Figure 6.2.

The household coping strategies stages decision are described as follows:

$$(6.1)\quad f(y_i \mid x_i) = \frac{e^{-\mu_i} \mu_i^{y_i}}{y_i!} \longleftarrow \boxed{\text{Poisson Model}}$$

where $y_{es} = 0, 1, 2 \ldots$

$E\,[y_i \mid x_i] = \mu_i = e^{(x_i'\beta)}$

$Var\,[y_i \mid x_i] = \mu_i$

$$(6.2)\quad f(y_i \mid x_i, \delta_i) = \frac{e^{-\mu_i \delta_i} (\mu_i \delta_i)^{y_i}}{y_i!} \longleftarrow \boxed{\text{Negative Binomial Model}}$$

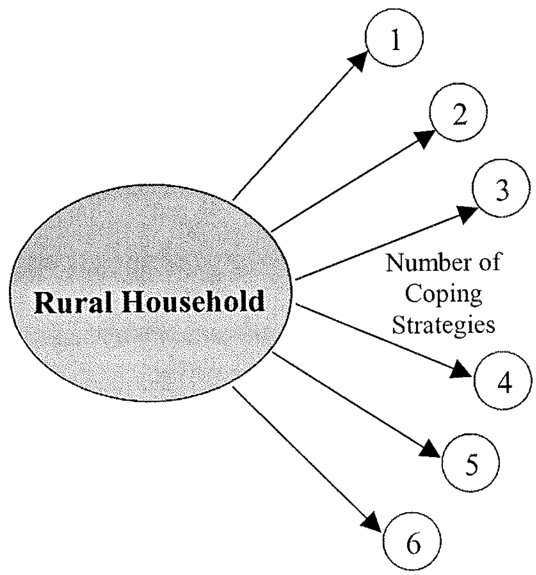
where $y_i = 0, 1, 2 \ldots$

$E\,[y_i \mid x_i] = \mu_i = e^{(x_i'\beta)}$

$Var\,[y_i \mid x_i] = \mu_i + \alpha\mu_i$ and where, α is a constant with value greater than zero

The dependent variable, y_i, is the number of occurrences of the event of interest, x_i is the vector of linearly independent regressors that determine y_i, the expected count (μ_i) has to be positive, and δ_i is the expected value of the random error that is assumed to be uncorrelated with x.

Figure 6.2 Number of Coping Strategies Model



In order to determine the best model for this data, a test for over dispersion will be conducted.

6.3 Overdispersion Test

Overdispersion occurs when the conditional variance is larger than the mean. In this case Negative Binomial model should be used. Assuming that the data are equidispersed when they are not can lead to similar consequences as when a heteroscedastic model is assumed to be homoscedastic in linear regression – leads to inconsistent estimators. Therefore, the Wald test and the Likelihood Ratio test will be used to test for overdispersion (Cameron and Trivedi 1998; Long 1997).

The Wald and the Likelihood Ratio test examine whether α is equal to zero. If α is equal to zero, then the variance equation for the Negative Binomial model reduces to the variance equation in the Poisson model. Both tests statistic has a nonstandard one-sided $\chi^2_{1-2\gamma}$ distribution due to the restriction that α cannot take value less than zero, with one degree of freedom. The Wald test is the ratio between the constant α and its standard deviation, which can be seen in Equation 6.3 (Greene 2000 ; Taylor 1974; Cameron and Trivedi 1998).

(6.3) $$\text{Wald} = \left(\frac{\alpha}{std.error} \right)^2 \sim \chi^2_{1-2\gamma}$$

The Likelihood Ratio (LR) Test is the comparison between the value of log likelihood of the Negative Binomial model (L_{NB}) and the Poisson model (L_P), as shown below (Greene 2000 ; Taylor 1974; Cameron and Trivedi 1998):

(6.4) $$LR = 2 \bullet (L_{NB} - L_P) \sim \chi^2_{1-2\gamma}$$

6.3.1 Results of the Overdispersion Test

The result of the Wald Test ($\chi^2_{0.1}$ = - 0.784, df 1) and the Likelihood Ratio Test ($\chi^2_{0.1}$ = 0.0001, df 1) show that α is equal to zero at the 95% confidence level. This indicates that this data is not overdispersed and the Poisson model should be used to estimate this model.

6.4 Exogenous Variables for the Count Model

The exogenous variables for this model are presented in Table 6.1. As mentioned in Chapter 5 (Section 5.1.1), the 'water delivery' program and 'work fronts' are highly correlated with each other (Pearson correlation coefficient = 0.64). Therefore these two government relief programs cannot be used in the same model. The 'Water Delivery' program was chosen for this model to exams if this program is significant for this model because it was significant in any other model.

The variables for 'Total Land' and 'Value of All Animals' are also correlated with each other (Pearson correlation coefficient = 0.569). 'Value of All Animals' was chosen as an exogenous variable for this model instead of 'Total Land' because there is already a variable related to land, which is 'Percentage of Land Owned'.

Table 6.1 Exogenous Variables for the Count Model

	Variable Name	Description
Household Characteristics	Family size	Number of people in the household
	Number of illiterate	Number of people in the household that are illiterate
	Production	Total amount of production of subsistence crops (beans, rice, manioc, and corn) measured in kg^2
Assets	Percentage of Owned Land	Total amount of owned land in km^2 divided by the total amount of irrigated and rainfed cultivated land in km^2
	Total Assets	Total number of assets in the household
	Value of all animals	Total value of cows, goats, donkey, and chicken in reais
Income Sources	Neutral Salary	Total amount salary – unskilled work, skilled work, business, employee, workmanship, help from family, and leased land
	Sensitive Salary	Total amount salary – agricultural labor
	Subsidized Salary	Total amount salary – work fronts and retiree pension
Government Policies	Water Delivery	Water delivery, a government emergency relief program, dummy variable where water delivery = 1
	Monthly Food Basket	Monthly food basket, a government emergency relief program, dummy variable where monthly food basket = 1
	Emergency Rural Credit	Emergency rural credit, a government emergency relief program, dummy variable where emergency rural credit = 1
Location	Limoeiro do Norte	*Município* of Limoeiro do Norte, dummy variable where Limoeiro do Norte = 1
Year	1998	Year of 1998, dummy variable where year of 1998 = 1

6.5 Expected Signs for the Count Model

The variable for family size is important because if there are more members, the more likely family is to be more sensitive to drought since assets and income will be less per household member. Therefore large households are more apt to adopt more coping strategies. Hence, the sign for this coefficient is expected to be positive. The number of illiterate people in a family can influence the amount and quality of resources a household has due to the opportunity of getting better or more diversify jobs.

Consequently, if a household member is illiterate, he/she is more likely to work in agriculture, which makes them more vulnerable to drought effects. Therefore, if a household has many illiterate members the less resources that family will likely have, thus forcing them to implement more coping mechanisms. Consequently, the sign for 'number of illiterate' is expected to be positive. Families, which depend on agricultural production, face serious problems during drought periods. Production can plummet, forcing the family to use coping mechanisms. Therefore, the sign for production is expected to be negative.

The variables for 'Total Assets', 'Value of All Animals', and 'Percentage of Land Owned' are expected to be negative because households which have many assets, especially valuable assets, valuable animals, and more owned land the more likely to sell them. Therefore families will not need to take other coping mechanisms to fight effects of drought.

The sign for the 'Neutral Salary' variable is expected to be negative because these salaries are not affected by droughts, whereas the sign of the 'Sensitive Salary' variable is expected to be positive because these salaries are based on agricultural jobs and thus related to drought effects. The 'Subsidized Salary' variable consists of work front salary and/or retiree pension. Both are given by the Brazilian government, however work fronts are only available during drought years while retiree pensions are given to rural farmers after the age of fifty, proving that they only worked in agricultural jobs their entire active life. Households receiving these subsidies therefore have greater monetary resources to deal with drought thus this variable is expected to have a negative sign. The dummies for government relief programs have negative expected signs because if a household has access to a government relief program, the less household will need to use coping strategies.

As mentioned in Chapter 5, the *município* of Boa Viagem is drier than Limoeiro do Norte. Therefore, it is expected that the farmers living in Limoeiro do Norte are more likely to implement more coping strategies because they are more likely to have more assets and animals to sell. Consequently, this variable is expected to be positive. The dummy for the year of 1998 is expected to be positive because the drought was more severe than in 1999.

Table 6.2 Expected Signs for the Exogenous Variables in the Count Model

Variables	Expected Signs for the Count Model
Family size	+
Number of illiterate	+
Production	-
Percentage of Land Owned	-
Total Assets	-
Value of all animals	-
Neutral Salary	-
Sensitive Salary	+
Subsidized Salary	-
Water Delivery	-
Monthly Food Basket	-
Emergency Rural Credit	-
Limoeiro do Norte	-
1998	+

6.6 Estimation Results for the Count Model

The results for the coefficient parameters, p-values, and marginal effects in the Count model are presented in Table 6.3. Seven variables were significant: Number of

Illiterate, Production, Percentage of Land Owned, Total Assets, Value of All Animals, Water Delivery, and Limoeiro do Norte.

Most of the coefficient signs for the significant variables were as expected, except for: 'Number of Illiterate', 'Value of All Animals', and 'Limoeiro do Norte'. Again the sign for the variable accounting for 'Number of Illiterate' is a confusing result. The negative sign on this estimate may be because these households already have a poor diet and therefore have little to change or they may have few assets and animals to actually sell or take to graze and drink. The sign for the 'Value of All Animals' is also unclear. The positive sign on this estimate may be because families employ other coping mechanisms to save valuable animals during the drought. For example, instead of selling all animals, families can still take animals out of the property to graze and drink and go great distances to get water for their animals. The sign for 'Limoeiro do Norte' is positive, although expected to be negative. This opposing sign may be because households there are more likely have more animals and assets, which may allow them to implement other coping strategies.

Table 6.3 Estimation Results from Total Number of Coping Strategies

Variable	Coefficient	P-value
Constant	1.02267	0.000***
Family size	0.018437	0.396
Number of illiterate	- 0.109582	0.011**
Production	- 0.720752E-05	0.055*
Percentage of Land Owned	- 0.157053E-02	0.064*
Total Assets	- 0.050071	0.001***
Value of all Animals	0.366689E-04	0.027**
Neutral Salary	- 0.237607E-04	0.308
Sensitive Salary	0.552725E-04	0.603
Subsidized Salary	- 0.307124E-04	0.319
Water Delivery	- 0.221828	0.008***
Monthly Food Basket	0.165996	0.140
Emergency Rural Credit	0.028175	0.786
Limoeiro do Norte	0.149113	0.061*
1998	- 0.926446E-02	0.900

* significant at 0.1 ** significant at 0.05 ***significant at 0.01
N = 240
R^2 = 0.178766
Log likelihood = - 375.578

6.7 Summary

The significant household related variables were 'Number of Illiterate' and 'Production' are significant in the Count model. However, as said before the variable for 'Number of Illiterate' has a puzzling result due to its negative sign. The negative estimate of the 'Production' variable indicates that the less production a family has the more coping mechanisms they will use to not face famine.

All three assets related variables were significant in the Count model. The estimates for 'Total Assets' and 'Percentage of Land Owned' were found to be negative, whereas 'Value of All Animals' was positive. This reveals that families with more assets and more owned land are less likely to implement various coping strategies. This may be because they can sell these goods in order to not change their diet or ask help from families or friends. However, the sign for 'Value of All Animals' is positive, which is contradictory to what was expected. Households that have a greater number of animals are more likely to implement a higher number of strategies. Households may want to preserve their animal stock and therefore choose alternate means to deal with drought effects. Furthermore there are two strategies that directly concern animals. Households may therefore be combining the animal related mechanisms with other non-animal related strategies in order to better cope with drought. This is interesting result because in the variable for 'Value of Animals' was indicating that families with more animals are more likely to sell their animals in order to not implement more strategies.

'Water Delivery' was the only government policy that was significant in this model. The negative sign on the coefficient indicates fewer coping mechanisms will be employed by a household if water is delivered. This is an interesting result because this government policy was not significant in any of the models estimated in Chapter 5. This is the only government program that diminishes household implementation of coping strategies during a drought.

CHAPTER 7

CONCLUSION

Drought conditions force farmers who depend on rainfed agriculture to find strategies to deal with few crop production. The factors affecting these coping strategies have been studied and documented throughout the world with special attention to India and Africa. However, the published studies utilize qualitative data to describe coping strategies implementation and no documentation was found that examines quantitatively the factors that influence adoption of coping mechanisms by individual households. Therefore, the main goal of this thesis was to understand how rural farmers in Ceará, a state in Northeast Brazil, cope with the consequences of drought using econometric methodologies.

7.1 Sequencing of Coping Mechanisms

The first objective of this thesis was to verify the sequential nature of coping strategies stages adopting, from the more reversible mechanisms (Stage 1) to the more irreversible mechanisms (Stage 2), using a Bivariate Probit model. However, upon investigation some households did not follow this expected sequence. Furthermore, it was discovered that the two stages have no correlation. Thus Stage 1 and Stage 2 coping mechanism used are independent and no statistical relation is present between them. Finally, when the dependence of Stage 2 on Stage 1 was modeled using a univariate probit model, the Stage 1 exogenous variable was found to be insignificant. Meaning that coping strategy Stage 2 is not dependent on coping strategy Stage 1. These results do does not support the qualitative findings from other studies of sequenced relationships among coping strategy stages. Individual categorical models should thus be used to identify the household characteristics and government policies that influence coping strategy stage use.

7.2 Factors Affecting Adoption of Coping Mechanisms

The second objective of this study was to understand how different variables influence how farmers and their families deal with drought in Ceará, Brazil. This was done by using two univariate Probit models for Stage 1 and Stage 2 coping mechanisms as well as for the eight individual coping strategies.

It was hypothesized that families with more access to assets, such as valuable animals and land, have more options to deal with drought without having to alter their diet. The estimation results for Stage 1 and Stage 2 Coping Strategies models confirm this theory because families with less assets were more likely to implement coping strategies from Stage 1 and families with more valuable animals were more likely to use coping strategies from Stage 2.

It was expected that government drought relief policies (Water Delivery, Work Fronts, Monthly Food Basket, and Emergency Rural Credit) would reduce household reliance on coping strategies, especially those classified in Stage 2. However, none of the government policies affected the households' implementation of coping strategies in either Stage 1 or Stage 2. Government policies may not be as effective as they could be in alleviating the stresses of drought on farming households in Ceará. However, it is not known if these government policies are adequate but do not penetrate sufficiently to those affected or if they are simply an insufficient means of relief.

Household characteristics, such as family size and production, were found to be more influential on the use of Stage 1 mechanisms. This is not surprising because larger families may be more rapidly affected by food shortages. In addition, Stage 1 strategies tend to require more manual labor, which larger households may have in abundance, and larger families may have members who work in non-agrarian jobs and can send help to the household.

There are general similarities among the influential factors in all the individual strategies models. Although, no clear and distinct patterns were found. It is interesting to point out that in contrast to the Coping Stages Strategies models, one government policy variable was found to be significant. It was expected that Work Fronts would negatively affect the use of temporary migration and non-agrarian work strategies. If a household was participating in work fronts it was assumed that they would not be migrating to find work or working in a non-agrarian job. The results of the 'Temporary Migration' and the 'Non-Agrarian Work' models validated this expectation. The Work Front policy therefore meets the government objective of reducing migration to urban centers.

The Poisson model was used to analyze why certain households implement more coping mechanisms than others during a drought. The combination of the negative signs of the production, total assets, and percent of land owned variables indicate that households with little production, fewer assets, and who do not own land are more seriously affected by drought by the evidence of higher coping mechanism usage. However, the sign of the 'Value of All Animals' variable was positive. Meaning that households that have a greater number of valuable animals are more likely to implement more strategies. According to the literature on coping strategies and previous findings in this thesis, it was expected that this variable would have a negative sign. While a contradictory result, households may want to preserve their animal stock and therefore choose alternate means to deal with drought effects. Furthermore, there are two strategies that directly concern animals. Households may therefore be combining the animal related mechanisms with other non-animal related strategies in order to better cope with drought.

'Water Delivery' was the only government policy that was significant in this model and that diminished household implementation of coping strategies. There is no clear reasoning for this outcome.

7.3 Limitations of this Study and Possibility for Future Research

The data utilized in this study was not specifically collected for this quantitative analysis. Information on the nature and magnitude of the individual strategies was not collected. It is not known by how much a family changed their diet or how much help the received from friends or other family members. The order of strategy use was also not collected. It is not known if the strategies were implemented simultaneously, or in a specific order; it is only known that they did utilize these mechanisms. Other information, like rainfall in the specific household location, household characteristics before the drought, detailed information on government policies and characteristics were also missing. Furthermore this was a retrospective study and relied on recall not on present actions. This may therefore bias the results.

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