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# An Exploration of the Economic Responsiveness of Emerging Commercial Bean Farmers in the Colombian Andes

by

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## ABSTRACT

The objectives of this work were first, to obtain a measure of subsistence farmers' response to price by developing a methodology which uses cross sectional data obtained at the farm level. A second objective was to find which factors influence supply response in an emerging commercial system.

The approach taken to achieve these objectives was to look at the area of study within a farming systems framework, to identify factors important in explaining response. The methodology developed, called the Frisch Interview Technique, is an iterative game which presents a farmer with two crop combinations to grow at his farm, given a certain price level. The price is increased and the change in the farmer's choice provides an indication of his change in bean acreage as a response to a change in price.

The results of the research indicated the farming system in the area is at an intermediate level of development possessing both subsistence and market-oriented goals. Three groups of farmers were identified from their response to the Frisch interview. The main distinguishing characteristics of these groups were their level of commercialization, and their perception of the two main crops in the system as complements or substitutes.

Various proxies of price response, including the one obtained from the game, indicated qualitative differences in farmer behaviour within a homogeneous region. The differences were interpreted as corresponding to stages of development. Farmers unresponsive to prices are preoccupied with subsistence and social obligations within their farming system. Farmers perceiving a complementarity between the two main crops are responding to their system environment to improve their social and subsistence achievements. Farmers substituting higher priced crops for lower priced crops in their system have made the transition to commercial goals from social and subsistence goals.

It is concluded that the interview technique provides a good indication of responsiveness to price. The results of the interview also aid in the distinction of groups of farmers, which is useful for the targetting of policy measures. It is not clear, however, whether a transition to commercial goals is a precondition to or a result of development.

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# I. INTRODUCTION

## A. Definition of the Problem

The contribution of agriculture to an economy is enhanced with greater production. Agricultural production can be increased by improving the terms of trade of agricultural products, by better economic efficiency or by increasing technical efficiency or productivity. This generalization applies to aggregate production as well as to individual commodities. The terms of trade for agriculture can be improved by raising the prices of agricultural goods relative to non-agricultural goods. On the other hand, productivity in agriculture can be achieved through the introduction of new production technologies, which are usually imbedded in new inputs.

This research will explore the effects of price changes in production and the relationship of adoption of technologies with prices with respect to a particular crop: Beans (*Phaseolus Vulgaris*) in Southern Colombia.

The effect of a price change on production is in itself an important topic of study. To implement an effective policy, policy-makers must have a good idea of the outcomes of price changes both in terms of direction and magnitude of the changes. However, agricultural sectors are not homogeneous. Responses of one group of farmers may not necessarily be the same as those which can be expected from another group of farmers. This heterogeneity of economic response is commonplace in developing countries, particularly in the case of developing countries which have dualistic economies. In developing countries subsistence farmers comprise the majority of the population. Their incomes are relatively low. It can be asked what are the factors which make one group of farmers react in a different way to prices than other farmers. The question can be taken to the lowest level of aggregation and ask, what makes one farmer react differently to prices than his neighbor?

It is believed that prices are more important in a more commercialized economy so farmers exhibiting higher levels of commercialization are believed to be more responsive to price changes in the way predicted by economic theory. As well, it is possible that as a system becomes more commercialized it needs to increase its production surplus to have enough to trade for other goods. The realization by farmers of a need for higher productivity may be a strong incentive to the adoption of new technologies. The farming system of Nariño is in transition between subsistence and commercialization. There are various subsistence characteristics such as growing crops only for home consumption, but there are also other activities which are of a purely commercial nature. The system seems to be opening its boundaries at the economic interface by using chemical inputs and selling parts of their crop. The activities within the system are closely interrelated with each other and dependent on each other. Thus, stubble is used to feed the animals and the animals are used to plough the land where the crops are grown. Similarly, all other activities of the system are interrelated and add to the system's complexity which is a characteristic of subsistence farming systems.

The problem of supply response in underdeveloped agriculture has been widely researched. Nevertheless, one of the major problems in undertaking this research is to find or collect complete and adequate data to do a traditional analysis of supply response. As an answer to this data problem a new technique to obtain information on supply response was developed and tested in the field. This methodology tries to indirectly estimate supply response to price changes by comparing beans with the other main crop in the system, and measuring how much more or less valuable beans become with respect to the other crop in the system as the price of beans is hypothetically changed.

A good understanding of the factors affecting response could not be achieved with a partial look at the particular problem of concern, such as price or production of beans. This is especially the case in a society where financial gain is not the only or the main concern of its members. A farming system framework is developed and used in the exploration of the place of prices, technology and other factors affecting production decisions in the system. In this way, all elements of the system are contemplated in their relationship with all the other elements of the system. The system is also studied in its relationships to other systems and the environment surrounding the system. The characterization of the system is based on cross-sectional microeconomic data collected at the farm level.

The area of study is found in the Southwestern corner of Colombia, in the department or province of Nariño. (Figure I.1). Colombia is the country in the Northern extreme of South America, bounded by Panama, the Pacific and Atlantic Oceans to the North, and Ecuador, Peru, Brazil, and Venezuela to the South. The country's proximity to the Equator, to the oceans, and its varied topography suggest a subdivision of the country into at least five distinctive regions. These are the Eastern Plains, the Pacific Coast region, the Amazon Basin, the Atlantic Coast region, and the Interandean zone[1],[2]. Nariño has land in the Pacific, Andean, and Amazonic zones. The area of study, however, is within the Andean region, relatively isolated from the political and cultural center of the country. The sampled farms are located in the valley formed by the Central, Oriental, and Occidental Mountain ranges. Nariño is one of the less developed provinces of Colombia, in economic, social and political ~~terms, as~~ was found in a study by Stollbrock[3]. The main economic sector of Nariño is agriculture and the main crops are wheat, barley, potatoes, beans, sugar cane, maize, and plaintain. The different crops are found in different micro-regions, defined by altitude characteristics[4].

## B. Objectives and Significance

The specific objectives of this research are:

1. To gain a wholistic understanding of the farming system of Southern Nariño, Colombia in order to identify the role of prices and new technology on changes taking place within the system.
2. To develop an alternative method to measure supply response of small semi-subsistence farmers where prices are not the primary decision criterion.

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[1]W. Jansen, "Market Impact on Cassava's Development Potential in the Atlantic Coast Region of Colombia," diss. Wageningen: University of Wageningen, 1986. pp. 32-36.

[2]H. J. Blutstein, et. al., Area Handbook for Colombia, 3rd. ed. (Washington: The American University, 1977)

[3]W. Stollbrock, "*El Desequilibrio Regional en Colombia,*" Economía Colombiana, June, 1986, pp. 45-57.

[4]*Unidad Regional de Planificación Agropecuaria (URPA). Plan Operativo 1985-1986 (Pasto: Ministerio de Agricultura. Gobernación de Nariño. 1985)* p. 2

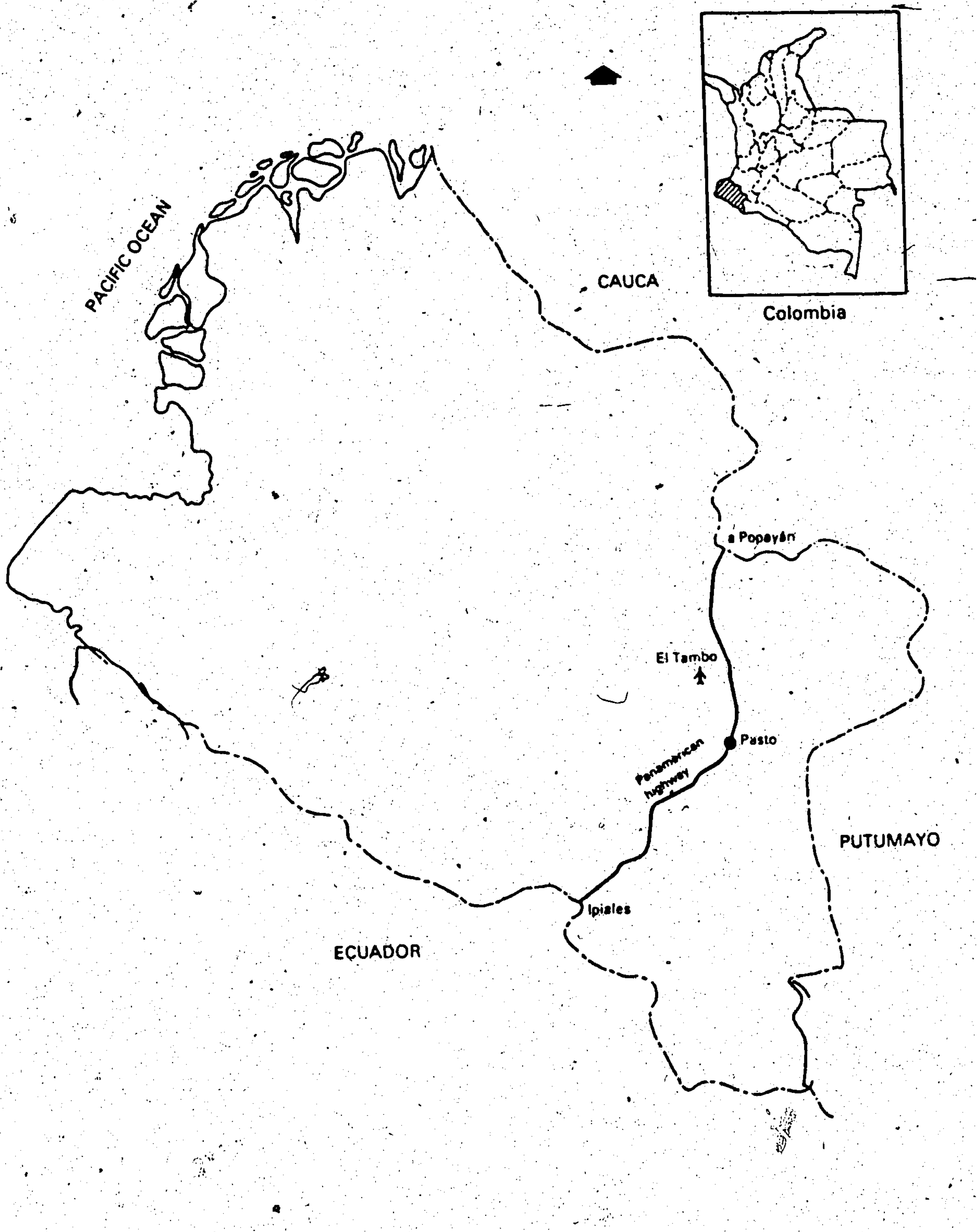


Figure I.1 The Department of Nariño in Colombia

3. To measure the price responsiveness of small farmers at a high degree of disaggregation.
4. To identify the linkages between technological change and price response.
5. To identify the factors which affect price response of farmers.

The significance of this study lies in the identification of factors which are important determinants in farmers' behavior with respect to prices, including among these factors the contacts of the farmer with the technical environment. This could allow the policy-maker to implement alternative policies to price incentives, which will pave the way for price policy to have the desired effect on the desired group of society. As well, it is hoped that the methodology developed here will be useful to other researchers in dealing with the problems of data collection in developing countries.

The significance of applying this research to beans in a semi-subsistence economy is twofold. On the one hand, beans are an inexpensive source of protein to low income rural and urban consumers in Latin America and parts of Africa[5]. On the other hand, in many parts of South and Central America they are a small-farmer crop[6]. Southern Nariño is representative of this situation. The importance of increasing bean production is to increase the availability of beans for low income urban consumers; also if producers see a surplus in their production they may increase their consumption of this crop, which is low in the area of study, since beans are considered a cash crop and are saved for the market rather than for on-farm consumption. Price incentives may not be sufficient to induce increased production, as well they may bring about higher costs to consumers or budget deficits to the treasury if prices are subsidized for consumers. The introduction of new technologies to increase productivity becomes of paramount importance in achieving increased production if the technology is appropriate and if the farmers are willing and able to accept it. Assuming that the technology is appropriate to the particular farming system in which it is being introduced, it would be useful to know what distinguishes farmers who adopt the technology and are informed about it from farmers who are very resistant to change. At this point, the aspect of new technology

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[5]CIAT, "Potential for Field Beans in Eastern Africa," Proceedings of a Regional Workshop held in Lilongwe, Malawi, 9-14 March, 1980. (Cali: CIAT, 1981)
[6]D. Pachico, "Bean Technology for Small Farmers: Biological, Economic and Policy Issues," Agricultural Administration, Vol 15 (1984), p. 72.

becomes closely knitted to the problem of price-incentive response. This supports some authors contention of a need for "balanced policy", i. e., price and non-price (technology) policy[7]. We conclude that these two elements are closely interrelated, and for development to occur, one cannot occur without the other.

### C. Organization of the Thesis

Once the problem has been defined in chapter one, a discussion of farming systems concepts begins the body of this study, to clarify to the reader which definitions were used and how the farming system of Nariño is looked at. Chapter two also reviews the ways which economists have used to measure production response to prices. A summary of pertinent elasticities is given for comparison purposes at the end of this chapter. The hypotheses are based on the findings of the literature reviewed in this chapter and the respective elasticity estimates.

Chapter three describes the methodology and data used in the study. Chapter four contains the description of the particular farming system of Nariño to allow the reader a preview of the place of beans and other crops in the system, as well as the specific input-output characteristics, goals of the system, constraints of the system and methods which farmers use to deal with such environmental constraints.

Chapter five presents the description and interpretation of the results of the research. Finally, chapter six is an attempt to summarize the findings, point out the limitations of this research and provide the reader with a conclusion which can be drawn from the results.

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[7]R. Krishna, "Some Aspects of Agricultural Growth, Price Policy and Equity in Developing Countries," Food Research Institute Studies, Vol. XVII, No. 3, 1982

## II. LITERATURE REVIEW AND THEORETICAL CONCEPTS

### A. Farming Systems

Most definitions and conceptualizations of farming systems agree in three main aspects. Firstly, that all systems are purposeful, secondly, that systems imply a transformation of inputs into outputs and thirdly that they form part of a larger system and are themselves comprised of subsystems.

Spedding provides some basic guidelines for conceptualization of agricultural systems. These include the purpose of the system, the boundaries as a way of deciding what is inside and what is outside the system, the context or external environment in which the system operates, the components of the system and their interactions or relationships, the resources which the systems use, as well as the inputs which emanate from outside the system, and finally the desired as well as the incidental but useful outputs of the system; that is, the final products and by-products of the system[8].

Ruthenberg similarly defines the characteristics of farms as a) units intentionally rational with goal-oriented activities; b) defined within physical boundaries or by the economic interactions which act as boundaries, c) places whose activities transform inputs into outputs, as well, the farm activities are all related to one another, either by the farmer's management decisions or by biological and physical interactions, d) affected in their structure by the environment, through external relations. The environment in this case involves the climate, institutions, economic climate and even the knowledge of the farmer on agricultural techniques or innovations, e) reflecting "the kind and the strength of the external relations in interaction with the kind and the strength of the internal relations[9]." This interaction is reflected in the farm structure[10].

[8]C. R. W. Spedding, The Biology of Agricultural Systems. (London: Academic Press, 1977), pp 24-5.
[9]Hans Ruthenberg, Farming Systems in the Tropics, 2nd ed. (Oxford: Clarendon Press, 1980), p. 9.
[10]Ibid.

Some minor differences in conceptualization include Spedding's division of inputs into energy or material inputs as is the case of solar radiation vs. water[11]. Ruthenberg in contrast divides inputs and outputs into economic and noneconomic, being economic those inputs and outputs which can be bought or sold or which have an opportunity cost. Non economic inputs are those which from the point of view of the farmer are free and could include solar radiation and rain.

Given the complexity of systems, traditionally people have studied the components of the system independently of each other. As Spedding points out, it is important to include and study the interaction of the components of the system to obtain a thorough understanding of the system. Systems theory attempts to do this by studying the system and the relationships among the components of the system, sometimes called subsystems, as well as looking at the relationships of the system of interest with its environment and other systems.

Some definitions of farming systems, however, still fall into the traditional pattern of division of the system. Robert D. Hart for example, argues that systems are arranged in a hierarchical order and there are systems at lower levels, such as the crop and animal systems[12]. The farm itself is part of a larger regional system. The regional agricultural system is composed of other farms, the market and credit institutions and the infrastructure which ties all these centers or institutions together. The farm is formed of subsystems which can be called agroecosystems and at the same time are comprised of crop and animal systems. There is also what he calls a socio-economic subsystem which includes the physical area of the farm and the economic exchanges of the family and management decisions that occur within the household. All these subsystems interact through the flow of energy and materials to form the farm system.

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[11]C. R. W. Spedding, The Biology of Agricultural Systems. (London: Academic Press, 1977.)

[12]Robert D. Hart, "An Ecological Systems Conceptual Framework for Agricultural Research and Development," in Readings in Farming Systems Research and Development, ed. W. W. Shaner, P. F. Philipp, and W. R. Schmehl (Boulder Colorado: Westview Press, 1982), pp 44-58.

David W. Norman asserts that a farming system is the result of a complex interaction of a number of interdependent components[13]. Norman, Simmons and Hays divide the environment that affects the farm into "human" and "technical" elements[14]. The technical elements in the environment include rainfall, temperature and soil type. They impose constraints in the cultivation and cropping practices in the farm. The human elements include social and cultural customs and economic constraints and are those equivalent to Hart's socio economic subsystem. The human elements are further divided into exogenous and endogenous factors which influence the farmer's decisions. The exogenous factors include the predominant norms and beliefs as well as the institutions which interact with the farm. History could be said to be part of the exogenous factors since the knowledge acquired through time, and the innovations made, influence the way people act today. The endogenous factors are those over which the farmer has some control but which also compel him to act in a certain manner. For example, the size and structure of the family influence a farmer's decision on labor allocation, depending on the needs of the members of the household.

The view taken in this study is more inclined towards Ruthenberg's definition of farming systems in which the farmer is at the center of the system and the socio-economic systems are not outside of the farm but within the boundaries of the farm where economic exchanges take place[15]. The farming system then ceases to be a purely physical unit but becomes a reunion of activities and interactions which affect the production processes of the farm.

The farm subsystems are related through the human activities of the farmer, that is, the farm system would not be without a human element who would act in all the subsystems therefore bringing them together into one farm system. In this sense there is not a hierarchy of systems interacting through the flow of energy. There are systems (biological, soils,

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[13]David W. Norman, "Defining a Farming System", in Perspectives on Farming Systems Research and Extension, ed. Peter E. Hildebrand (Boulder: Lynne Reinner Publishers, 1986), p.32-3.

[14]David W. Norman, Emmy B. Simmons, and Henry M. Hays, Farming Systems in the Nigerian Savanna: Research Strategies for Development. (Boulder: Westview Press, 1982)

[15]Ruthenberg's Farming Systems in the Tropics, pp. 4-5.

animal), which become subsystems of a farm system in the efforts of man to appropriate the production from them, thereby transforming them by adding or extracting inputs or materials (e. g. fertilizer, minerals, water, etc. ) and bringing them together through the flow of these new inputs, which come from other subsystems thereby creating flows of energy around the farm. In other words, when man comes to an ecological system and decides to take some plants out for his use he is doing no more than an animal in the ecological chain does. However, when this man decides to plant some seeds himself, add compost, take out weeds that he cannot use and till the land, thereby changing its structure, he is effectively transforming an ecological system into another one which can be called a farming system. The transformation of the ecological system at first implies a disequilibrium of this natural system, or the ecological system in its natural state, the farming system has therefore to find ways of bringing equilibrium to this new system. This comprises all the activities that take place in the farm, and become the purpose of the system. Its purpose is to obtain more than the natural ecological system can supply, but also to find an equilibrium so the system will not be depleted very soon. Ruthenberg explains how once an ecological system has been transformed into an agricultural system, man has to, through the use of inputs, maintain its productivity, and prevent it from falling into a "low level steady state of equilibrium"[16].

Systems are therefore always changing. Farmers are always searching for ways to increase productivity with scarcer land resources. Scientific research has the same goals of increasing the productivity of a farming system. However, it is much more difficult for a farm system to adapt to radical changes brought about by scientific research outside the system. This is because those changes may not be "appropriate" or because they bring disequilibrium to other parts of the system. For example, agricultural technology has produced herbicides which have displaced labor in labor-surplus economies; produced undesirable side effects in the soil; and increased the deforestation rate dramatically in some areas[17].

[16] Ruthenberg's Farming Systems in the Tropics, pp. 9-13.
[17] Jones and Wallace, "Social Science in FSR: Conclusions and Future Directions." in Jones and Wallace, (eds.) Social Sciences and Farming Systems Research, (Boulder: Westview Press, 1986)

Changes occurring within the system, developed by farmers within the system are less drastic, they follow more smoothly from within the system. Changes introduced from outside the system, on the other hand, may need a lot more adapting from various parts of the system or they can have disequilibrating consequences in the system. This is why farming systems studies usually try to find the effects of new technologies in a system, or to determine the appropriateness of this new technology before it is introduced into the system.

Thus when changes occur outside the farm system which affect farmers, they may not be able to adjust immediately to such changes, because they are generated outside the system. According to Ruthenberg, farmers may not perceive certain factors outside their environment or they may interpret these factors wrong therefore producing unexpected results on the part of the farmer.

This research looks at the boundaries from the farm to the outer environment, in trying to understand what characteristics of farmers stops them from either perceiving price incentives, or if they perceive them from reacting to them in the expected manner as defined by economic theory.

**Summary of Farming Systems Concepts**

Recapitulating, then, we have in our definition of a farming system the farm at the center of the activities. The farmer controls, or sometimes just deals with his environment, to obtain the maximum he can without creating strong disequilibrium in any other parts of the system.

In the boundaries with the agronomic (biological and physical) environment there is a tendency to close the system from these influences, through the use of inputs, but on the boundaries with the economic environment there is a tendency to open the system by relying more and more on purchased inputs, and on the market for the disposal of crops. As the biologic and physical environment is each time more successfully isolated (or enclosed), farmers can increase production beyond their basic needs. They therefore have to dispose of the surplus somewhere else, to obtain cash to purchase the new inputs. The increased commercialization of the system then seems to work through a feedback effect. That is, there is a small change in one part of the system and this part sends signals to other parts of the system that they have to change. Once these new parts change they send signals to all other parts to change and so on. Change is thus an ongoing process and a system is never static.

The purpose of the farmer is to close his system at the boundaries; but while the biological boundaries are being closed, the farmer has to deal with the opening of the system at the economic boundaries.

Change is implicit in this idea of improving the system. Ruthenberg does show possible venues of change from Ley systems to Permanent Cultivation Systems, to highly technified systems[11]. Within this perspective then, it can be argued that not all parts of the system simultaneously change at the same time and in the same proportion. Some things change first and adjustments have to be made to adjust to that change. The need for a change in the way of cultivation or use of technology may be evident or suspected in a community, but the farmer's mind may be holding on to traditional ideology, disallowing the adjustment process to take place. Within this perspective it could be argued that farmers in Nariño may not have adjusted to changes taking place in their environment, such as the market place or government institutions. For this reason, a method of dealing with change for some farmers may be to close the system at the economic boundaries, thereby isolating the system from economic environmental effects.

Economists concerned with the transfer of technology are especially concerned with the farming systems approach, since by introducing "appropriate technology" they try to minimize the adjustments needed to embrace the new technology in its totality.

The next section deals with the methods which researchers have used to explain the strength of the links of the farming system with the economic environment, mainly in the way of farmers' responsiveness to changes in economic factors, such as prices.

[11] Ruthenberg's, <u>Farming Systems in the Tropics</u>.

## B. Supply Response

### Introduction

The boundary of the farming system with the marketing system is formed by the monetary transactions either in the purchase of inputs or on the sale of outputs. The particular issue in this research is the exploration of one aspect of these linkages; that which relates outputs and prices. In subsistence economies these linkages are very weak or nonexistent. The conventional methods of measuring the strength of these relationships is with price elasticity of supply.

### Concept of Price Elasticity of Supply

The elasticity of supply is a measure of sensitivity of supply or production to price changes. It expresses the percentage change in quantity supplied that results from a one percent change in price, other factors held constant. Algebraically, price elasticity of supply is expressed as:

$$(dQ/dP)(P/Q) \text{ or } (dQ/Q)/(dP/P)$$

where Q = quantity supplied and P = price.

Economic theory predicts that quantity supplied increases when prices increase. However, given the nature of agriculture this is not always the case. Supply is said to be elastic when the elasticity estimate is greater than one. That is, when prices increase by one percent quantity supplied increases by more than one percent. An elasticity estimate between zero and one denotes an inelastic supply. A negative elasticity, on the other hand, represents an inverse relationship between supply and prices, which contradicts the predictions of economic theory. Nevertheless, negative elasticities for some crops have been estimated in developing countries.

Elasticity can vary for the same crop from the short run to the long run. In general, in the long run there is more time for adjustment and all resources are variable so supply is more elastic than in the short run where resources and inputs are relatively fixed. On the other hand, it is also argued that aggregate supply of agriculture is less elastic than the supply of individual crops. This proposition stems from the fact that it can be very difficult to increase the land base for agriculture, whereas it is relatively easy to switch resources among crops.

Elasticities reflect the average response of a group of farmers who in reality may have different responses to prices. In this way, if some farmers within a sample have a very strong negative response and other farmers have a strong positive response to the same price change, the ultimate result, i. e., the calculated elasticity, shows little or no aggregate change[19]. On the other hand, elasticities may reflect the response of only a minority of farmers who may own large extensions of land, or the very large producers of the country who have a major contribution to total production. Nevertheless, price elasticity of supply is the most useful and most used measurement of agricultural production responsiveness to price changes.

C. Discussion of Methods of Measuring Price Elasticity of Supply

By far the most commonly used method to estimate price elasticity of supply is based on the Nerlovian distributed lag model. Nerlove applied this model to the study of cotton, wheat and maize in the United States[20]. The popularity of this method is well documented in Askari and Cummings' survey of elasticities [21]. In this work many estimates are presented, all of which have been estimated with Nerlove's method or an updated version of the same. Nerlove's model calculated actual output as a function of lagged past and expected prices as well as expected or desired area. The source of data for this model is always time series.

[19] J. W. Mellor, "The Subsistence Farmer in Traditional Economies" in Subsistence Agriculture and Economic Development, C. R. Wharton. ed. (Chicago: Aldine Publishing Company, 1969) pp. 209-27.
[20] M. Nerlove, The Dynamics of Supply: Estimation of Farmers' Response to Price. (Baltimore: The John Hopkins Press, 1958)
[21] H. Askari and J. T. Cummings, Agricultural Supply Response. (New York: Praeger, 1976)

Many authors have used a basic Nerlovian model but have altered it to solve some of its inadequacies. The main alterations to the model reside in:

1. The inclusion of non-price and non-area variables such as yields, as in Behrman's study of Thai agriculture. Behrman included variables such as weather and technology to take into account unexpected changes in output [22].
2. The use of nonlinear methods of calculation, or methods of calculation which avoid the correlation of the error term, which is commonplace when using OLS with time series data. One such method is maximum likelihood estimation. One example applied to underdeveloped agriculture is Narayana and Shah's study of Kenyian agriculture using an ARIMA model [23].
3. The adaptation of the model to non-annual crops.

One of the main inconveniences in using a Nerlovian model for the estimation of elasticities in underdeveloped agriculture is the difficulty of obtaining reliable and complete time series data. Furthermore, the estimates obtained from this method describe what happened historically and are not necessarily good predictors of what will happen when some of the circumstances change.

In more recent years, Nerlove himself has recognized some of the problems of adapting his model to the study of underdeveloped agriculture:

> The inadequacy of the basic supply response model to disentangle the forces shaping agricultural supply in the context of a developing economy is far more serious. We are lacking both the necessary theoretical and econometric tools and the basic data. (my underlining)[24].

As a response to these problems, other methods of estimating price elasticity of supply from cross-section data have been developed. Peterson applied regression analysis directly to cross-sectional data of production and prices from many developed and underdeveloped countries with the objective of measuring the lost output caused by policies in some countries

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[22] J. R. Behrman, Supply Response in Underdeveloped Agriculture (Amsterdam: North Holland Publishing Company, 1968)

[23] N. S. S. Narayana and M. M. Shah, "Farm Supply Response in Kenya." European Review of Agricultural Economics, Vol. 11-1 (1984), pp. 85-105

[24] M. Nerlove, "The Dynamics of Supply: Restrospect and Prospect," AJAE Vol. 61-5, (1979) p. 886.

which keep agricultural prices low[25].

One of the problems associated with this method of analysis is to find data with sufficient variation to allow estimation. Within one region variation may be hard to accomplish. Another source of error is that the parameters in the model may reflect other factors different to prices, relevant to the region and therefore include long-run parameters and not only those found by short-run estimates where everything else is kept constant. Furthermore, for the supply function to be relevant, actual supply shifters have to be included in the equation, and these shifters should not be correlated with demand shifters[26].

Nerlovian models, furthermore, are very limited to finding the influences of prices in production with little regard to specific farming system characteristics which help in the determination of production.

Other methods of estimating price elasticity of supply from cross section data use a production function approach and linear programming. These methods are sometimes called "normative" while regression models, such as Nerlove's, are called "positive" models.

According to Economic Theory, in an economy with perfect competition and in which economic units aim to maximize profits, the supply function of a firm can be derived from its production function. An example of the use of a production function approach to estimate price elasticities is Gardner's study. In this study, Gardner derived own and cross price elasticities of supply in a two product, two input case[27].

Linear programming models, on the other hand, simulate optimal quantities produced to different prices[28]. Many options have been developed to make linear programming models more realistic. These models can be monoperiod or polyperiod, that is, in monoperiod models resource constraints do not change while in polyperiod models resources may change according

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[25]W. Peterson, "International Farm Prices and the Social Cost of Cheap Food Policies," AJAE Vol. 61 (1979) pp. 12-21.
[26]Ibid.
[27]B. L. Gardner, "Determinants of Supply Elasticity in Interdependent Markets," AJAE, Vol. 61-3 (Aug. 1979) pp. 463-75.
[28]K. Cowling and T. W. Gardner, "Analytical Models for Estimating Supply Relations in the Agricultural Sector" Journal of Agricultural Economics Vol. 15-3 (June 1963) pp. 439-50.

to output generation in earlier periods, and depending on behavioral patterns assumed, for example in the case of saving propensity. Furthermore, "recursive" programming models may include constraints derived from time-series data and therefore restrict the transference of resources among enterprises, and limiting technological diffusion. The "flexibility coefficients" thus obtained are similar to adjustment coefficients of distributed lag models. These models include real data and the inclusion of restrictions which simulate risk aversion of producers presents a distinct advantage from Nerlovian-type of studies which have not been able to incorporate risk variables[29]. One such study is Pomareda and Samayoa's application of a linear programming model to a region of Guatemala [30].

Pomareda and Samayoa divided their sample into large and small farmers, and included a measure of risk aversion which was higher for small farmers, based on empirical evidence. Small farmers were those with holdings of less than eight hectares and they concentrated their production on rice, cassava, maize in monoculture, and maize in association with either beans or sesame.

The model is quite flexible since it allows for several ways to produce each crop but subject to limited resources. A shift in the use of labor, machinery and animal power is seen as a movement along the production function, since these factors are considered substitutes. An increase in yield from fertilizer or chemical input application or better cultural practices is considered a shift of the production isoquant.

Though normative models of supply estimation take many characteristics of the farm system into account, they are also an aggregation of a group of farmers, nevertheless, the group can be stratified into different groups, as was done by Pomareda and Samayoa's division of the farmers into large and small owners and further differentiating them by their risk aversion coefficient.

Some of the drawbacks of the cross-section models are the inclusion of assumptions of producers objectives, such as profit maximization. In other words, as Timmer, Falcon and

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[29] Ibid.

[30] C. Pomareda and O. Samayoa, "Area and Yield Response to Price Policy: A Case Study in Guatemala C. A." AJAE Vol. 61 (Nov. 1979) pp 683-6.

Pearson put it, these studies assume what is sought, i. e. the extent to which farmers respond to price changes. They ascertain that these estimates are useful for placing upper bounds to plausible farmer responsiveness. More information however is needed on the production process in order to make predictions of price elasticities of supply. As well, factor prices must be known, and there is no room for economies or diseconomies of scale[31].

Other studies which incorporate other farming systems characteristics and allow for different behavior other than maximization of financial gains, are those which try to incorporate the consumer and producer aspects of farmers in less developed agricultures. These studies usually try to model an agricultural household by using the production function approach in which the farmer is assumed to maximize utility subject to leisure time available (family labor), consumption needs, or income constraints. Chihiro Nakajima developed some models using this approach, dividing farms into four groups, according to the degree of hired labor used on the farm and the level of commercialization of such farms[32]. Strauss applied a model of this type to estimate the elasticity of marketed surplus in Sierra Leone. In his study, Strauss incorporates production and consumption criteria by having the farmer maximize profits from a production function and utility subject to full income and time constraints[33].

Barnum and Squire applied a similar model in Malaysia[34]. As complete or accurate as Barnum and Squire's model may be, it must be pointed out that for this work 839 households were interviewed weekly during the course of one year. Surely this kind of studies is very difficult to accomplish given the length of time and amount of resources, both material and people skills, needed.

[31] C. P. Timmer, W. P. Falcon, and S. R. Pearson, Food Policy Analysis (Baltimore: The John Hopkins University Press, 1983)

[32] C. Nakajima, "Subsistence and Commercial Family Farms: Some Theoretical Models of Subjective Equilibrium" in Subsistence Agriculture and Economic Development, ed. C. R. Wharton, Jr. (Chicago: Aldine Publishing Company, 1969) pp. 165-85.

[33] J. Strauss, "Marketed Surpluses of Agricultural Households in Sierra Leone" AJAE Vol. 66-3 (Aug. 1984) pp.321-31.

[34] H.N. Barnum and L. Squire, A Model of an Agricultural Household: Theory and Evidence, Baltimore: The John Hopkins University Press, 1979)

**Comparison of the Methods and Results Obtained from these Methods**

Production function estimation and linear programming are similar methods conceptually, but they differ in that linear programming assumes zero variance throughout. This means that the input ratio is assumed to be the same for all producers. Both methods assume maximization subject to constraints, but linear programming allows for the inclusion of inequalities which permits the non use of resources. In production function estimation there are usually only two crops or groups of crops considered, while it is easier to consider many crops in linear programming[35]. In summary, in comparison with the production function model, the linear programming model is less flexible because of its assumptions, but it is more flexible because it can include more constraints.

On empirical grounds, elasticities obtained from time series analysis are usually considered more reliable, but when compared with cross-section results it is not obvious which estimates are mo-e accurate. Wipf and Bawden compared estimates obtained from regression of time series data with supply functions derived from production functions for various lengths of run and of various forms[36]. They found that different elasticity estimates are obtained depending on the specification of the production function and found that the logarithmic function provided erroneous predictions. As well, they thought that estimates obtained from derived supply functions were over-sensitive to changes in the length of run. Finally they concluded that derived supply elasticities are not consistently under or overestimating the magnitude or direction of bias, sometimes overestimating and sometimes underestimating actual output[37].

In testing the predictive accuracy of both kinds of estimates, Shumway et. al. reached a very different conclusion. They found that linear programming estimates are half of the time more accurate predictors of output than "positive" estimates [38].

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[35]K. Cowling and T. W. Gardner, "Analytical Models for Estimating Supply Relations in the Agricultural Sector" Journal of Agricultural Economics Vol. 15-3 (June 1963) pp. 439-50.

[36]L. J. Wipf and D. L. Bawden, "Reliability of Supply Equations Derived from Production Functions," AJAE Vol 51-1 (Feb. 1969)

[37]Ibid

[38]C. R. Shumway and A. A. Chang, "Linear Programming versus Positively

As a partial conclusion it can be said that even though Nerlovian models are usually considered to provide more reliable estimates of elasticities, researchers face data constraints in the application of these models to less developed countries. Application of linear regression to cross sectional data involves the introduction of supply shifter variables and problems when the data does not present enough variation. Linear programming models and those that use a production function approach present the advantage of permitting stratification of producers but need very detailed data. Furthermore, these models must make assumptions about the producers' objectives. The full objectives of semicommercial farmers in less developed countries have not as yet been properly specified. It is hoped that the method used and developed in this work will aid in the understanding of semi-commercial producers' objectives and in the estimation of a disaggregated measure of response to prices.

The following section will present the actual estimates of elasticities which have been obtained using the methods outlined in this section. These results point out the achievements and the limitations of such methods.

D. Estimates of Supply Elasticities of Various Crops

The study of supply elasticities can be divided in three broad areas. Studies of supply elasticity of aggregate agricultural production, studies of single crop response, and studies of elasticity estimation of marketed surplus. In this section we concentrate on single crop response studies and also report some results of marketed surplus studies, since this work looks at the response of a single crop (beans), with commercial and subsistence characteristics.

The results presented in this section pertain to:

1. crops in subsistence agriculture which present similar characteristics to beans in Colombia, obtained from any method,
2. bean and similar legume price elasticities found for either developed or developing countries,

[31](cont'd) Estimated Supply Functions," AJAE Vol. 59 (May 1977) pp. 344-57.

3. non-price factors reported to affect supply response of farmers.

**1. Crops in Subsistence Agriculture with Similar Characteristics to Beans**

Concerning the first point most studies done on elasticities in developing countries have been done with time series Nerlovian models and on staple grains such as rice, maize and wheat, or on export cash crops, such as cocoa, coffee, rubber and palm[39].

Beans are an important food crop in Latin America and Africa and are usually a nutritional complement to other cereals. Given the demand for beans in urban centers, beans can also be an important cash crop, as is the case in Southern Nariño, Colombia. Since in Nariño beans are intercropped with a subsistence crop, maize, the planting decision is also determined by subsistence characteristics.

Maize in Thailand is a crop which seems to parallel the bean crop in Southern Nariño. It is often intercropped and a small portion of the output is consumed on the farm. Behrman applied a Nerlovian model to maize but found that the yield and malaria control, proxi for clearing of more land, variables were usually more significant than the expected price variable. The estimates of price elasticities obtained by Behrman range from .27 to 4.47 for the short run and from .41 to 14.13 for the long run, depending on the region [40]. In Kenya, pulses, especially beans, are often broadcast with maize. The results obtained from Narayana and Shah show that own expected price of maize was significant in explaining bean acreage response [41].

In Guatemala the results obtained for maize are very interesting. The net output elasticity estimated in this model is +.68, which includes a yield elasticity of +.5. The estimate for area of maize alone is +1.336 but for maize associated it is -1.89. This means that as prices for maize increase, there is an increase in plantings of maize alone and a decrease in maize planted in association. The higher yields for monoculture therefore

[39] See for example Askari and Cummings's survey of response studies
[40] J. R. Behrman, Supply Response in Underdeveloped Agriculture (Amsterdam: North Holland Publishing Company, 1968)
[41] N. S. S. Narayana and M. M. Shah, "Farm Supply Response in Kenya." European Review of Agricultural Economics, Vol. 11-1 (1984), pp.85-105

contribute to higher output even if total area planted with maize remains the same. Interestingly, monoculture is also more risky, since it requires higher expenditures and as reported by the authors it has higher variability of returns [42].

In summary, the increased production of maize takes place at the expense of bean and sesame production, which are only planted intercropped with maize. These results are very relevant for the present study. However, it must be pointed out that maize seems to be a more commercial crop in Guatemala than in Southern Nariño. As well there is a known complementarity of beans and maize for nutrition in Central America, including Guatemala, and therefore beans are probably more a subsistence crop in Guatemala than in Colombia.

With this in mind, it can be hypothesized that in the case of Colombia, a positive change in the price of beans is also likely to increase the bean area planted in monoculture at the expense of maize production. This would, however, only take place, at prices high enough for beans that the farmer could purchase his/her deficit of maize caused by such planting changes.

Rice is an important food and cash crop in Thailand. Barnum and Squire reported elasticities for rice production with respect to price ranging from -.02 to .11 but concluded that "...the effects of government price intervention on output and marketed surplus have been essentially nil." [43].

Other estimates which may provide a guideline to our study are those presented by Strauss on root crops (.10), oils and fats (.02), and miscellaneous foods including legumes (.15) [44]. These crops are consumed on the farm but mainly sold. A summary of elasticities of crops similar to beans is presented in Table II. 1.

[42] C. Pomareda and O. Samayoa, "Area and Yield Response to Price Policy: A Case Study in Guatemala C. A." AJAE Vol. 61 (Nov. 1979) pp 683-6.
[43] H.N. Barnum and L. Squire, A Model of an Agricultural Household: Theory and Evidence, Baltimore: The John Hopkins University Press, 1979) p. 95.
[44] J. Strauss, "Marketed Surpluses of Agricultural Households in Sierra Leone" AJAE Vol. 66-3 (Aug. 1984) pp.321-31.

Table II.1: Supply Elasticities, Semi commercial Crops, Selected Regions

| Crop | Estimate | Source | Region |
|---|---|---|---|
| Maize s-r | .27 - 4.47 | Behrman(1968) | Thailand |
| Maize l-r | .41 - 14.13 | Behrman(1968) | Thailand |
| Maize s-r | .68 | Pomareda & Samaypa(1979) | Guatemala |
| Cotton s-r | .41 | Falcon(1964) | West Pakistan |
| Wheat s-r | .10 - .20 | Falcon(1964) | " |
| Root crops and other cereals | .10 | Strauss(1984) | Sierra Leone |
| Oils and fats | .02 | Strauss(1984) | " |
| Miscellaneous (including legumes) | .15 | Strauss(1984) | " |
| Sorghum s-r | .18 - .24 | Medani(1975) | Sudan |
| Sorghum l-r | .25 - .47 | Medani(1975) | " |
| Rice | -.02 - .11 | Barnum & Squire(1979) | Malaysia |

Source: Compiled by the author.
Note: Complete source information can be found in the bibliography.

**2. Bean and Similar Legume Elasticities**

Elasticity estimates for beans vary widely according to the country of study, as can be seen in table II. 2.

In the United States, specifically in California, where bean growing is a very commercial enterprise, estimates of price elasticity range from 4 to 14.1, where the best predictor is the positive estimate 12.8 [45]. In Britain in data from 1938 -1953, the predictors obtained by Jones, as reported in Askari and Cummings, were .39 for the short run and .53

[45] C. R. Shumway and A. A. Chang, "Linear Programming versus Positively Estimated Supply Functions," AJAE Vol. 59 (May 1977) pp.344-57.

for the long run [46].

In Kenya, Narayana and Shah found that expected own price was important in the acreage allocation decision. Since beans and other pulses were often broadcast in the maize fields, expected bean yield and current maize area were also significant determinants of pulse production [47].

Estimates from Brazil show very low and negative elasticities. In many studies the price coefficients were non-significant. It must be remembered that beans are an important food staple in Brazil.

According to Sampaio, acreage planted is independent to bean prices and bean production responds more to the price of the crop with which it is interplanted[48]. Brito's study support these results. Cross elasticity of bean plantings with respect to price of maize was estimated as .04, while own price elasticities were -.22 and -.23 for the short and long term respectively. For yield the bean price elasticity was .58 and for output it was .37[49].

From these observations it can be hypothesized that crops presenting subsistence and commercial characteristics have very inelastic response to prices. it is possible that a minimum acreage must be planted each year by the farmer to assure subsistence. Price response may take place in growing some extra beans with the specific objective of marketing the excess from production. At low product prices, then, there may be no response of production, showing only a habit factor. At high enough prices, elastic price response may be achieved, over and above subsistence requirements.

[46]H. Askari and J. T. Cummings, Agricultural Supply Response; (New York: Praeger, 1976)
[47]N. S. S. Narayana and M. M. Shah, "Farm Supply Response in Kenya," European Review of Agricultural Economics, Vol. 11-1 (1984), pp.85-105
[48]Y. Sampaio, "An Analysis of the Market for Dry Edible Beans in Northeast Brazil," unpublished Ph.D. diss. Davis: University of California, 1974
[49]A. J. P. Brito, "*Estimativa da Oferta de Feijao, na Micro-regiao Homogenea,*" unpublished M.Sc. diss., Lavras: *Escola Superior de Agricultura de Lavras, Brazil,* 1980.

**Table II.2: Supply Elasticities, Beans, Selected Regions**

| Region | Estimate | Source | Observations |
|---|---|---|---|
| California | 4.0 - 14.1 | Shumway & Chang(1977) | l-r |
| Britain | .39 | Jones in Askari & Cummins(1976) | s-r |
| " | .53 | " | l-r |
| Bahia (Brazil) | -.22 | Brito(1980) | s-r acreage |
| " | -.23 | " | l-r " |
| " | .37 | " | w r to output |
| " | .58 | " | w r to yield |
| " | .04 | " | w r to maize |
| Brazil | .31 | Toyana & Pescarin (in Sampaio(1974)) | s-r non significant |
| " | .44 | " | l-r significant |
| Brazil | .04 | Brandt et al (in Sampaio(1974)) | |
| Brazil | Non. sign | Paniago (in Sampaio(1974)) | w r to maize |
| " | .16(s-r) | " | " |
| " | .46(l-r) | " | " |
| Northeastern Brazil | Non. sign | Sampaio(1974) | Mix of X-sect and time series data |
| Brazil | | Smith (in Sampaio(1974)) | |
| Kenya | Significant but unreported | Narayana & Shah(1984) | ARIMA model |

Source: Compiled by the author.
Note: Complete source information can be found in the bibliography.

**3. Non-price Factors Affecting Suppply Response of Farmers**

Studies usually intended to find price elasticities of supply often have to include other variables to increase the R square of the equation or the level of significance of the price variable. In most studies of supply response, the variables included, aside from prices are a weather variable, a yield variable, a technology variable and a time trend variable. As Krishna reports, the technology variables, such as the proportion of land under irrigation are often more significant or of larger magnitude than the coefficients of the price variables[50]. Falcon found in his study that the rainfall variable was more significant than the price variable in explaining acreage of wheat, a food crop in the area of study[51]. In Sampaio's study, only the acreage in the year t-1 was significant in explaining acreage in year t, and was considered as little explanation of supply response, seen only as a time trend. The inclusion of non-price variables is common-place in many other studies of supply response and it implies that prices alone cannot account for a large enough portion of the variation of supply. Falcon asserts that weather and grainstock uncertainty may be more important consideration if subsistence is at risk, i. e., meeting the family's food needs.

Pomareda and Samayoa also conclude that since resources are very scarce in developing agriculture, namely land and labor, production increases have to come through the development of technologies, i. e. the increase in yields.

**Observations Based on These Results**

The estimates that have been presented vary widely not only across countries but even within the same countries, as can be seen in Behrman's regional differences for maize price elasticities and the various elasticities found for beans in Brazil as shown in table II.2 . Only two studies to my knowledge have intentionally attempted to explain the variability in response. Askari & Cummings' survey and Petzel's study of the effects of education on the

[50]R. Krishna, "Some Aspects of Agricultural Growth, Price Policy and Equity in Developing Countries," Food Research Institute Studies Vol. XVIII-3 (1982)
[51]W. P. Falcon, "Farmer Response to Price in a Subsistence Economy: The Case of West Pakistan," American Economic Review Vol. LIV-3 (May 1964) pp. 580-91.

adjustment process of agricultural producers[52]. Other authors have pointed out this variability and stressed the need to understand the source of variation of the estimates.

In 1965 Mellor wrote that: "An important research need is to study variability within communities in order to provide guidelines for action programs[53]." Mellor mentions farm size, asset position, income, level of education and "other social factors", as possible sources of the variability, and further explains that farmers' objectives and values may change over time therefore, "It is important that policy recognize and adjust to such changes[54]." Boussard, twenty years later, acknowledged again the heterogeneity of agriculture but does not believe farm size influences price response. He sees the main variable affecting supply-response variability to be the degree of asset fixity and argues that "input fixity can be as important on a big farm as on a small one[55]." Furthermore, he argues that in LDC's "...it is generally admitted (...) that price-elasticity of supply is high on peasant farms because they have few fixed inputs[56]." Boussard also acknowledges the changing nature of farmers' objectives and values, and asserts that as some farmers are able to achieve some goals, others achieve them later, and thus aggregate elasticities are forever changing.

Askari and Cummings in their survey of the econometric evidence chose estimates from various regions and on various crops and tested how land fertility, risk, size of holding, education, land tenancy pattern, farm income, availability of irrigation facilities, unutilized arable land, and relative importance of the crop in the area, affected the magnitude of the reported price elasticities. The results for relative importance of the crop and weather related risks are inconclusive. However, price and yield related risks were negative and significant while fertility or yield, farm income, male literacy, size of holding , and percentage of land in hands of owner cultivators were all found to be positive and significantly related to price

[52]T. E. Petzel, "The Role of Education in the Dynamics of Supply," AJAE (Aug. 1978) pp. 445-51.

[53]J. W. Mellor, "The Subsistence Farmer in Traditional Economies," in Subsistence Agriculture and Economic Development. ed. C. R. Wharton, Jr. (Chicago: Aldine Publishing Company, 1969) p. 216.

[54]Mellor, p 216

[55]J. M. Boussard, "Is Agricultural Production Responsive to Prices?" European Review of Agricultural Economics Vol. 12 (1985) p. 41

[56]Ibid.

elasticity of supply.

Petzel's study of speed of adjustment of response in U. S. Agriculture support Askari and Cummings results with respect to education. He found that the more education farmers had, the faster was the adjustment towards equilibrium.

Boussard contributes to this point when he concludes that

> ...'factor shares' which characterize both the structures and the states of techniques are liable to play a large role in the explanation of elasticities at a given place and time[57].

Following this discussion, some more specific hypotheses can be formulated on variables which affect responsiveness. Some of the variables believed to affect response are level of education, level of adoption of technology, and other variables reflecting farmers' attitudes. Farm size is not considered to affect elasticity as Mellor suggests, since total acreage is probably influenced by farm size, but changes in acreage are not necessarily influenced by this variable.

As Dillon & Scandizzo reported, owners seem to be more risk averse than sharecroppers; so the larger the area owned by the farmer the less willing the farmer is to take a risk and change his production from his habitual response[58].

From the data in table II. 2., it can be seen that bean price elasticities are higher for the developed country; United States, than for the developing country; Brazil. These two countries represent two extremes of commercialization, the U. S. representing a highly commercialized agriculture and Brazil, given the subsistence characteristics of beans in this country, representing a subsistence agricultural system.

This permits us to hypothesize that the more commercialized the agricultural system is, the fastest and the more responsive this system is to react to a change in prices. This hypothesis was already in the gestation stage in the discussion of the farming system, where it was mentioned that the more open a system is to purchased inputs and materials, the more open it must be to the market system, i. e. relying on this system for disposal of production

[57]Boussard, p. 42

[58]J. L. Dillon and P. L. Scandizzo, "Risk Attitudes of Subsistence Farmers in Northeast Brazil: A Sampling Approach," AJAE (Aug. 1978) pp. 425-35.

and therefore the more dependent the farmer is on prices for his products and the more flexible he has to be to respond to price changes. Variables which represent level of commercialization are the proportion of crops sold/consumed, the income obtained from sales, the proportion of land in commercial crops, the involvement of family labor in the market economy and possibly the use of credit and value of machinery and animals owned by the farmer.

Some authors may not agree on this point, arguing, such as Boussard does, that the most important factor restricting the price reaction is the level of factor fixity of the farmer, which is not necessarily stronger for less developed agricultures. Many authors, however, agree that a farmer in a less developed country has other problems to worry about rather than obtaining a good price for his crops. As Falcon concludes weather factors may restrict the extent of the farmers' reaction to price.

Medani provides supporting evidence to these arguments. In a study done in Sudan, Medani divided the sample into 6 groups denoting different levels of development defined "according to the extent to which they are involved with the market mechanism in purchasing their inputs and selling their output[59]."

Medani's study concentrated on the four more subsistence groups and calculated their respective price elasticity of marketed surplus for sorghum. These elasticities proved to differ among groups with an F test, and even though he did not find a general pattern in the estimates, it was true that the least-developed group had the lowest estimate while the most developed group had the highest estimate of elasticity.

From this discussion, we can summarize our findings by asserting that:

1. Crops with subsistence characteristics often have inelastic response to price or insignificant price coefficients in the analysis.
2. Elasticities are useful concepts but when they represent highly aggregated groups of

[59]A. I. Medani, "Elasticity of the Marketable Surplus of a Subsistence Crop at Various Stages of Development," Economic Development and Cultural Change Vol. 23-3 (April 1975) p. 424

farmers, they can be misleading or provide policy-makers with misleading interpretations.

3. It is therefore useful to stratify the sample according to some criterion and then try to estimate an elasticity per group.

4. Since in underdeveloped agriculture, time series data is in short supply, especially good quality data, it would be useful to use or develop a method using cross-section data to find a measurement of supply response, not necessarily price elasticity of supply.

Krishna further argues in his survey, that in most studies of supply response, variables with a strong technological content are often more significant or have higher magnitudes than the price coefficients used in the same regressions. Although Krishna bases his observations on studies of aggregate agricultural supply response, it is believed that this situation is applicable to the case of single crop response. Technology refers, in this case, to the technology relevant to the crop in question, such as new varieties or input use. Technology applicable to other crops in the system may also have indirect effects on the commodity in question, though this issue is not dealt with here.

5. It is important, as Krishna asserts, to take into account technology policy in conjunction with price policy. Recapitulating the discussion of Farming Systems concepts and the description of the farming system, as a system closes its boundaries to the biological environment, through the use of new inputs, it also becomes more commercialized, relying more in the market system for the acquisition of these inputs and the disposal of excess production.

In summary, the hypotheses put forward on this chapter are that:

Prices are not expected to be strong determinants of production in a system with many subsistence characteristics. However, there may be some price response over and above a minimum requirement of maize acreage. As well, response may come from moving from intercropping to monoculture practices.

With respect to factors affecting response, higher education, knowledge and appropriate use of new technology, as well as possibly a younger age positively influence price response. Farm size per se may not influence response but it does allow greater flexibility to a farmer who wants to change production in response to prices.

The more important the crop is in the system, the more specialized the farmer is with this crop and the more commercial he probably is as well. Commercial farmers are highly dependent on market fluctuations and must be flexible in their response to market signals to continue to be successful in commercial agriculture.

In the next chapter, the methodology employed for data collection and for testing the relationships hypothesized, will be presented.

## III. RESEARCH METHODOLOGY

### A. Data Collection

#### The Sampling Frame

After an exploratory survey of the area, it was decided to restrict the sampling area to elevations between 2600 and 2800 meters of altitude. This was done to obtain some homogeneity in the area. The climatic and marketing environments are the same for all farms. The topography is also similar and the altitude restricts the type and variety of crops grown and the season in which to grow them. The distances to the main market in Ipiales are between 10 and 20 kilometers and all farming areas have similar transportation facilities. See figures III.1 and III.2 for the location and topography of the area.

Aerial maps were to be used in the random selection of farms but the maps were outdated or incomplete. The land registration office in Ipiales was not a good source of lists of the population either because of problems of double counting. This source would also exclude landless sharecroppers. Lists of names of the farmers inhabiting each *vereda* were obtained from a prominent or popular member of the community. With the aid of government extension workers and CIAT's technicians, six *veredas* were chosen in which beans were an important crop. A *vereda* is a geographical area and the smallest political unit.

#### The Sampling Method

Each household from the list was associated to a number and numbers were drawn to reach the sampling fraction. If all these farmers could not be interviewed, numbers were drawn again to reach the sample size. The sampling fraction of .10 was arbitrarily selected to bring the number of interviews to 60, which was considered a manageable number given resources. Sixty one farmers were finally interviewed to form the study sample.

Tests for normality were done for some of the variables and showed the data came from normal distributions. With analysis of variance, veredas were tested for differences of

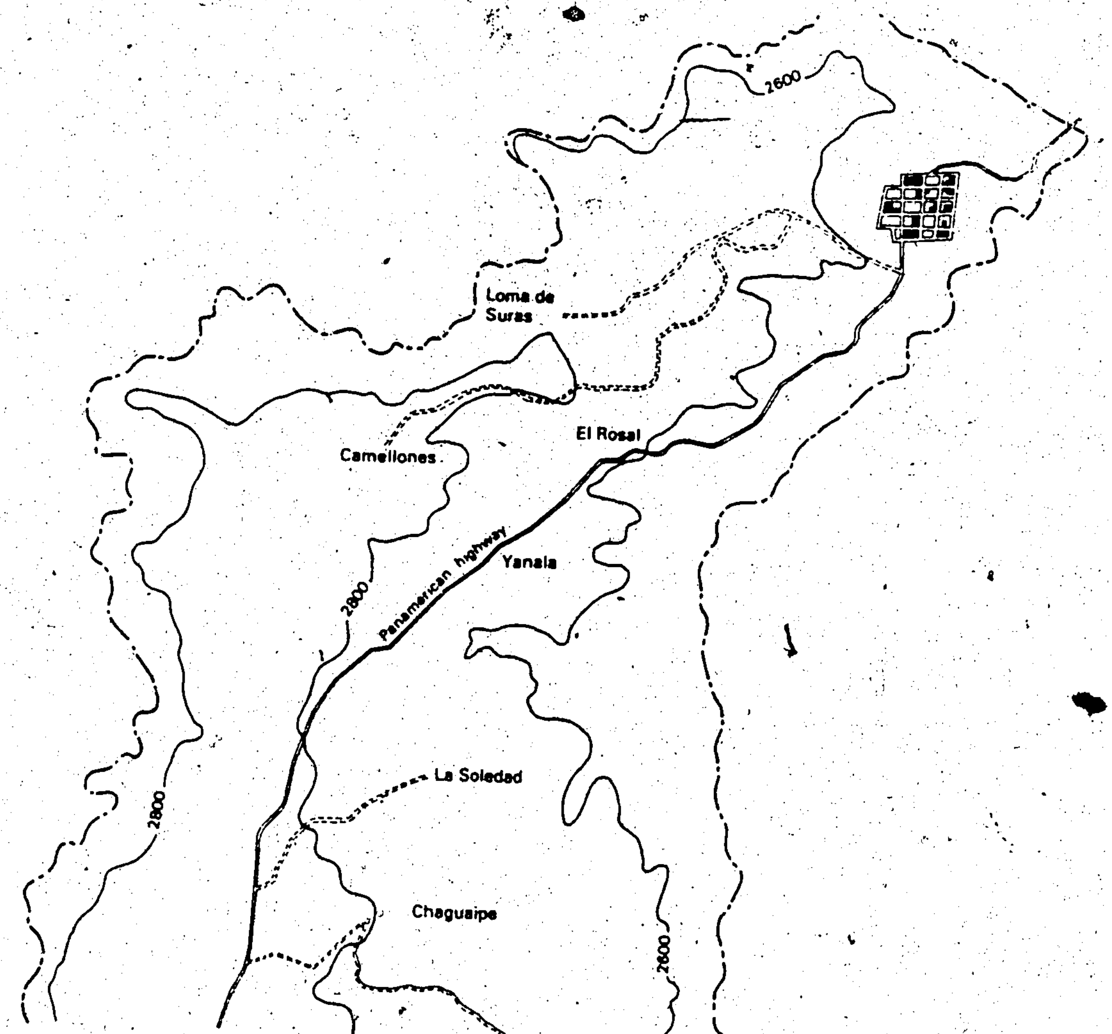


Figure III.1 Map of the Research Area

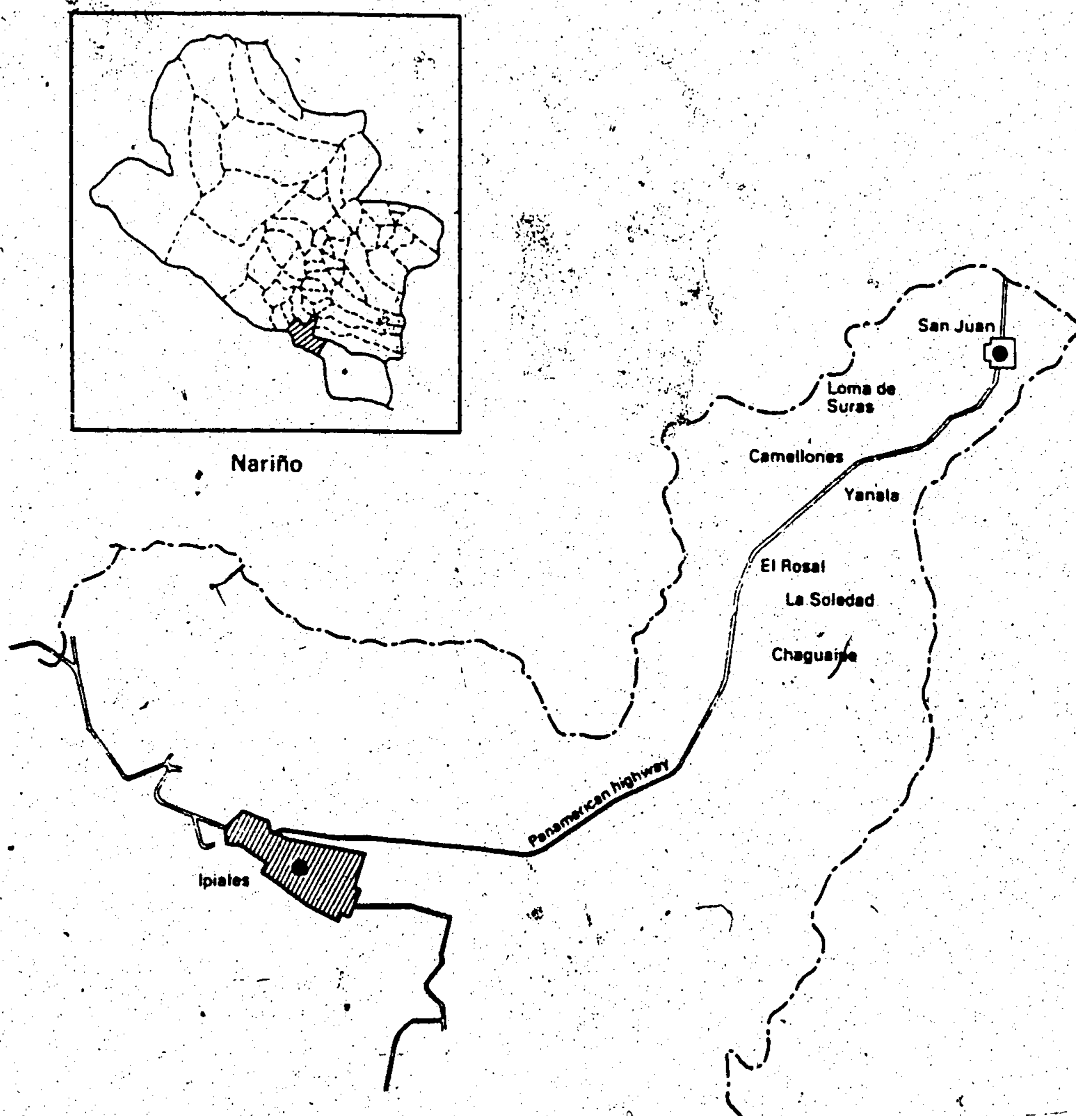


Figure III.2 Partial Map of the Municipio of Ipiales, Nariño means. The veredas did not differ with respect to family size, farm size, type and quantity of crops grown. Accordingly, all veredas are treated as a homogeneous sample. Factors differing between farmers are not directly related to the area where they live.

## The Questionnaires

Two questionnaires were developed to collect the data. One was based on descriptive data of the farm and the farming system, including data on production and prices and factors thought to be related or to influence price behavior. The other questionnaire used actual data on acreage and seed planted obtained from the questionnaire, but consisted of hypothetical questions. This questionnaire is called the Frisch Interview and is explained below.

The questionnaire was designed to cover all variables which were thought to enter into the farming system or the definition of its boundaries. The questionnaire generated data which could be obtained from the farmer, or through manipulation of information directly obtained from the farmer. The questionnaire covered the following subjects: the farm, the family, use of technology, ownership of goods, production, consumption and marketings of three crops, and detailed information on prices and plantings of beans for the last two years.

Data was obtained on farm size, tenancy and composition of crops including quantities of seed and time of planting, detailed seedings, and prices for beans for two seasons, 1984 and 1985. Production, consumption, and marketing data was also obtained for the three main crops: beans, maize and potatoes. Use and knowledge of technology as encompassed in the use of inputs and seeds, with particular reference to maize and beans was also recorded, as well as ownership of machinery, animals (excluding poultry) and tools. Finally education, age and occupational information of all members of the household, thus considered as all members who lived in the house and either depended or contributed to the household in some way, was recorded.

**Field Procedure**

The questionnaire was pre-tested in the field and benefitted from input by CIAT's economics team. Modifications were made to obtain the desired data, and to make the questionnaire easily answered by the farmer. Usually two visits were necessary to complete the questionnaire which had advantages and disadvantages. The advantage was that farmers showed more confidence in the second visit and therefore data could be checked for reliability. The disadvantage was that sometimes the questionnaires were incomplete if farmers were not available for the second visit. Incomplete questionnaires which were substantially answered, as judged by the researcher, were kept, because of the great expense of time and effort otherwise needed to replace them.

**Data Processing**

The questionnaire was coded by the researcher and inputed into computer files by CIAT's staff, to be used with the Statistical Analysis System (SAS) package. Variables which were not easily obtained from the questionnaire will be explained presently as to how a final calculation was made.

Farm and plot sizes were calculated from the average planting density of each crop as grown in the region. Two grades were given for level of technology. This technology refers to inputs used in maize/bean cultivation. Grade A was an addition of the quantitative variable of use of inputs. A high grade therefore implied only a use of many inputs, including chemical and organic fertilizers, foliar fertilizers, seed disinfectants, insecticides, fungicides, and limestone to counteract soil acidity problems. Grade B, however, was a measure of the farmer's knowledge of his technology. Points were given according to what he knew about the input used, with respect to what the input should be used for (what problem), and when it should be used. These points were given following specific guidelines from the agronomists in the CIAT bean program, with experience in the region. The points for each input were simply added to obtain grade B.

The production and consumption data for maize and beans for a year was obtained easily, since there is only one growing season of these two crops in one year. Annual data for potatoes was more difficult to determine. Data could only be obtained for the last one or two potato crops of several grown in one year. Many farmers could not remember data for the last two crops. The yearly figures were obtained by multiplying by three when there was only data for one season. If data for two seasons was provided, the average of this was multiplied by three to obtain yearly data. The figure three was chosen from the observation that farmers had between two and four crops of potatoes a year, and because potatoes can be stored from four to six months, depending on the variety.

## B. The Frisch Interview

### Introduction

The Frisch interview is a hypothetical game developed by Ragnar Frisch to estimate the tradeoffs among policy objectives for different groups of policy stakeholders. This method relies on an iterative and converging series of comparisons of pairs of policy variables. No sources have been found on exactly how the technique was applied by Frisch. However, there is reference to the technique with the objective of obtaining an estimate of "money flexibility" in Frisch's study: New Methods of Measuring Marginal Utility [60]. Dillon and Scandizzo developed and used a related method of interviewing farmers to find their attitudes towards risk[61].

### Theoretical Considerations

The use of this technique enables an approach to price behavior within the theory of choice, as it is applied to consumer behavior. A producer in a semi-subsistence economy is

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[60] R. Frisch, New Methods of Measuring Marginal Utility. (Tubingen: Verlag Von J. C. B. Mohr, 1932)

[61] J. L. Dillon and P. L. Scandizzo, "Risk Attitudes of Subsistence Farmers in Northeast Brazil: A Sampling Approach," AJAE, (Aug. 1978) pp. 425-35.

faced with choices. Their outcome may achieve his personal satisfaction but not necessarily achieves maximization of financial gains. His objective function may include his standing in the eyes of the other members of the society, the minimization of land degradation and of other resources, etc. As is defined by Judge et. al.,

> Economic theory is concerned with explaining the relationships among economic variables and using this information within a general theory of choice to explain production, allocation, and distribution decisions for a system that must operate within the implications of scarcity[62].

There is, then, a generalized theory of choice for preferences not exclusively applied to consumer behaviour.

The Frisch Interview confronts the farmers with choices in the way of crop combinations, which imply a certain distribution decision of the farm's and the farmer's resources. In semi-subsistence economies it is not advisable to make a strict distinction between production and consumption decisions, it may actually be counterproductive to make such distinctions. General choice in this type of economy is based on a complex set of preferences that reflect technical circumstances, family needs and cultural obligations, which can be summarized as "domestic circumstances". In this interview the farmer is in his mind making the decisions, concerning his available resources, tastes, and preferences, when he chooses between the combinations provided to him. The relationship between price and production is explored with this interview. The interview tries to overcome the problem of unavailability of time series data, which is normally used in supply response studies. The data obtained from the Frisch interview is cross-sectional and strongly experimental.

In the Frisch interview, a land base is initially defined as the area planted to beans and potatoes at the time of the interview. This land base is part of the constraints binding production decisions of the farmer, and which can be broadly called the "outlay constraint". In Figure III.3, this outlay constraint is represented by the line CD. The slope of this line depends on the prices of both beans and potatoes. The curve AB, is a product transformation curve of beans for potatoes[63]. This curve is also called the production possibility curve. The

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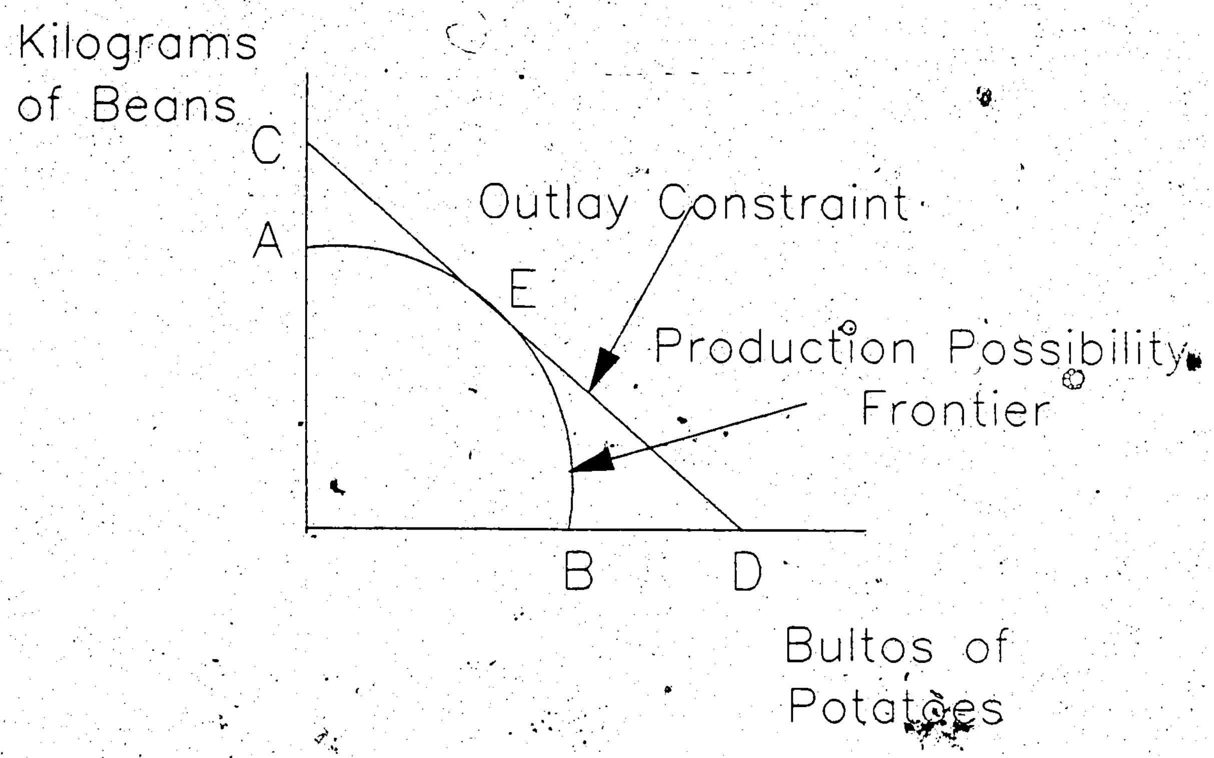
[62]G. G. Judge et. al., The Theory and Practice of Econometrics, (2nd. ed.) (New York: John Wiley & Sons, 1980)

[63]J. H. Henderson, and R. E. Quandt, Microeconomic Theory: A Mathematical

Figure III.3.: Schematic Representation of the Outlay Constraint and the Production Possibility Frontier in the Frisch Interview.




data obtained from the Frisch Interview gives a point on this curve, or a marginal rate of product substitution (MRPS), which is also called a marginal rate of transformation (MRT). The MRPS is defined as the slope of the production possibility curve. Thus, MRPS of beans for potatoes = ΔPotatoes/ΔBeans[44].

The Frisch Interview leads the farmer to get as close as possible to point E. This is the point at which the production possibility curve is tangent to the outlay constraint, whose slope is dependent on the price ratio of the two products.

**Method of Application**

The interview presents the farmer with two different combinations of beans and potatoes which he can grow on his farm. The initial quantities are chosen from the farmers'

[43](cont'd) Approach, 3rd. ed. (New York: McGraw Hill, 1980) p. 94.
[44]J. P. Doll and F. Orazem, Production Economics: Theory With Applications, (Columbus: Grid Inc., 1978) p. 143.

actual quantities planted at the time of the interview. All the plots that have beans or potatoes at the moment of the interview are considered. A conversion is made of how the quantity of beans which could be seeded to all these plots if only beans were to be grown on the farm, or how many potatoes could be seeded if only potatoes were grown in these plots. From here it is known how many beans he could grow if he only planted beans and how many potatoes he could grow if he only wanted potatoes. When giving the farmer choices, there was opportunity for land to become slack. That is, not all land had to be used for planting beans and potatoes. The farmer was reminded that he could use the land left out of the combination in the various iteration steps for other crops.

The starting point was established as planting 10 percent beans with 90 percent potatoes (converted to the farmer's units and quantities) or planting the contrary, 90 percent of the land with beans with the remaining 10 percent of the land in potatoes. The farmer was then asked which combination he preferred. One combination was called the preferred combination and the other one was called the deferred combination. Once it was established which combination was preferred, the dominant crop in the preferred combination was decreased through an averaging procedure and became part of a new choice given to the farmer. The farmer was again asked which combination or package he preferred. After each iteration, there were less differences between the two combinations, that is, the comparisons were converging. The iteration was done until the farmer was no longer able to choose one package, or to consider one a preferred and the other one a deferred combination. At this point, an indifference point was reached were the farmer felt equally satisfied of producing either crop combination.

The game is close ended since it forces a definite choice. The game was done two times for two different bean prices, keeping potato prices constant. The prices of beans were chosen close to the lower and upper bounds of farm-gate prices for 1984 in the area. The potato price was considered medium-high for the same time period.

**Justification of Interview and Meaning of Results**

This method of interviewing, to obtain hypothetical data was hoped to aid in dealing with the problems of obtaining data which is not available from official sources. At the same time, this interview overcomes the problems of using straight hypothetical questions such as, "how much would you grow if prices rose by 10 percent", etc. In this case, it is very possible that farmers would respond the way they think the interviewer wants them to respond. It is not possible for the farmer to imagine what the interviewer wants from the Frisch interview.

By allowing the farmer to choose combinations within a broad outlay constraint, the farmer is implicitly defining his own specific constraints. He knows how many beans he can substitute for potatoes. In his mind, the farmer is making the relative conversions of production costs, labor available on the farm, and food needs. This was noted from the farmers' comments as the interview was being applied. The theory of production assumes that farmers are profit maximizers, as well as not allowing economies or diseconomies of scale. However, farmers in developing countries cannot only consider monetary costs in their decisions. In the case of the farmer in Southern Nariño, there are consumption factors and risk factors involved as well. By applying the Frisch interview technique, the constraints that the farmer faces are not specified. The farmer picks choices which best satisfy him or in consumption-theory language, his choices place him in the highest possible utility curve.

The methodology used not only arises from the data constraint, but also from the hypothesis that the farm system is constantly changing and adapting. Farmers cannot adapt as fast to institutional constraints and this will be reflected in their decisions. In the case of non responsiveness to price it could be the case that farmers simply do not interpret the prices correctly. It is hoped that this methodology would show this fact. By comparing the two crops' prices, we are indirectly measuring the farmers' responsiveness to price. The ratio obtained is a marginal rate of product substitution of beans for potatoes. This could give a production possibility curve and the choice of the farmer gives a point in this curve.

The final data obtained from each farmer consist of two combinations of beans and potatoes for one price, and two more combinations of the same crops at a higher price of beans which give him the same level of satisfaction. The final figures represent the value of beans to the farmer, in terms of potatoes, when beans are worth two different prices. That is, a marginal rate of product substitution of beans for potatoes can be calculated from this data for both prices. From these rates of substitution, the relationship between beans and potatoes is clarified, that is, whether they are complement, substitutes, or supplementary. Supplementary means that changes in production of one output are not related to changes in production of the other output. Furthermore, in terms of potatoes it is known how much more beans are worth to the farmer when the price changes.

A fundamental problem of this interview technique is the difficulty for many farmers to simultaneously imagine these two comparisons and to choose <u>one</u>. That is, there is a high level of abstraction. Drawings were used to reduce this problem. The farmers tended to focus on only one combination, choosing between only beans or potatoes within one combination. The farmer had to be constantly reminded to look at both combinations simultaneously given the established prices.

Farmers in their real decisions are usually assumed to face many more complicated choices in their farming system. They have to choose from a variety of crops, with different seasons and with different problems other than prices to be realized[65]. Nevertheless, the question of choices involving prices was not easily understood by all farmers. Of the 52 farmers available for this part of the interview, only 26 farmers were able to get to an indifference point. The remaining 26 farmers showed reliance on convention and tradition in decision making suggesting that they may not perceive that there is a choice. More on this issue is discussed with the results of the research.

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[65] D. Byerlee, L. Harrington, and D. L. Winkelman, "Farming Systems Research: Issues in Research Strategy and Technology Design," <u>AJAE</u> (Dec. 1982) p. 898.

## C. Data Analysis

### Description of the Farming System

Simple statistical analyses such as means and frequencies were used with many of the variables obtained in the questionnaire for a description of the farming system. This description was also supplemented by observations from the many trips and time spent in the field, from informal interviews with some farmers and government officials in the area, such as extension workers and credit officials, and from some secondary sources based on government publications. Since the analysis of variance showed the veredas to be similar in their descriptive characteristics, averages and frequencies of all sampled farms were pooled in the description of the Farm system of Southern Nariño's "cold zone" in Chapter IV.

### Comparison of farmers with respect to their ability or inability to answer the Frisch questionnaire

A typical result from our analysis provided us with four numbers for each price of beans:

$5\alpha_1$ and $10\alpha_2 = 4\alpha_1$ and $12\alpha_2$,

where $\alpha_1$ = beans and $\alpha_2$ = potatoes.

The farmer had said that to him having five kilograms of bean seed with 10 bultos (one bulto is equivalent to 60 kilograms of potatoes) of potato seed planted, gave him the same satisfaction as having four kilograms of beans and twelve bultos of potatoes seeded. From here the MRPS or MRT is calculated as the negative of $\alpha_1/\alpha_2$:

$5\alpha_1 - 4\alpha_1 = 12\alpha_2 - 10\alpha_2$ ,

MRPSpotatoes/beans $= \alpha_1/\alpha_2 = -2/1 = -2$.

This number tells us that if the farmer is going to decrease his bean crop by one kilogram he needs to grow two more bultos of potatoes to stay at the same level of satisfaction. Another MRPS was obtained for a higher price of beans, for most, though not all of the farmers, keeping the potato price constant. MRPS1 is the ratio obtained at the initial price for beans and MRPS2 is the ratio obtained once the price of beans in the game has increased.

The results from the Frisch interview seemed to point at three groupings of farmers according to their response. These groupings are justified by noticing that some farmers showed complementarity in their relationship of beans and potatoes (positive marginal rates of substitution). Another group showed substitution relationships between beans and potatoes (negative MRPS); however, another group of farmers showed total inability to respond. In an attempt to test if indeed the division of the sample into these three groups was justified, various variables were used to statistically test the groups' differences. These variables were those which were thought to make farmers different within the same farming system. They consist of individual biographical and farm characteristics, such as age, farm and family size and form of land tenancy. Level of education of the farmer and knowledge of agricultural technology were also thought to be important in influencing farmers behaviour and ability to understand hypothetical questions Finally, level of income and commercial orientation were also seen as a measure of the strength of the farmer's relationship with his economic environment. These variables were therefore used in the comparison of the groups. If the groups are indeed different, it is believed that each group may also respond in a different way to prices.

The tests were done with analysis of variance with SAS General Linear Model (GLM) procedure. Once the analysis of variance indicated differences between the groups, pairwise comparisons were done with Tukey's test. Pairwise comparison refers to the comparison of one group with one other group. In cases in which the ANOVA indicated differences and where these differences were not pairwise, Scheffe's test was used to compare the combination of two groups against one other, such a comparison is called a contrast.

It was believed that substitution characteristics are more in line with the definition of an economic man, while complementary relationships are more characteristic of subsistence agriculture. This distinction follows from degree of specialization positively related to degree of commercialization. A low degree of specialization implies the production of the farmer's own needs, including food, cover and dress. Farmers who were unable to play the Frisch game at all, were believed to be at an even lower level of commercialization, or more subsistence-oriented, than the farmers who were able to appreciate and choose the alternatives given to them in the simulation.

It was believed that farmers showing substitution characteristics and from now on called group one, would have larger incomes, larger farms, greater proportion of land owned, more education, and would be younger than all other farmers. It was thought that farmers which had shown complementarity of beans and potatoes, now called group two, would have an intermediate value with respect to these variables, while farmers in group three, which consisted of farmers unable to answer, would be at the other extreme with respect to the mean value of these variables.

**Exploration of the Relationship Between Production and Prices**

In an attempt to obtain a measure of the farmers' production response to prices, regression analysis was used with the data on actual production and prices, as obtained from the questionnaire. The dependent variable was expressed in various forms. First it was expressed as actual plantings in 1985: BEAN85; a change variable was specified as the change in bean plantings from 1984 to 1985, now called BEANΔ. A quantity of extra seed was calculated as the excess bean seed planted above what the farmer had said was his minimum seed requirement, and now called EXTRA85. This was done to test the hypothesis that production is responsive to prices once a minimum requirement has been met. Finally, this dependent variable was also specified as a change and called EXTRAΔ. The absolute variables were regressed with PRICE84 and PRICE85 as the independent variables, whereas, when the quantity variables were expressed as a change the price variable was also expressed as a change and called PRICEΔ.

Initially, for the pooled data the model was expressed as a linear relationship, in semi-logarithmic form and as a logarithmic function. All models gave similarly insignificant results for the price variable. A linear function was used for all other regressions. The price variables were the farm-gate prices received by the farmers for the two seasons immediately preceding the 1985 planting season. If an equation could be found in which prices are significant explanatory variables, a price elasticity could be estimated. However, two year data is not enough to appreciate the trend of production following prices. The price coefficients in the regressions were neither significant nor accounted for much of the variation of production. Since it was hypothesized that farmers would have different response to prices, the regressions were applied to each group separately. For these regressions a general inspection was done to find any differences which might indicate difference of response.

**Individual Variables Affecting Supply-responsiveness of Farmers and Behavioral Functions to Explain Response**

Two variables were used as proxies for farmers response to prices. From the Frisch results, the change in the MRPS from the initial price to the final price, now called MRPSΔ was used. It was calculated by subtracting MRPS2 from MRPS1. The difference in these two MRS's was interpreted to give us an idea of how much more, or less, beans are worth to the farmer in terms of potatoes after a price change had taken place. The change in the MRPS's is an absolute change, and the sign indicates the direction of the change. A negative number indicates that the farmer has moved towards complementary characteristics, while a positive change implies a movement towards substitution characteristics. A movement towards substitution is interpreted as an indication of positive response to price changes, as predicted by economic theory, since they imply a stronger preference for beans once the price of beans has gone up. To corroborate and compare these results, an elasticity was calculated as the ratio of production change to price change from 1984 to 1985.

Thus ARCELAST = BEANΔ/PRICEΔ.

The independent variables are divided into four general headings; those belonging to a level of commercialization, those related to attitudes of the farmers towards change, those relating to general biographic characteristics, and those showing the relative importance of the two main crop combinations in the farm: beans/maize and potatoes. The hypotheses on how these variables are expected to affect production have already been stated in Chapter II.

In testing the assumptions of linear regression, it was found that some multicollinearity existed, which is not surprising given the nonexperimental nature of the data[66]. To solve this problem, a matrix of correlation coefficients was obtained for all the independent variables, to use only uncorrelated variables together in the same regressions. Heteroscedasticity was also detected through the use of analysis of residuals, but only for the dependent variable ARCELAST with several independent variables. Weighted least squares was applied in these cases by dividing all variables by the square of the variable showing heteroscedasticity. OLS was then applied to the transformed data[67].

The method used in the obtention of variables which could best explain response was of an exploratory nature. Econometric theory tells us that we must specify the right model, however, with social data there is little theory developed on how social, economic and biographic characteristics affect supply response of farmers. All that is available are other studies which hypothesized the variables, and by using common sense tested their hypotheses. Eleven variables were finally selected as best representatives of variables affecting price responsiveness, as hypothesized in Chapter II. These variables are defined in table III.1.

All the variables were used individually in linear regressions with ARCELAST and MRPS$\Delta$ to obtain an indication of the most important variables explaining response. From these individual regressions and by looking at the intercorrelation matrix, several combinations were obtained and put together to find a behavioural equation, which best explained response. The process of choosing a model was based on the criteria of parsimony. As defined by Berenson et. al., parsimony means to develop a multiple regression model which "...includes the fewest number of (independent) variables that permits an adequate interpretation of the responses[68]".

[66] J. Neter, et. al., Applied Regression Models, (Homewood, Ill.,: Richard D. Irwin Inc., 1983) p. 383

[67] Ibid., p. 168

[68] M. L. Berenson, et. al., Intermediate Statistical Methods and Applications: A Computer Package Approach, (New Jersey: Prentice Hall, 1983)

Table III.1: Independent Variables Used in the Analysis of Price Response

| Variable | Definition |
|---|---|
| Biographical | |
| AGE | For head of household |
| FARM SIZE | Total farming area (ha) |
| OWNFARM | Area owned by farmer/farm size |
| FAMLABOR | Labor equivalents defined as 1 for males over 18, .75 for females over 18, .50 for males and females between the age of 12 and 18, and 0 for children under the age of 12. |
| Main Crops in the System | |
| MAIZFARM | Area in maize-beans/farm size |
| PAPAFARM | Area in potatoes/farm size. |
| Commercial | |
| ADDANIM | Value of animal stock (Colombian pesos) |
| INGFRIJ | Annual income from sale of beans (Colombian pesos) |
| INPAPAYC | Annual income from sale of potatoes (Colombian pesos) |
| Attitudinal | |
| EDUCATION | Years of schooling of head of household |
| GRADEA | Cumulative grade given for use of inputs in Maize/bean cultivation. |

The independent variables were chosen after careful examination of the farming system in the area. The following chapter presents a full description of the system.

# IV. THE FARMING SYSTEM IN SOUTHERN NARINO

## A. The System at its Boundaries

### Agroclimatic Setting

The zone of study is located in the Southwest part of Colombia near the Ecuadorian border (See Fig. I.1) The sampled farms are found in the interandean deep valley formed by the Central, Oriental and Occidental Mountain ranges. As a result the topography is very rugged and farming takes place on undulating hills on the top of some mountains or on steep hillsides. The soils are susceptible to erosion. The altitude at which the farms are found ranges from 2650 to 2790 meters above sea level. The relative humidity is 84% and the average annual temperature is 12°C[69]. Despite the high altitude of the zone, heavy frosts are not a risk every year.

The average yearly rainfall is 1000 mm. distributed in two rainy seasons. The main rainy season is from September to October and the other season is from April to May.

According to a study done by the Colombian Agricultural Institute (ICA in Spanish abrev.)[70], the soils in the sample area are classified as Andepts. They are young soils derived from volcanic ash and have an A C horizon. In the lower part of the A horizon there are stony layers ranging from a few centimeters of depth to five meters and in the steep hills they come right out to the surface. This factor could limit root growth if such layers are not very deep. There is very high phosphate fixation, requiring high levels of phosphate fertilizer applications to make the phosphate available to plants. These soils have a high water-holding capacity (100%-200%) but also shrink very fast upon drying. The farmers face problems when after a good rain followed by strong sunshine the soils become very compressed. This causes dificulty in plant germination and growth. Andept soils compress highly under heavy machinery. However at the present time only a very few farmers use tractors which are the

[69] J. V. Peñuela, *Información Básica del Departamento de Nariño, Para Programas de Desarrollo Agropecuario.* (Pasto: ICA, 1971), pp. 76-8.
[70] Ibid.

only heavy machinery used. The soil structure is fine to medium-subangular with high organic matter, high porosity and low bulk density. There is, then, good aeration and easy penetration for plant roots but there could also be leaching away of nitrates, calcium and magnesium. Cation exchange capacity is dependent on the pH and it is known that the soils are lightly acidic.

**Biological Environment**

As documented in the questionnaires, the crops grown in the region are maize, beans, barley, potatoes, wheat, peas, squash, quinoa and occasionally vegetables and fruit trees. See table IV.1 for percent of area occupied by each crop. All the farms in the region are located under the 2800 meters altitude; but some farmers have land in other towns or higher up the mountain. When this is true, those plots are restricted to carrying less crops. These crops can be broad beans, maize (monoculture), barley (with lower yields), potatoes, and pastures. Every year there are mild frosts but they affect only on certain plots, depending on the steepness, orientation, etc. Only once about every six years is there heavy frost damage.

Only maize/beans, barley, and wheat are reported to have a more or less established planting time. This is after the rains when the soil is moist and can be prepared. Farmers report that all other crops can be planted any time during the year. Farmers also report that the rains have been quite erratic in the last few years. Occasionally they have some draught problems, though they do not affect all the farms in the same manner.

*Crops Grown on the Farm*

Maize and beans are always grown in association and are in some towns intercropped with broad beans, quinoa, and squash. Only six percent of the plots with beans were monoculture, the rest were maize/beans in association. Beans can be harvested green in small quantities for consumption the seventh month after planting. Eight months after planting the dry pods can be harvested. Maize stays on the ground until the tenth month, but again, farmers consume maize after the seventh month when it is fresh (green). Broad beans, quinoa

Table IV.1: Percentage of Land Occupied by the Crops in Ipiales[1] at the Time of the Questionnaires, March - May 1986

| Crop | Percent | Length of cycle (months) | Planting Month |
|---|---|---|---|
| Beans and Maize | 46.57 | 8/10 | September |
| Potatoes | 13.1 | 4-6 | - |
| Barley | 12.13 | 4-4.5 | March and Sept. |
| Peas | 10.6 | 5.5 | - |
| Broad beans | 6.63 | 8 | - |
| Pastures | 6.6 | - | N. A. |
| Wheat | 1.44 | 5 | March and Sept. |
| Gardens and tree plots | .1 | irregular | - |
| Others not specified | 2.05 | | |

[1]Fallow land is entered as the last crop that was there before.
Source: Survey results.

and squash if grown with maize are harvested before the maize, so they do not extend the normal growing cycle of maize/beans. In the sample area there are many bean varieties grown. The variety mortiño predominates being grown in 63 percent of the plots in the sample. The rest are other varieties which may be local ancient varieties or introduced from other areas. In six percent of the plots a newly released variety was also cultivated. Different bean varieties are mixed in some plots. There are two kinds of maize varieties grown and most farmers cultivate both of them at the same time since they have different consumption uses.

The main disease for beans is root rot and foliar and pod diseases. There is also a leaf miner causing problems to beans. To maize the main problem is the underground worm, as well as a leaf disease.

Barley and wheat have two planting seasons and both are after the rains. The most important planting is in March and April and it is also planted in September and October but with lower yields. The barley growing cycle is of four to four and a half months, depending on the plant variety. Wheat takes five months from planting to harvesting. The main problem affecting barley is rust which has to be prevented by farmers.

Potatoes, according to farmers, can be planted any time during the year. Their vegetative cycle ranges from four to six months, depending on the variety. Farmers do not like to plant more than two consecutive crops in the same plot. The more preferred varieties have the six month growing cycle but they also require more fertilizer and chemical inputs. Potatoes are heavily affected by diseases and pests of which the main one is the white worm. Farmers usually control all these problems; but it makes potatoes the most chemical input-intensive crop.

Broad beans are also planted in monoculture. They have a cycle similar to that of beans, but with no defined planting date. Peas are another important crop in the region and are planted any time during the year. The only problem they face is if it rains a lot when the plants have green pods. Peas are sometimes harvested green (fresh) four months after planting or they are left to dry in the field which takes five and a half months.

Farmers state that there must be crop rotation in all plots. Farmers usually do not plant the same crop in the same plot more than two times or sometimes three. Maize and beans are usually planted only once on the same plot but there is not a strict rotation cycle of what goes after what. Sometimes two crops of barley are planted after one of maize but after that there is no rigidity.

In summary, the land is very intensively cultivated. It is fallow for only one or two months during the year while the animals feed on the stubble until the farmer is ready to prepare the plot for the next crop. The R value as defined by Ruthenberg is close to 100 but it is difficult to calculate because of intercropping practices [71]. Occasionally a plot is put on

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71

> ...the number of years of cultivation multipled by 100 and divided by the length of the cycle of land utilization ... The characteristic R indicates the proportion of the area under cultivation in relation to the total area available for arable farming.

in:Ruthenberg, Hans. <u>Farming Systems in the Tropics</u> 2nd ed. Oxford: Clarendon Press, 1976, p. 15.

pastures for six or seven years but it is not too common. Sometimes farmers use improved pastures but it is not commonplace. Most farmers have been cultivating the same land as long as they can remember. There is no defined cropping cycle but it is agreed that crops have to be rotated.

*The Place of Animals in the Farming System*

All farmers own some kind of livestock, be it a horse, oxen, cow, lamb, or pig. Most farmers have chickens and *cuyes*, (guinea pigs), but the numbers are highly variable according to the time when the farmer is interviewed.

Feed and use of land

Most animals are fed on pastures with very little processed feed bought. Chicken are preferably fed with maize but when not available with other grains such as barley, wheat or even rice. Chickens also eat worms and insects.

Pigs are left to graze and when small they can usually be kept with kitchen wastes, when grown the farmer has to purchase low quality grain from the mill. *cuyes* are fed with fresh grass or weeds and green maize stems. (Larger animals are occasionally also fed on green maize stems.) Sheep are usually tethered at the side of the road or at the side of a field. Farmers purposely leave grassy edges around their plots to feed the animals. If the farmer does not have enough pastureland the animals can feed on the stubble from the crops, or on stubble from other farmer's plots through rental or sharecropping agreements. For example the farmers may exchange plowing for pasturing bullocks or milk for the pasturing of cows. In a study done by Hoefsloot, it was reported that one head of cattle[72] can be fed with one hectare of maize stubble for 152 days, with one ha. of barley or wheat for 70 days and with one ha. of peas for 131 days[73]. Potatoes do not provide stubble since the plants are cut before the potatoes are harvested. However these plants when fresh are fed to *cuyes*. The main purchased input for animals is salt and vaccines.

[72]One head is equivalent to one horse or one cow or one ox or three sheep or two calves.

[73]S. Hoefsloot, "Rapid Appraisal of Animal Production Systems in Southern Nariño," (Cali: CIAT internal report, Bean Program, 1986).

Table IV.2: Animal Ownership in Southern Nariño, 1986

| Animal | Number of farmers who have at least one | percent | Average number of animals per farmer | Number of farmers who answered |
|---|---|---|---|---|
| Horse | 30 | 55.6 | 0.63 | 54 |
| Oxen | 27 | 47.4 | 0.82 | 57 |
| Cows | 37 | 66.7 | 1.18 | 56 |
| Calves | 22 | 40.0 | 0.78 | 55 |
| Sheep | 19 | 78.0 | 1.20 | 50 |
| Pigs | 27 | 69.2 | 1.33 | 39 |

Source: Survey results.

Farmers always keep at least one cat and one dog which are fed with kitchen wastes or find their own food. Cats are an important part of the system since they kill the rats that eat the stored maize. Dogs are kept to protect the farmer from cattle and crop thiefs which abound depending upon the proximity of the city and the scarcity of cattle for meat in the area.

## The Market and the Infrastructure

### *Crops Grown for the Market*

It is known that barley, wheat, peas, and beans are grown mainly for the market and are consumed at home in very small quantities. As can be seen from the data on table IV.3, most of the bean crop is sold while maize is grown mainly for home consumption. It is difficult to generalize in the same way for potatoes. Since farmers have usually more than one harvest a year they sometimes sell all of it, or half of it or they do not sell any at all.

This situation can also be appreciated at the departmental or provincial level in the proportion of Nariño's production which is commercialized and sold in other departments of Colombia. For example, eighty one percent of the beans produced in the department in 1984,

**Table IV.3: Disposal Channels of Main Crops, Southern Nariño, 1986**

| Crop | Number of farmers who sold some | Average quantity sold in kilograms | Average percentage of harvest sold[1] |
|---|---|---|---|
| Maize | 5 | 32.4 | 3.1 |
| Beans | 56 | 166.3 | 69.8 |
| Potatoes | 22 | 531.5 | 25.0 |

[1]Dividing among all farmers who harvested.
Source: Survey results.

was exported to other departments. On the other hand, of the total maize production sixteen percent left the department. In the case of potatoes it is estimated that sixty percent of domestic production was consumed in the department and the rest was exported to other departments[74].

*Market Channels*

All the veredas sampled, are in a similar location with respect to Ipiales, which is the Municipal capital, and the largest near-by market. All veredas, except Yanala and El Rosal, are on a gravel road 2 to 7 kilometres from the panamerican highway which cuts across Colombia from North to South. It is the only highway connecting the south of Colombia with the main cities. Yanala and El Rosal are cut across by the highway so have better access to transportation to the market. Once the gravel roads connected with the panamerican highway, there is about 4 to 10 kilometres to Ipiales. In the midst of this panorama, farmers have 3 ways to dispose of their crops, as can be seen in figure IV.

1. Farmers can sell their produce to the end-point in the market, that is the consumer or the processor. Beans, maize, and potatoes are sometimes sold to other farmers for seed or consumption. Occasionally some small farmers take small quantities of beans or quinoa and

[74]*Unidad Regional de Planificación Agropecuaria (URPA). Plan Operativo 1985-1986 (Pasto: Ministerio de Agricultura. Gobernación de Nariño. 1985)*

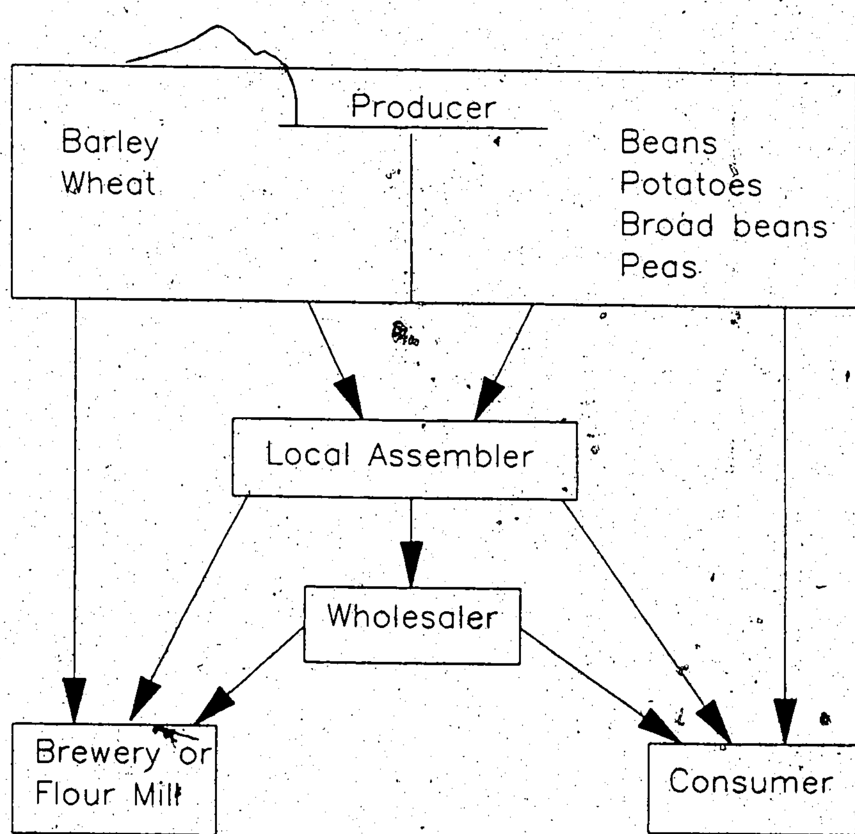


Figure IV.1 Marketing Channels of the Main Agricultural Commodities in Southern Nariño, 1986 sell directly to consumers in markets on either side of the border. Barley and Wheat are often sold to the brewery and the flour mill. Farmers have to supply the packaging or container. This can be a problem in the case of a bulky crop, such as potatoes. If prices are low, packaging adds considerably to production costs.

2. Farmers can sell their produce to a smaller assembler at the farm level. Assemblers are sometimes farmers themselves. Most assemblers go around the farms and know when the crops are becoming due for harvest. Sometimes they buy the crop before it is harvested, guessing at the yield and price. They may bring their own workers and take all the harvest. Assemblers are usually well informed of prices in the markets but occasionally lose money with quick price changes. Norman, Simmons and Hays provide a very similar description of this situation:

> All information must be obtained and disseminated through private contacts, as there is no public information available. Along with the nature of production and farmers' marketing patterns, this introduces uncertainty of supply and increases the risk of trade in more distant markets, where there is even less information. This prevents specialization and many small-scale traders develop contacts in certain areas, to keep informed on market conditions, and engage in trade in those areas, with little knowledge of market conditions elsewhere. Markets around centers are competitive, but the network of markets is not integrated[75].

Assemblers then have to arrange transportation for the crop to the larger markets. Assemblers usually have to select the grains or dry the crop as in the case of barley and wheat, since it commands a different price according to grade.

3. Farmers can take their produce to a big market such as Ipiales or Pasto (the state capital) and sell it to wholesalers with warehouses who have information on prices at country level, and own or rent trucks to ship the beans to where the price is best, and where there is the demand for the given variety in stock. In this case the farmers has to pay for his and his product's transportation, but can do some shopping in the town at the same time.

4. The government's marketing board IDEMA. Few farmers seriously consider this option since IDEMA does not pay farmers on the spot but a month or two after the purchase. No farmer in this area can wait that long for his payment.

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[75] D. W. Norman, E. B. Simmons, and H. M. Hays, Farming Systems in the Nigerian Savanna: Research Strategies for Development. (Boulder: Westview Press, 1982.) p. 90.

Barter is a common practice with potatoes. When a farmer has a bad potato harvest or did not save enough until the next crop he borrows some potatoes from a neighbour or relative or somebody gives him some potatoes which he later repays. When a farmer has a very good harvest he sends some to his relatives in other areas but it does not happen too often. (see table IV. 4)

*Storage Facilities*

Farmers have in-farm storage facilities only for the maize and the potatoes which are saved for consumption. Maize is stored on the cob and some is stored thrashed, in the house attic. There are high losses from rodents. Potatoes are usually stored in sisal sacks in a dark room in the house. Beans are sometimes stored in speculation of better prices. They do not take up much space since farmers usually only have from a few kilos to two or three sacks.

Small local assemblers who go around the farms do not have storage facilities so they take the produce directly to the market or to the wholesaler.

Warehouses are only found in the large cities, mainly Pasto and Ipiales. According to URPA[76], the government marketing board (IDEMA) has insufficient warehousing facilities in the region. The IDEMA silos have a capacity for 7.409 tons and the warehouses for 2.880 tons. While they are usually used for wheat, sometimes IDEMA also buys beans and maize. In 1984 IDEMA purchased 13.978.8 tons of wheat, which amounted to only 25 percent of total production in Nariño. CRESEMILLAS, an agency which insures the maintenance of certified seed, on the contrary, used only 70 percent of its warehouse storing capacity of 600 tons because of low stocks. Silos which had a storing capacity of 3500 tons were not used at all because of phytosanitary problems. Products stored by CRESEMILLAS include maize, beans, barley and wheat. The government agencies, "Caja Agraria" and "Provision Agricola" have warehouses and silos for the storage of agricultural inputs, equipment, and machinery. The coffee federation also has warehouses in the department of Nariño but they are only used for coffee. Altogether, the government storage facilities for agricultural products (not inputs or

[76]*Unidad Regional de Planificación Agropecuaria, (URPA). Plan Operativo 1985-1986 (Pasto: Ministerio de Agricultura. Gobernación de Nariño.* 1985).

Table IV.4: Main Bartered Commodities, Southern Nariño, 1986

| Commodity | Number of farmers who gave some to their family | Average quantity bartered in last harvest [kgs] |
|---|---|---|
| Maize | 7 | 23 |
| Beans | 6 | 13 |
| Potatoes | 7 | 88 |

Source: Survey results.

machinery) is of 14.389 tons, excluding the coffee federation and taking account that not all of the capacity is used because of sanitary limitations.

On the private sector the storing capacity is of 81.015 tons of which 77 percent is owned by private businessmen, 18 percent belongs to the Brewery "Bavaria", and the remaining 5 percent is owned by flour mills in the area.

*Credit and Extension*

The Colombian Agricultural Institute provides extension and credit services for the community in the Ipiales area. The extension agents give technical advice and supervise the crops of the farmers making use of the credit facilities. Credit can be provided through the DRI program (*desarrollo rural integrado* - "rural integrated development") or through the *Caja Agraria* (Agrarian Bank).

Farmers must own some land to take out a loan and they have to state what crop the loan is for. The credit representative decides how much to lend the farmer according to the production costs of the given crop. Sometimes the loans or parts of them are made in kind in the way of fertilizers.

The agricultural crop which commands most of the loans and loan resources is potatoes. Some of the loans, however, are given for investing in animals. Animals are an investment and a saving for bad times. Oxen and cows are usually bought for work in the farm and to provide the milk for the household. Only if a farmer has more than one cow or two oxen (and a small farm) will he rent out his oxen team or sell the milk. Pigs are bought for two reasons. A female pig will be used for reproduction and the piglets will be sold after winnowed. Piglets may also be bought to fatten up and then sold for meat. A pig can be fed on kitchen wastes until it reaches six months, after that it must be fed with purchased feed. After six months the pigs can be sold at a higher price. Wheat is the next crop after potatoes commanding more credit for farmers, even though it was only cultivated by 28 of the farmers sampled. (Table IV. 5)

The DRI has a program of development which tries to include the women on the farms. Women are usually in charge of the hogs, the chickens and the *cuyes*. *Cuyes* are by tradition grown for consumption on special occasions. A few women, however, have taken credit for breeding them for commercial purposes. The loans are given for the construction of sanitary *cuyeras* to keep the animals out of the kitchen, to buy good quality animals, and for vaccines and insecticides. Other loans which try to include women in the development process are those related to house improvements such as building stoves or making vegetable gardens.

Of 61 farmers interviewed, 31 have taken an agricultural loan at some time, but only 14 take a loan regularly, once or twice a year.

There are also local money lenders but they are not a major source of credit or at least it did not seem so from the interviews. A wealthy farmer lent money to another farmer and expected the ninth part of everything grown on the farm as an interest payment. In that way they were diversifying the risk since some crops could do very well even if others did not. Among families not only is money lent but also food and even land.

The extension agency has various technicians who go around the veredas on their motorcycles. They usually visit people who have credits, advising them at the same time on whatever crop or animal problems they may have. In 1985 a new bean variety was released by the Colombian Agricultural Institute and CIAT. At the time of the interviews, in 1986, 24 of the 61 farmers randomly interviewed knew about this new variety and 14 of them had planted it. In one vereda where there had not been any information about it no farmer knew about this new variety. The ICA and the DRI program also have female technicians who go around

**Table IV.5: Distribution of Loans in the Ipiales District, 1983**

| Disposal | Number of Veredas | Hectares Attended | Number of Credits | Amount (pesosX1000) |
|---|---|---|---|---|
| Potatoes | 18 | 147.5 | 114 | 8,474 |
| Sheep | 19 | | 58 | 4,380 |
| Oxen | 18 | | 38 | 2,229 |
| Housing | 14 | | 28 | 2,223 |
| Wheat | 15 | 76.2 | 40 | 1,701 |
| Cow and calf | | | 38 | 1,272 |
| Hogs | | | 49 | 1,013 |
| Maize/beans | 5 | 17.0 | 12 | 421 |
| Birds | 1 | | 2 | 260 |
| Barley | 5 | 11.25 | 8 | 229 |
| Broad beans | 8 | 11.8 | 11 | 215 |

Adapted from: Carlos Adolfo Luna, "*Costos y Retornos en frijol y Otros Cultivos. Nariño, Clima Frio,*" Paper presented in the Workshop on Research in Bean Fields for Latin America, February 16 to 25, 1987. Cali: Ciat, 1987. p. 12.

to some farms and advise farm women on nutrition and animal care. Once in a while a meeting is organized in a vereda. All farmers are invited with their wives but usually only credit-users and people involved in trials with the agricultural institute attend the meetings.

Farmers were asked if they had ever been advised on agricultural practices or inputs by an agricultural technician. Of the 56 farmers who answered this question, 23 said yes, and 21 of those who said yes said they had changed something in their agricultural practices as a result of this contact.

**The Political Environment**

A *vereda* is a geographic area, delimited by natural boundaries, such as rivers and ravines. Each *vereda* was probably formed by a family or group of families since in each vereda a few family names predominate. By definition each vereda must have its own school. All veredas or villages sampled in the study are part of the same municipio or municipality of Ipiales. (See fig. 4) This is the lowest level of government. The capital of the municipio is the city of Ipiales, which means that a lot of the resources of the municipio are spent in the municipal capital.

*Political organization of the community: The Junta de Accion Comunal*

The veredas political representation is constituted in the "junta de accion comunal", which is a group of farmers elected by the community and headed by a president also elected within the vereda.

This *junta de accion comunal* acts as a pressure group with the municipal government. There is also a mayor in the municipal capital appointed by the departmental (provincial) government. A council of representatives acts as the link between the mayor and the community or vereda. The major himself is a link between the council (representing the veredas or communities) and the provincial government. (Fig. IV.2)

Some *juntas* are very active and can pressure the government into the allocation of funds for road construction and improvement, school renovations and upkeep (since each vereda by definition has a school), construction of aqueducts and installation of electricity. A good example of an active vereda is Loma de Suras, which has a drinking-water aqueduct, organized the farmers for construction of a road and also has electric lines. Chaguaype and Soledad, on the other hand, do not have running water or electricity so they rely on water wells. Yanala and El Rosal have electricity but no running water. For community projects the veredas have to provide most of the labor involved, so farmers who wish to benefit from the projects must donate labor days or food. There is also a fee to be paid but the labor donation is a requirement to obtain any benefits from the project.

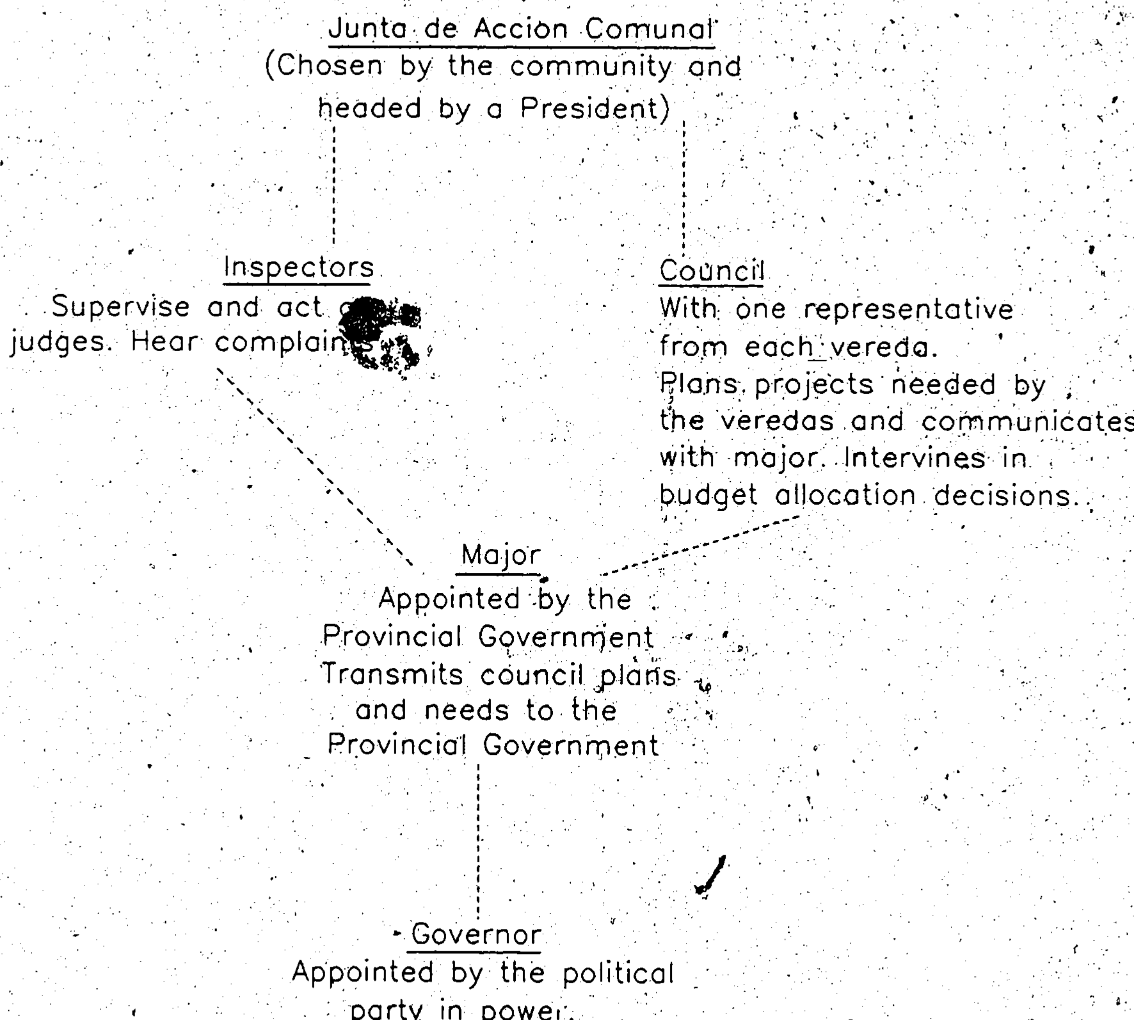


**Figure IV.2 The Veredas Position in the Political Structure, Southern Nariño, 1986**

**Strategies Which Farmers Use to Deal With their Environment**

Through the years farmers have developed strategies to decrease or ameliorate environmental risks. There are mainly two ways of dealing with environmental risks. One is by distributing the risk , through diversification and intercropping. The other way is by closing the system at its economic or climatic boundaries. In the agroclimatic sense, the system's boundaries can be closed by the use of irrigation, fertilization, and pest control. The ultimate closing of a farming system is in the case of a green house. In an economic sense, the system's boundaries can be closed by not relying on the market as a channel for the disposal of agricultural production, and by not relying on purchased inputs for agricultural production. New technologies, then, are instrumental in the closing of the system at its biological boundaries, but this implies at the same time that the system is more susceptible to changes in the economic environment, with the purchase of inputs and the use of the market for the disposal of the agricultural surpluses obtained as a result of using improved technologies. One last way of dealing with environmental changes could be through the creation of pressure groups to achieve concessions from the government.

*Use of Lime*

Fifteen percent of the farmers interviewed reported the use of lime and this is appropriate since the soils are usually acidic.

*Use of Fertilizer*

All farmers interviewed use some kind of fertilizer. Seventy two percent use organic fertilizer and 72 percent use chemical fertilizer. This type is restricted by what there is in the market, which is 10-30-10, 13-26-6, or 15-15-15. Farmers do not always give a reason why they use one ~~kind as~~ opposed to another. It is believed 13-26-6 and 10-30-10 are the best though farmers often give price differential as a reason for using a particular type of fertilizer. Fifty five percent of the farmers interviewed use some kind of foliar fertilizer, which they apply in the same container, mixed with insecticides and fungicides, when they fumigate their fields.

*Use of Insecticides and Fungicides*

Of the 61 farmers interviewed 59 fumigate their crop with some kind of chemical. Twenty five percent disinfect the bean seeds before planting. Some kind of insecticide is used by 97 percent of the farmers and at least one fungicide is used by 90 percent of the farmers.

*The Ridge System of Cultivation*

When preparing the land, the farmers make furrows with the plow. According to Norman, Simmons and Hays, this system (ridge) is "not completely related to climate, soil, topography, or land conservation; rather it contibutes to management of all factors at once"[77]. Kowal and Stockinger cite four main advantages, including the control of erosion on the slopes, cutting time of seed-bed preparation in half, the enrichment of the topsoil with ash and plant residues and the provision of aeration to the plant's roots[78].

*Diversification*

It has already been mentioned that for planting certain crops farmers wait until after the rain to take advantage of the moist soil. Since there is no irrigation in the zone, farmers are always at risk if rains are late. This may be one of the reasons why farmers have two or more plots of maize and beans but which are planted at different times. In the sample there is an average of 2.098 plots of maize/beans or beans per farmer. Having more than one plot of a crop at a different planting time is also a good insurance against price variability which is very high for potatoes and relatively high for beans.

[77]Norman, David W.; Simmons, Emmy B.; and Hays, Henry M. Farming Systems in the Nigerian Savanna: Research Strategies for Development (Boulder: Westview Press, 1982) p. 50.
[78]Cited in Ibid p.50

*Intercropping*

Several crops are intercropped in the farming system, but by far the most popular combination is maize and beans. Many other crops are occasionally grown with maize and beans, such as squash, quinoa (a traditional andean cereal) and broad beans.

## The Maize/Bean Association

Maize is always grown in association with beans. In Southern Nariño, of the 119 plots planted with beans, only ten were monocropped, three of which were CIAT trials. Two times beans were found interplanted with broad beans. The remaining plots contained beans and maize intercropped.

There are advantages and disadvantages to the maize/bean association but farmers in the study seem to consider that the advantages outweigh the disadvantages.

In the agronomic side, the maize provides an adequate support for the beans, which are of the climbing-type varieties typical of cold, high altitude climates. The nitrogen-fixing bacteria found in all legumes helps to maintain soil fertility while maize absorbs the nutrients from the soil. As well, crops in association also show a lower incidence of pests and diseases, as documented by Tejada et. al. The increased competition between maize and beans in the same plot results in a decrease in weeds[79].

In agronomic terms, the main disadvantage of intercropping is the lower yields obtained as opposed to those obtained in monoculture. Studies have shown that climbing bean yields in this system as compared with monocropping, are decreased by 50 percent while maize yields are reduced by 36 percent[80]

On the economic side, the advantages of intercropping stem sometimes from the agronomic characteristics and at other times from the resource constraints of the farm. The lower incidence of pests, diseases, and weeds has important advantages to farmers with restricted cash resources. The effect of nitrogen-fixing bacteria in the beans' nodules may help reduce fertilizer expenditures. There is also a saving of labor when fumigating both crops

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[79]Tejada, Gerardo; Davis, Jeremy; and Garcia, Susana. *Factores Agronómicos en la Asociación Fríjol-Maíz*. Paper presented in the IV Training course for Bean Production, CIAT, Colombia, 1979.
[80]Ibid

simultaneously since farmers mix all their products in the same fumigation tanks. This method saves having to carry the water from wells which are not always close to the field. The same is true of foliar fertilizers which are also applied when fumigating.

The use of labor is also controlled through the preparation and fertilization of the land, and the simultaneous planting of both crops. Furthermore, the association of these two crops also permit a distribution of labor at the end of the cropping cycle, harvesting can be extended for one month since beans require two or three harvests and maize ripens after beans have been harvested.

Planting two crops in one plot also implies an intensive utilization of the scarce resources of land and there is an obvious saving of work and money when maize is used to support the bean plant.

One of the main reasons why maize is grown in conjunction with beans surfaces when looking at the consumption and marketing data obtained from the questionnaires, which is summarized on table IV.6. Of the 57 farmers who harvested maize only five of them sold part of their crop. On the other hand, of the 56 farmers who harvested beans, 52 of them sold part or all of their crop. Furthermore, the average percapita consumption of maize was 80 kgs. per year but for beans it was only 6.5 kgs. This shows a high level of complementarity between these two crops in the sense that beans provide the farmers with cash while maize contributes to his food requirements.

One last very important reason for intercropping of any crop is the possible reduction of risk, either agronomic or economic [11]. Intercropping is one way of diversification. In agronomic terms, the crops are affected differently by weather disasters, either frost or drought. In economic terms, the explanation is a paraphrasing of the food-cash complementarity already mentioned, that is, if one of the crops is lost the farmer still has one to sell or feed his family.

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[11] J. K. Lynam et. al. "Economics and Risk in Multiple Cropping," in Multiple

Table IV.6: **Annual Maize and Bean Production and Consumption (Kilogrammes per capita), Southern Nariño, 1986**

| | Average | Minimum | Maximum |
|---|---|---|---|
| Annual maize production | 79 | 0 | 420 |
| Annual maize consumption | 80 | 10 | 270 |
| Annual bean production | 40 | 0 | 225 |
| Annual bean consumption | 6.5 | 0 | 42 |

Source: Survey results.

**B. The Internal Structure of the System**

These are factors constraining the farmer from within the system.

**The Land**

Land is a scarce resource in the area. Latifundia is not really a phenomenon here though land is not evenly distributed. (Table IV.7)

In an analysis of variance test done to compare the differences between veredas, according to size of farm, it was found that the veredas are not significantly different in relation to this factor. The average farm size for the veredas Soledad, Loma de Suras, Chaguaipe and Camellones is 2.69, 2.61, 2.43 and 2.35 hectares respectively. Only El Rosal and Yanala have different farm sizes, being 3.09 for El Rosal and 1.87 for Yanala. Both of these veredas are one next to the other but in El Rosal, out of 4 farmers one was a very large farmer so that probably drew up the average considerably.

Since land is a scarce resource it has to be used intensively. The average size of a farm in Ipiales is 2.43 hectares and in average a farm is divided in 5.82 plots carrying 4,11 crops. (Table IV.8) All farmers grow maize and beans and almost all farmers grow potatoes. All other crops are grown only by some farmers. Pasture land, not counting the grass edges, is not usually kept unless the farmer has a large farm

Table IV.7: Distribution of Farms by Land Size, Southern Nariño, 1986

| Size of Farm (ha) | % of Farms | Cumulative % |
|---|---|---|
| < 0.5 | 8.2 | 8.2 |
| 0.5 - 1.5 | 41.0 | 49.2 |
| 1.5 - 3.0 | 18.0 | 67.2 |
| 3.0 - 5.0 | 19.7 | 86.9 |
| > 5.0 | 13.1 | 100.0 |

Source: Survey results.

Counting the crop that occupies the largest extension of land in the farm it was found that the maize/beans combination occupied the first place in 38 of the 61 farms (counting fallow land as the crop which was there before), or 62.3 percent of the farm. Barley occupies the second place with 10.6 % of the farmers, peas come in third with 9.8 % of the farmers, followed by potatoes with 8.2 % and broad beans by 6.6 %. Pasture land occupied the largest area in only two farms to make 3.3 % of the farmers. It is interesting to compare this data with that of farmers' own opinion on which crop is the most important to them in terms of which gives them more income. Of the 53 farmers who answered this question 39.6 % said that beans or the maize/beans association is their main crop. 30.2 % said barley is their main crop and 11.3 % said it is broad beans while 9.4 % said it is potatoes (see table IV.9).

Most people in the Ipiales area own some or all of the land they cultivate. Land can be rented or lent but a common arrangement is crop sharing in which a farmer with too much land and not enough labor or cash shares the costs and returns on a plot either for only one harvest season or for a few years in a row. Usually the people who "take" the land have to supply all the labor but only half of the purchased inputs, such as fertilisers, pesticides and seeds. Even if labor is hired it is totally paid for by the landless crop-sharer. People who "take" land in a crop sharing agreement, however, are not usually totally landless but feel

Table IV.8: Average Farm Size, Number of Plots and Number of Crops, Southern Nariño, 1986

| Variable | Average (ha) | Standard Deviation | Minimum Value | Maximum Value | Variance | Variance Coeff. |
|---|---|---|---|---|---|---|
| Farm Size | 2.43 | 1.99 | .27 | 6.97 | 3.99 | 82.124 |
| Number of crops | 4.11 | 1.46 | 1 | 7 | 2.13 | 35.524 |
| Number of plots | 5.82 | 2.38 | 2 | 11 | 5.68 | 40.965 |

Source: Survey results.

Table IV.9: Main Crop by Area Occupied a[illegible]s' Opinions, Southern Nariño, 1986

| Crop | % of Farms in which it has the Largest Area (61 Farmers) | % of Farmers who Say it is Their Main Crop (53 Farmers) |
|---|---|---|
| Maize/beans | 61 | 40 |
| Barley | 11 | 30 |
| Peas | 10 | 4 |
| Potatoes | 8 | 9 |
| Broad beans | 7 | 11 |
| Pastures | 3 | - |
| Vegetables | 0 | 4 |

Source: Survey results.

equally between the two sharecroppers. Occasionally land is also shared by more than two people. On one occasion a large farmer "gave" some of his land in a share-cropping agreement but did not invest anything in inputs, and therefore received only one fourth of the harvest. He thought he did very well. Arrangements vary in the details but it is usually land in exchange for labor. According to the proportion of land in a farm in a given tenancy, the percent of farms with the different tenancies is described in table IV.10.

### The Input Market and Machinery and Implements Used in the Area

*Input availability*

There seems to be no scarcity of inputs in this area. As long as farmers can get transportation to the municipal capital of Ipiales, they can buy most inputs they need. Occasionally a certain brand or product is discontinued but manufacturers usually have something else to replace the product. The only problem with this is that it confuses the farmer who is used to certain products. There are three kinds of fertilizers always available in the area: 13-26-6, 15-15-15, and 10-30-10. There are slight price differentials which sometimes influence farmers in their purchasing decisions, either because they want to buy the cheapest, or because they want to buy the "best" (most expensive).

*Agricultural Implements*

Besides the use of implements such as handtools, the other major purchased implement is the fumigation tank. Most farmers have at least one of these tanks. The ox-drawn plough is a major implement in the cultivation of the land in Southern Nariño, irrespective of the rugged aspect of the terrain. Not all farmers have a team of oxen; therefore rental of an oxen team in exchange for letting the oxen feed on the stubble of the land to be ploughed is a common arrangement.

Threshers and diesel grinders are owned by a few farmers who rent them to other farmers at times of harvest. There seems to be enough of this machinery, though farmers may have to wait a few days to use it in peak seasons.

Table IV.10: Land Tenancy Pattern, Southern Nariño, 1986

| Greatest proportion of farm land in | Percent of farms |
|---|---|
| Ownership and worked by owner | 52 |
| Takes in share-cropping arrangement | 34 |
| Gives in share-cropping arrangement | 11 |
| Rents from someone | 2 |

Source: Survey results.

**The People**

*Ethnic Background and Heritage*

Each vereda was probably colonized by one family or a small group of families since there is always one or a few predominant family names in each vereda. Indian heritage can be traced by the last name but there has been a lot of racial marriages so now, the contemporary population is quite homogeneous. When talking to an elderly Indian it was found that their food patterns have changed from a predominance of maize, potatoes and beans a diet based partly on to purchased foods such as rice with potatoes remaining a main source of food. *Chicha*, a fermented maize drink, has apparently been displaced by *aguardiente* and fruit juices.

There are other traditions affecting the cultivation methods. Farmers believe they have to plant when there is a full moon, etc. They also think it is good to plant on certain saint festivals. However these traditions are not very strict so they plant when they can, or when they have the space, and the water is good, etc.

The only Indian tradition that seems to remain is the formation of *mingas* or groups of volunteers that work on the public works, such as roads and aqueduct creation.

*Household Structure*

All the people living on the farm are considered part of the household, independently of their relationship with each other. The lowest level of organization is the nuclear family with occasional inclusion of other members of the extended family.

As can be seen in table IV.11, the households have an average of 5.5 members, which is similar for all veredas. The average age of the family members is 26.46 years. The average length of education is 2.7 years of schooling. If we only take into account the members of the family older than 8, we find an average education of 3.5 years of schooling. It was found that there are more men than women in an average farm, with 2.8 men and 2.67 women. There are 1.6 active people who support 3.9 "inactive" people, defined as people who are not involved in money-making activities, or who study and do cooking. The ratio of active to the total number of family members is then .35. That is, for each member in the family there is .35 member who works and contributes in economic terms to the family. The average age of all farmers in the sample, (be it male or female main undertaker of farm activities and decisions) was 46.21, ranging from a minimum of 23 to a maximum of 85, and that of the spouses 41.17. On average, a farmer had received 2.84 years of schooling with a maximum of 6 years. The spouses, who were females in all but one case, did not lag far behind with an average of 2.69 years of schooling. A study done in the rural areas of Colombia found that farmers with two years of schooling or less, were functionally illiterate.

*Labor Allocation*

i) Within the farm

There is clearly division of labor within the family according to sex and age. The housework and cooking are done by the women and the crops are tended by the men. "Small" animals such as chickens, *cuyes*, and pigs are tended by the women while cows, oxen, and horses are tended by the men and children since they only need to be moved around for feeding on the grass. Sheep are moved around for feeding by the women and the children but it is the women who shear them for their knitting. Men do the land preparation and

Table IV.11: Summary Statistics of Family Descriptive Variables, Southern Nariño, 1986

| Variable | Average | Minimum | Maximum |
|---|---|---|---|
| Size of family | 5.47 | 1 | 10 |
| Age | 26.46 | 12.1 | 72.6 |
| Education | 2.72 | 0 | 7 |
| Males | 2.81 | 0 | 6 |
| Females | 2.67 | 0 | 7 |
| Number of active people/farm | 1.61 | 1 | 3 |
| Number of inactive people/farm | [illegible] | 0 | 8 |
| Males/Family size | .53 | 0 | 1 |
| Active/Family size | .35 | 0.11 | 1 |
| Education of members older than 8 | 3.52 | 0 | 7.5 |
| Farmer's age | 46.21 | 23 | 85 |
| Farmer's education (years of schooling) | 2.84 | 0 | 6 |
| Spouse's age | 41.17 | 23 | 69 |
| Spouse's education (years of schooling) | 2.69 | 0 | 6 |

Source: Survey results.

fumigation of crops while women bring the food to the men if the work area is far from the house. Other cultivation practices such as planting, weeding and harvesting are done by both men and women. Green pea harvesting, however, is usually done by women and youths from other farms who are paid not by the day, as is the usual arrangement, but by sacks harvested. Women can be very active in agriculture if they wish but that was usually not the case. There was only one woman interviewed who on her own initiative took care of the farm and administered it. It was observed in the interviews that women usually knew the basics of cultivation but were not informed in the fumigation products or quantities to use. However, most women seemed to participate in the planting decisions, since the farmer discussed with the family what he would plant in each field. The division of labor by sex and age can be appreciated in tables IV.12 and IV.13.

ii) Secondary occupations and work outside the farm.

Even though 44 percent of the people under 12 years old are in school, by looking at table IV.14, we find that 87 percent of the people in this age group work on the farm as a secondary activity, either with the crops and animals or helping in the kitchen, according to the sex differentiation. Most children were sent to school even though they were not always allowed to finish elementary school.

In table IV.12 we can see how many heads of households had occupations other than agriculture as their main occupation. There are five males involved in non-farming activities as their main source of employment, and eleven people whose main activity is working on other farms. From table IV.14, we can see that 33.3 percent of the people over 18 years of age work on other farms as a secondary source of income. People under 18, on the other hand, concentrate their work efforts on their own farm.

*Labor Mobility and Migration*

When farmers were asked how long they had been farming they usually replied "all of their life", but could not give a figure. This is because since childhood they are integrated into the farm work in a gradual process through chores that become increasingly more difficult or time consuming. In view of this aspect, and the observation that many farmers in the area had at one time migrated to large cities but had returned, the farmers were asked if they had migrated and for how long. The main reason given for the migrations was that they had been drafted for military service and had sometimes stayed on after the service; but they had returned when they inherited some land or circumstances in the city changed. A summary of the migration results can be seen in table IV.15

Table IV.12: Division of Labor by Sex, as Exemplified by the Farmer and Spouse, Southern Nariño, 1986

| Main activity | Number of Males | Percent of Males | Number of Females | Percent of Females |
|---|---|---|---|---|
| Farm own l[illegible] | 44 | 72.13 | 1 | 1.92 |
| House work and cook | 1 | 1.64 | 49 | 94.23 |
| Day work other farms | 11 | 18.03 | 1 | 1.92 |
| Commerce of crops | 2 | 3.28 | 0 | 0 |
| Driver | 2 | 3.28 | 0 | 0 |
| Construction | 1 | 1.64 | 0 | 0 |

Source: Survey results.

Table IV.13: Division of Labor by Age Southern Nariño, 1986

| Main Activity | Percentage of people in each age group: 0 - 12 | 13 - 18 | 18 - 65 | 65 - up |
|---|---|---|---|---|
| Work on the farm | 3.76 | 48.21 | 79.1 | 81.82 |
| Work on other farms | 0 | 14.29 | 10.45 | 0 |
| Trade of crops | 0 | 1.79 | 2.24 | 0 |
| Services and urban work | 0.75 | 1.79 | 3.73 | 0 |
| Study | 43.61 | 32.14 | 4.48 | 0 |
| Disabled or too young | 51.88 | 1.79 | 0 | 18.18 |
| Total Percent | 100.00 | 100.00 | 100.00 | 100.00 |
| Total Number | 133 | 56 | 134 | 11 |

Source: Survey results.

Table IV.14: Secondary Occupation by Age Group, in the Farms of Southern Nariño, 1986

| Secondary Activity | Percentage or people in each age group | | | |
|---|---|---|---|---|
| | 0 - 12 | 13 - 18 | 18 - 65 | 65 up |
| Work on the farm | 86.96 | 69.7 | 58.33 | 0 |
| Work on other farms | 4.35 | 12.12 | 33.33 | 100.00 |
| Trade of crops | 0 | 3.03 | 2.78 | 0 |
| Services and urban work | 0 | 3.03 | 2.78 | 0 |
| Study | 8.7 | 12.12 | 2.78 | 0 |
| Total Percent | 100.00 | 100.00 | 100.00 | 100.00 |
| Total Number | 23 | 33 | 72 | 5 |

Source: Survey results.

Table IV.15: Farmer Mobility and Migration in Southern Nariño, 1986

| Farmers who... | Number | Percentage |
|---|---|---|
| -have never left their area | 19 | 41.3 |
| -migrate every year for about two months | 1 | 2.2 |
| -were gone from 1 to 7 years | 19 | 41.3 |
| -were gone from 12 to 26 years | 7 | 15.2 |
| Total | 46 | 100.00 |

Source: Survey results.

C. Concluding Remarks

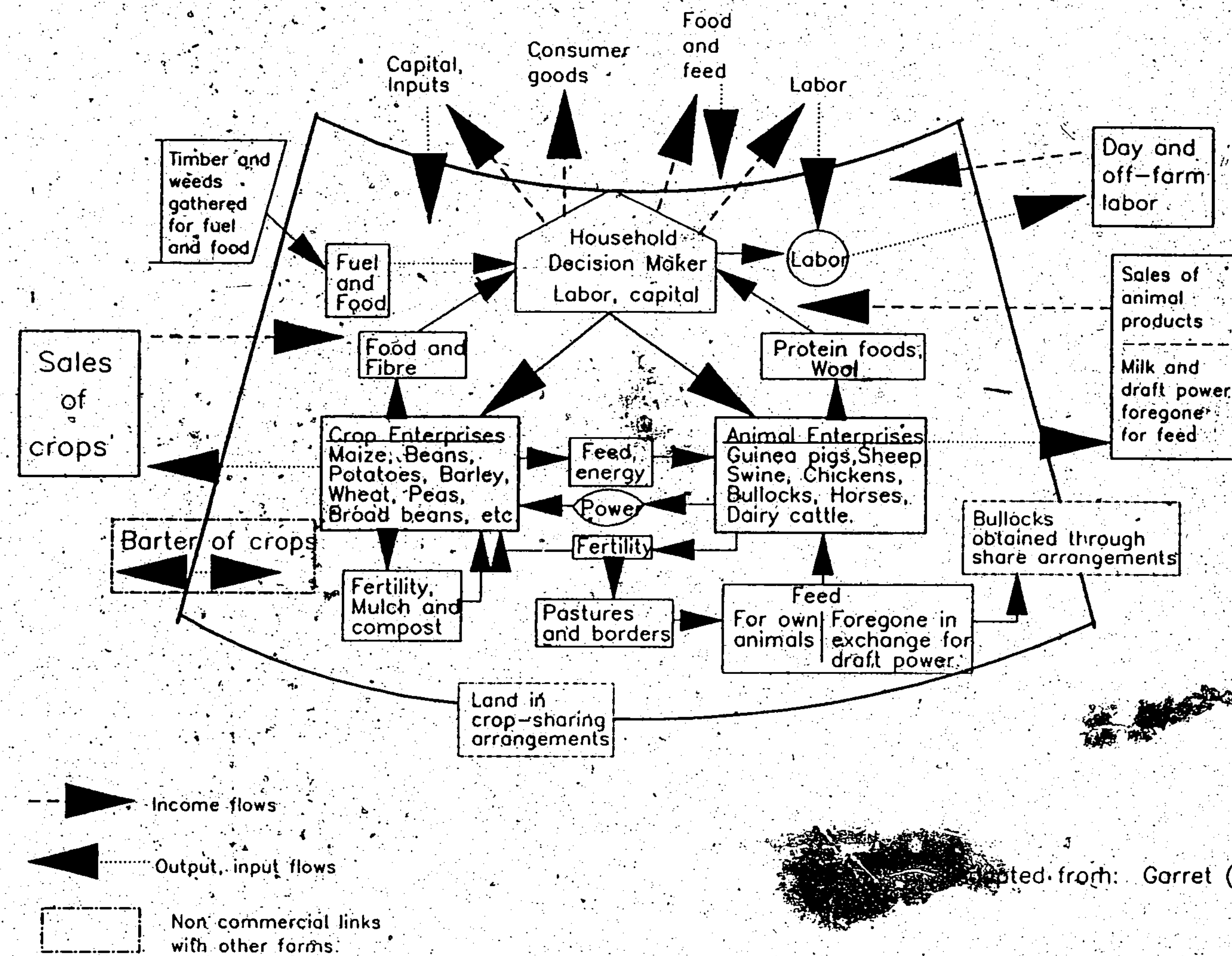
Now that a description of the system has been provided, it is possible to discern key elements governing farmers' production decisions, as well as elements governing changes in production. All of the descriptive variables that have been described in this chapter will be used in differentiating farmers who respond to economic incentives versus those who do not respond.

As is depicted in Figure IV.3, the farms in Southern Nariño are very complex systems. All the activities of crop cultivation and animal management are closely interrelated. The farmer depends on a general equilibrium of all these factors for his survival. Because of the concept of diversification which is a form of insurance, losses on one part of the system do not cause the system to collapse.

Figure IV.4 presents a schematical representation of the farming system, based on the review of farming systems concepts. The ring represents the agricultural farm system formed by the farms. At the center of each farm is the farmer, who decides on the distribution of the farm resources according to the household's needs and wants. All the farms are related through the flow of resources, on a cash or barter basis, the flow of information, and the sharing of land or animals.

The environment surrounds the system from every direction. Different levels of commercialization or subsistence are defined by the openness or closeness of the farm system to the economic and biological environments. The economic environment in general affects the system, while the farmers have little power in affecting this environment. The more subsistence or traditional farmers minimize the effects of the biological and physical environments through diversification of the farm activities. If the more commercial farmers are more specialized in certain enterprises, they forego the benefits of diversification. The more commercial farmers, then, try to close their system to physical environmental effects through the use of inputs. The political environment influences the farming system through policies. Farmers can somewhat affect the political environment through pressure groups, such as the *Juntas de Acción Comunal*. The institutional environment affects the farm system

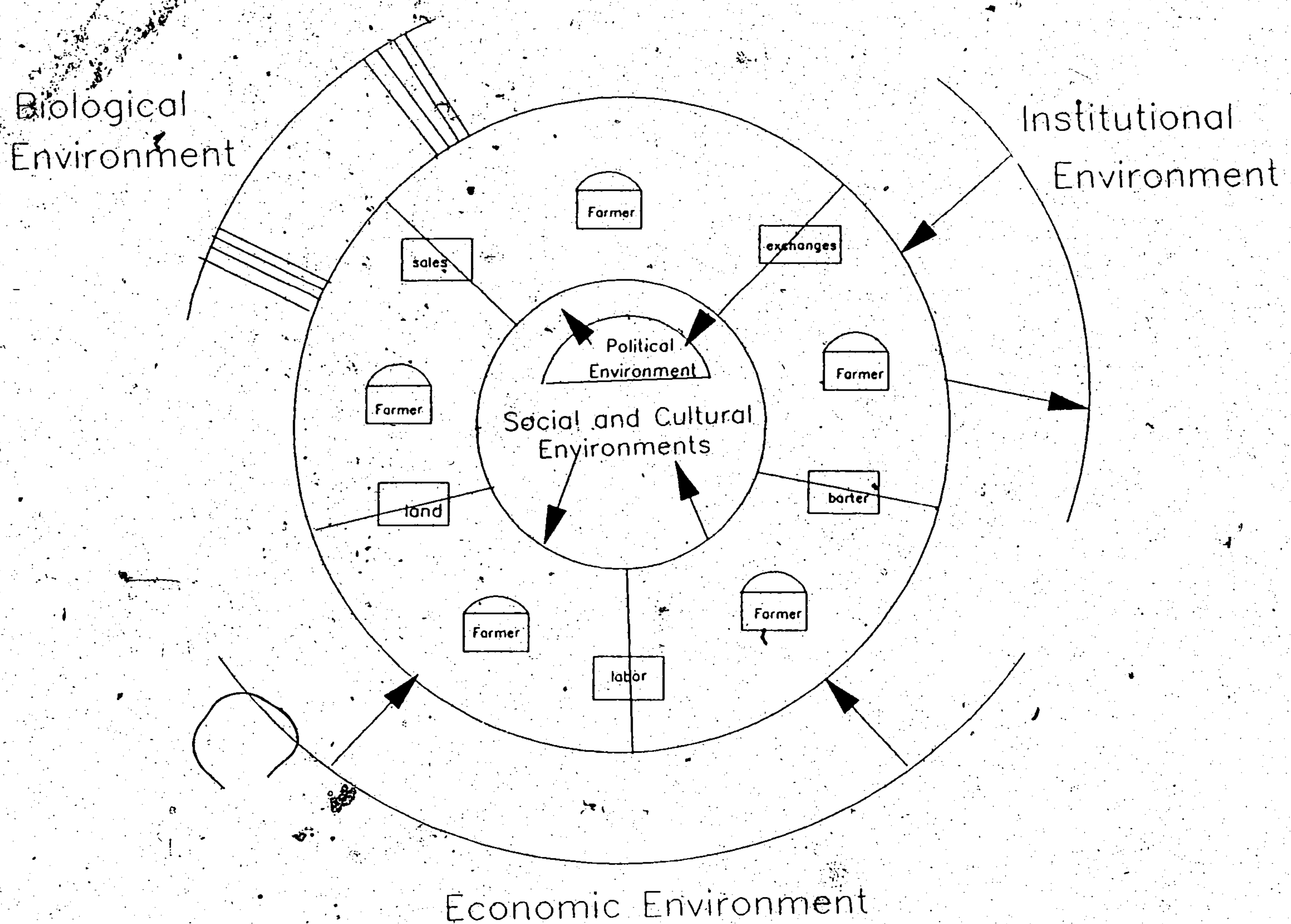
# Figure IV.3 The Farm as a System




...ted from: Garret (1984).

but may need some feedback from the farmers. This is particularly the case in the development of new technologies by research institutions.

Figure IV.4 Schematic Representation of the Farming System of Southern Narino, Colombia



# V. DESCRIPTION AND ANALYSIS OF RESULTS

## A. The Frisch Results

### Description and Meaning of Frisch Results

The results of the Frisch interview method to determine supply responsiveness are presented in table V.1. Seeding rate was used as a proxy for output because yields are highly variable in the area. It was very difficult for a farmer to think in terms of output, with any degree of certainty, so it was decided to use seeding rate in the implementation of the game. It was not possible to use acreage either because of the difficulty of measuring each individual plot, since farmers did not know the size of their plots. Planting densities are assumed to be stable.

The calculation of the MRPS's and MRPSΔ have already been described in Chapter III. The meaning of the MRPS can be explained with an example. For one farmer, the MRPS1 was calculated as -7.33. This number indicates that if this farmer were to decrease his bean plantings by one kilogram, he would have to increase his potato plantings by 7.33 bultos to stay at the same level of satisfaction. It was expected that when the price of beans increased the MRPS obtained would be a larger negative number than with the first bean price. MRPS is an opportunity cost of beans; a large negative number means that many potatoes are needed to substitute one kilogram of beans. At a higher price of beans, more potatoes should be required to keep the farmer satisfied when giving up one kilogram of beans. Thus, there should be a movement towards a higher substitution ratio. The example provided above is an actual result from the interview. It is, however, an extreme case of a high MRPS. The planting density of beans with maize is about 15 kgs per hectare and that of potatoes is about 30 bultos per hectare.

As can be appreciated from table V.1, some farmers had positive MRPS's, which means that when less beans are grown, less potatoes must be grown as well, to keep the farmer at the same level of satisfaction. It is difficult to understand this relationship because

Table V.1: Results From the Frisch Interview, Southern Nariño, Colombia, 1986.

| OBS | GROUP | F1 | PA1 | F2 | PA2 | F3 | PA3 | F4 | PA4 | MRPS1 | MRPS2 | MRPS CHANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 6.00 | 3.00 | 3.0 | 25.00 | 6.0 | 3.00 | 3.0 | 25.00 | -7.333 | -7.333 | 0.000 |
| 2 | 1 | 3.50 | 1.00 | 0.0 | 5.00 | 7.0 | 1.00 | 0.0 | 5.00 | -1.143 | -0.571 | -0.571 |
| 3 | 1 | 6.00 | 2.00 | 3.0 | 4.00 | 9.0 | 2.00 | 3.0 | 4.00 | -0.667 | -0.333 | -0.333 |
| 4 | 1 | 5.50 | 1.25 | 0.5 | 9.00 | 5.5 | 1.25 | 0.5 | 11.75 | -1.550 | -2.100 | 0.550 |
| 5 | 1 | 3.00 | 2.00 | 1.0 | 8.00 | 3.0 | 2.00 | 1.0 | 10.00 | -3.000 | -4.000 | 1.000 |
| 6 | 1 | 3.50 | 1.00 | 0.5 | 3.00 | 3.5 | 1.00 | 0.5 | 6.00 | -0.667 | -1.667 | 1.000 |
| 7 | 1 | 4.00 | 1.00 | 0.5 | 2.00 | 3.5 | 1.00 | 0.5 | 4.00 | -0.286 | -1.000 | 0.714 |
| 8 | 1 | 10.00 | 1.00 | 1.0 | 5.00 | 8.0 | 1.00 | 1.0 | 5.00 | -0.444 | -0.571 | 0.127 |
| 9 | 1 | 27.00 | 7.00 | 6.0 | 15.00 | 15.0 | 7.00 | 6.0 | 26.00 | -0.381 | -2.111 | 1.730 |
| 10 | 1 | 2.50 | 0.50 | 0.5 | 3.00 | 2.5 | 0.50 | 0.5 | 3.50 | -1.250 | -1.500 | 0.250 |
| 11 | 1 | 2.00 | 1.50 | 1.5 | 13.50 | 2.0 | 1.50 | 1.5 | 13.50 | -24.000 | -24.000 | 0.000 |
| 12 | 2 | 1.50 | 1.00 | 1.5 | 0.75 | 7.0 | 1.00 | 1.5 | 1.50 | . | -0.091 | . |
| 13 | 2 | 2.00 | 2.00 | 1.5 | 2.00 | 7.0 | 2.00 | 1.5 | 15.00 | 0.000 | -2.364 | 2.364 |
| 14 | 2 | 3.00 | 1.00 | 1.5 | 5.00 | 1.5 | 1.00 | 1.5 | 7.00 | -2.667 | . | . |
| 15 | 2 | 15.00 | 5.00 | 5.0 | 8.00 | . | . | . | . | -0.300 | . | . |
| 16 | 2 | 1.25 | 7.00 | 5.0 | 21.00 | 15.0 | 7.00 | 5.0 | 7.50 | 3.733 | -0.050 | 3.783 |
| 17 | 2 | 4.50 | 1.00 | 1.5 | 3.00 | 1.5 | 1.00 | 1.5 | 0.00 | -0.667 | . | . |
| 18 | 2 | 5.00 | 5.00 | 7.5 | 7.00 | 10.0 | 5.00 | 7.5 | 5.00 | 0.800 | 0.000 | 0.800 |
| 19 | 2 | 1.50 | 1.50 | 1.5 | 1.50 | 4.0 | 1.50 | 1.5 | 3.00 | . | -0.600 | . |
| 20 | 2 | 1.50 | 1.00 | 0.5 | 8.00 | 0.5 | 1.00 | 0.5 | 3.00 | -7.000 | . | . |
| 21 | 2 | 0.00 | 2.00 | 2.5 | 18.00 | . | . | . | . | 6.400 | . | . |
| 22 | 2 | 15.00 | 15.00 | 15.0 | 15.00 | 15.0 | 15.00 | 15.0 | 15.00 | . | . | . |
| 23 | 2 | 12.00 | 8.00 | 6.0 | 4.00 | 10.0 | 8.00 | 6.0 | 12.00 | 0.667 | -1.000 | 1.667 |
| 24 | 2 | 2.50 | 2.00 | 3.0 | 3.00 | 1.0 | 2.00 | 1.5 | 2.50 | 2.000 | 1.000 | 1.000 |
| 25 | 2 | 5.00 | 2.00 | 1.5 | 13.00 | 0.0 | 2.00 | 1.5 | 13.00 | -3.143 | 7.333 | -10.476 |
| 26 | 2 | 0.00 | 4.00 | 1.5 | 11.00 | 3.0 | 4.00 | 1.5 | 4.50 | 4.667 | -0.333 | 5.000 |

NOTE: F1 AND F2 ARE KILOS OF BEANS AT THE INITIAL PRICE OF 8000.00 PESOS PER BULTO OF BEANS.
PA1 AND PA2 ARE BULTOS OF POTATOES AT THE INITIAL PRICE OF 8000.00 PESOS PER BULTO OF BEANS.
F3 AND F4 ARE KILOS OF BEANS AT THE SECOND PRICE OF 14000.00 PESOS PER BULTO OF BEANS.
PA3 AND PA4 ARE BULTOS OF POTATOES AT THE SECOND PRICE OF 8000.00 PESOS PER BULTO OF BEANS.
MISSING DATA IS INDICATED BY .

beans and potatoes are never intercropped. Beans and potatoes are not complementary with respect to the land base but they may be with respect to other things.

The dual characteristic of beans/maize and potatoes as complementary or substitute crops is understandable knowing that the maize/bean crop combination and potatoes have both subsistence and commercial characteristics. It may be remembered that beans are sold while maize is consumed and that potatoes are half of the time sold and half of the time consumed on the farm. If one crop is seen by the farmer as the cash crop and the other one as a food crop, they would be complements because the farmer may need money from sales of the commercial crop to buy inputs for production of the food crop. If both crops are seen as [illegible] crops then a complementary relationship can be suspected because farmers like to [illegible] maize and potatoes and must plant certain proportions of each crop to remain [illegible]

[illegible] complementary and substitution attitude may be related to maintaining the [illegible] system. If both crops are seen as profitable with similar risk in the eyes of [illegible] there may be competition for resources to grow optimum quantities of both [illegible]ops. A complementary relationship may aim at maintaining the equilibrium of the system in a different way. For example growing more maize and beans creates more stubble to feed the animals and therefore animals can work in other large fields. If the farmer has many animals, he may need large acreages of beans and maize to feed the animals, be they chicken, fed with maize kernels or livestock, fed with the stubble of the crop. From chapter IV, we know that stubble from one hectare of maize can support one head of cattle for 152 days, which is better than most other crops in the system. If the farmer can feed all his animals satisfactorily he can obtain larger quantities of organic fertilizer which is an important input in potato cultivation.

**Classification of Farmers**

One of our basic hypotheses is the heterogeneity of agriculture. As was mentioned in the methodology chapter, three groups of farmers were distinguished from their answers to the Frisch interviews. These groups are used in testing the hypothesis of the heterogeneity of agriculture and according to the variables which show differences, recommendations for policy may emerge given on which should be the basis for discriminating technology adoption policies for farmers. In other words, these variables may provide the decision maker with useful basis for dividing farmers into target groups for policy.

The three groups are numbered for ease of discussion. The group which shows consistently in both MRPS's that beans and potatoes are production substitutes was called group 1. The farmers who considered beans and potatoes as complements for at least one part of the game were grouped into group 2. Finally, farmers who were unable to play the game were allocated to group 3.

To see whether this division of the sample into three groups was justified, the group means with respect to many variables were statistically compared. As a first stage of the analysis, the three groups were compared on the basis of various socioeconomic variables, to see what made them different.

*Differences Among the Groups*

The variables used to compare the three groups were those which seemed to represent the three main characteristics differentiating farmers, as underlined in the hypotheses. That is, the level of commercialization, the level of technology and various proxies for attitudes. The area planted to the three main crops (maize/beans, barley and potatoes) was compared to test if the group differences corresponded to whether farmers were heavily concentrated in production of either crop.

Groups 1 and 2 showed little differences between each other but when combined together and compared with group three there were significant differences with respect to many variables. Usually the mean value for group two was in between groups one and three, denoting a high degree of difference between groups one and ~~three and~~ a smaller degree of difference of group two with either groups one or three. That is, group two usually had an intermediate value.

Group 1.

By looking at table V.2. group one can be characterized as having the youngest farmers, with the largest families. The farmers of this group also have attended school longer than the farmers in the other groups, as well they not only use more inputs in maize and bean cultivation (Grade A), but also know more about the inputs they use (Grade B), they use credit more often and own a smaller proportion of the farms that they operate than the other farmers.

With respect to the crops grown in the farm, on average they grow more barley and potatoes and accordingly sell more potatoes and have higher income from sales of crops than the other groups of farmers. However, they own less livestock than either groups 2 or 3.

Group 3 (other extreme).

Farmers in group three, by contrast are the oldest of the sample, and have the smallest family size as well. They have the least years of schooling, use less inputs in maize and bean cultivation and also know very little about the inputs they use. These farmers use credit less often than farmers in groups one and two, their operating land areas are the smallest in the sample (on average) but they own the largest percentage of this area. These farmers have the smallest area in the cultivation of barley and grow considerably less potatoes than the other farmers. Consequently these farmers sell less potatoes and have the lowest income from sales of this crop as well as from the sale of maize, beans and potatoes together. Even though their maize production is similar to group one's average maize production, not one of these farmers sold maize in 1984. These farmers, however, own more livestock than either groups one or two.

Group 2.

Farmers in group two have intermediate values with respect to groups one and three for age, family size, use and knowledge of technology, use of credit and proportion of land owned. These farmers, relative to groups 1 and 3, grow intermediate quantities of potatoes and barley. Their incomes from sales of potatoes and all beans, maize and potatoes are also of intermediate value, but closer to group one than to group three. The value of the livestock

Table V.2: Average Value of Selected Descriptive Variables for a Sample of Farms, Nariño District, Colombia, 1986

| Variables | Means | | |
|---|---|---|---|
| | Group 1 | Group 2 | group 3 |
| <u>Farm Biography</u> | | | |
| Size of family *[a] | 6.8 | 5.2 | 4.9 |
| Size of farm(ha) *[b] | 2.6 | 3.3 | 1.9 |
| Land per capita *[b] | 0.4 | 0.8 | 0.4 |
| Proportion of area owned(%) | 43 | 60 | 63 |
| <u>Attitude Toward Technology</u> | | | |
| Farmer's age **[a] | 37.1 | 45.8 | 49.7 |
| Farmer's education | 3.5 | 3.1 | 2.5 |
| Use of technology GRADE A | 10.7 | 10.1 | 9.3 |
| Knowledge of technology GRADE B **[c] | 3.4 | 3.3 | 2.5 |
| Frequency use of credit (in 10 ys.) | 4.33 | 3.6 | 3.0 |
| <u>Crop Area in Maize/Beans</u> (ha) | 0.9 | 1.7 | 1.0 |
| Potatoes **[c] | 0.6 | 0.4 | 0.2 |
| Barley | 0.3 | 0.3 | 0.2 |
| <u>Annual Crop Production</u> (100 Kg) | | | |
| Maize | 3.9 | 5.5 | 3.2 |
| Beans **[c] | 2.7 | 2.8 | 1.3 |
| Potatoes | 44.1 | 29.5 | 19.2 |
| <u>Annual Crop Sales</u> (100 Kg) | | | |
| Maize | 0.4 | 1.1 | 0.0 |
| Beans *[c] | 2.3 | 2.3 | 1.1 |
| Potatoes | 23.1 | 15.9 | 6.7 |
| <u>Annual Consumption</u> (100 Kg) | | | |
| Maize | 4.6 | 4.9 | 3.6 |
| Beans *[c] | 0.4 | 0.5 | 0.2 |
| Potatoes | 16.8 | 15.4 | 19.9 |
| <u>Income from Sales and Animal Stock</u> (Colombian 1000 pesos) | | | |
| Value of animals owned | 88.0 | 112.0 | 116.3 |
| Income from sales of beans ***[c] | 44.4 | 44.0 | 18.6 |
| Income from sales of potatoes | 53.2 | 35.6 | 13.7 |
| Income from sales of beans, maize and potatoes **[c] | 98.5 | 83.6 | 32.8 |
| Percapita income from sales **[c] | 15.1 | 15.9 | 6.5 |

Source: Survey results. Figures rounded to nearest decimal.
Significance level indicated by *(10%), **(5%) and ***(2.5%).
[a]Indicates difference of group 1 versus the average of groups 2 and 3.
[b]Indicates difference of group 2 versus the average of groups 1 and 3.
[c]Indicates difference of groups 1 and 2 together versus group 3.

they own is also in between the values for groups one and three.

There are some exceptions to this pattern in the ordering of the variables by groups. For example, group two farmers have the largest farms and grow more maize and beans than either group one or three, therefore also selling much more maize but selling about as much beans as farmers in group one, who had the highest total income. Group two also had the smallest person/land ratio of the three groups (land per capita). This follows from having the largest farm area but with intermediate size of family. When total income is divided among all the family members, group two comes slightly ahead of group one (again because the families in group two are smaller).

**Discussion of Results from the Frisch Interview**

*a) Differences between the groups*

In the comparison of means tests, it was consistently noted that with respect to most variables, group one was usually at one extreme of size, group three was at the other extreme and group two had an intermediate value. It was also noted that groups one and two did not have many significant differences with each other but when combined and compared to group three there were many statistically significant differences.

It was apparent that farmers of groups one and two had a higher level of education, knowledge of their technology and were younger than farmers in group 3. All these variables are thought to be highly correlated with a positive attitude towards change. For this reason, these characteristics seem to show farmers in these two groups more open to change and to accept change. They are farmers who have more contact with extension workers and technical advisors in the area, as denoted by their knowledge of technology and use of credit.

Potato area is significantly lower for group three in comparison to groups one and two. Potatoes are a high risk crop which can occasionally command a high price in the market. This is one of the reasons to assert that farmers in groups one and two may be more willing to take risks but group one even more than group two since it grows more potatoes (.6 vs .43 hectares, while group three only grows .17). Another reason for saying that group two is more risk averse than group one is because farmers in group two grow more maize and beans than farmers in any other group. Beans have a relatively high market risk, because of high price variability and fluctuation of demand of different varieties according to in what part of the country has a bean shortage. Each part of Colombia has a different varietal preference. However, we know that maize has a stable price and beans can be consumed if they are difficult to sell. If farmers do not sell their crop they can always store the maize and the beans and speculate on price improvement. However, old beans always command a lower price than new beans, unless there is scarcity of beans in the market, in which case all beans have a market.

The fact that group two farmers may be minimizing their risk by assuring a high margin of maize/beans planted and less potatoes, is also supported by the surplus of maize production that they show. They sell more maize than any other group and have the highest consumption of beans: 50.2 kgs or 22% of production, while group 3 consumes 21 kgs. and group 1 consumes 41.4 kgs.

Groups one and two are very similar in most descriptive characteristics, but the main differences seem to lie in their production and sales practices of maize and potatoes (not beans). For example, group two has almost twice as much land in beans and maize as group one but they both sell the same quantity of beans. Group one, however, grows and sells more potatoes than group two. Group two, on the other hand, sells more maize than group one. It is possible that farmers in group two complement their lower sales from potatoes with sales of maize. Though maize does not command such a high price, there could still be a large difference in total income, but family size is smaller and income per capita turns out to be almost the same as group one's.

Group one seems to be more efficient in production than group three since they plant about the same quantity of seed but harvest much more beans (twice as much) and a little more maize. Farmers in group three risk less of their capital by putting it into livestock as a way of saving.

In summary, group three seems to be a very closed system, using less inputs, having fewer connections with the outer environment including technicians or the market system. Other variables, such as status, tradition, and risk appear to govern their decisions, rather than prices. For these reasons this group is called the non-responsive group. These farmers are not expected (assumed) to respond to price changes with a change in production. If a change in production occurs it is probably governed by the other reasons just mentioned and agronomic factors, such as rotation restrictions, weather outlook , incidence of pests in fields, and frosts. Experience in selling the last harvest or changes in family maize requirements, may also influence production changes according to farmers' comments during the interviews.

*b) Interpretation of Differences*

The grouping of the sampled farmers into these three groups is justified on the basis of statistically significant differences. Different groups of farmers can be found even in the case of a small geographic region.

Furthermore, the analysis has provided us with some useful variables or criteria, to divide farmers into groups for policy purposes. For example, level of education and use of technology are variables over which policy makers have control and which are expected to be positively correlated with price response. As well, we have seen that farm size is not a useful basis for division of farmers, contrary to Mellor's[12], but in agreement with Boussard's argument[13]. Neither is predominant form of tenancy a useful division factor, at least not with the predominant land-sharing agreements in the area. The major factor differentiating these groups is the level of commercialization of the farmers. It is now our desire to demonstrate that level of commercialization, as well as the variables mentioned above (education, technology, age and others) positively influence supply response. Unfortunately no estimate of supply response for group 3 was possible, so the analysis of the variability of the response

[12]J. W. Mellor, "The Subsistence Farmer in Traditional Economies," in Wharton, Subsistence Agriculture and Economic Development. (Chicago: Aldine Publishing Company, 1969)

[13]J. M. Boussard, "Is Agricultural Production Responsive to Prices?" European Review of Agricultural Economics Vol. 12 (1985) pp. 31-44

is limited to groups 1 and 2.

Before trying to see which factors affect the magnitude and direction of change of the MRPS's, linear regression was used to explain the effect of short term prices and short term price changes on production.

**B. Linear Regressions to Find Explanatory Power of Prices and Other Variables in Production Decisions.**

**Using absolute values for the dependent variable: BEAN85**

The dependent variable for this regression was defined as total seed planted in 1985, called BEAN85. The price variables used were the farm gate prices for the two seasons immediately preceding the 1985 planting season, and respectively called PRICE84 and PRICE85. The model was specified in three ways, as a linear function, as a semi-logarithmic function and as a logarithmic function. The explanatory power of prices on production and the significance levels of the price coefficients were extremely low for all specifications of the model, as can be seen in Table VII. 1, in the Appendix.

When separate regressions were run for each group, apparently there was a different response to prices by each group. However, since the $R^2$'s were very low for all regressions and F statistics were not significant, even though the $R^2$ for group one was .2593; no comparison could be made on the basis of these regressions. It seems absolute prices have zero correlation with production for all groups.

The group regressions showed that the coefficient for PRICE84 is always negative while it is positive for PRICE85 for groups 1 and 2. This seems to indicate a negative elasticity for all farmers, but may simply show price pessimism and uncertainty. In no case were the price coefficients statistically significant.

Regressions were used also to test other variables which aided in the explanation of the planting decision. The three main variables influencing the absolute quantity of bean seed were farm size, bean seed in 84 and the potato acreage (seed) in 1985. The strength and direction(sign) of the relationships varies among groups. For example, farm size accounts for 71 and 77 percent of the variation in bean plantings in groups 2 and 3 respectively but it accounts for 55 percent of the variation for group 1. Bean seed in 1984, on the other hand, accounts for about 40 percent of the variation of groups 2 and 3 but only for 15 percent of the variation of group one's planting decision. Furthermore, the coefficients of the independent variable seed in 84 are significant for groups 2 and 3 but not for group 1, as can be seen in Table VII.3.

When using potato plantings in 85 as the independent variable the F statistics are not significant but the sign of the coefficients support the results from the Frisch interview. The coefficient for potatoes for groups 2 and 3 is positive, indicating complementarity between the two crops. The coefficient for potatoes for group 1 is negative, which shows that farmers in this group consider beans and potatoes as substitute crops.

**Results Using Change in Seed Planted From 1984 to 1985 as the Dependent Variable: BEANΔ**

Since seed planted in 1985 is an absolute value and does not show a change in production, the change in bean seed from 84 to 85 was used as the dependent variable in different regressions. The results are summarized in Table VII.4. The pooled regression shows low explanatory power and level of significance of the price variable, which was defined as the price change from 1984 to 1985. When the sample was divided by group the $R^2$ for groups 1 and 2 increased and the price coefficients remained positive while the price coefficient for group three was negative, indicating an inverse relationship between production and price changes.

Other variables which aided in the explanation of planting changes were farm size and changes in potato seed planted in the same time period. These results are similar to those obtained when using absolute acreage as the dependent variable but the explanatory power is smaller now.

Farm size accounts for 35 percent of the variation in changes in production, which indicates that farmers with a larger land base are more flexible in their production decision, but again this variable is much weaker in explaining the behavior of substitute-response farmers than the other groups of farmers.

The POTATOΔ variable still shows the complementary and substitute characteristics of groups 2 and 1, respectively but shows substitute characteristics for farmers in group 3, as indicated by the negative coefficient for price change. The $R^2$ and F values are low, however. This potato variable is significant at $\alpha = .01$, and with great explanatory power for group 1.

**Results Using Extra Bean Seed in 1985 as the Dependent Variable: EXTRA85**

To test the hypothesis of a minimum production of beans to satisfy the farmers' maize requirements, not depending on prices, extra seed in 85 was used as the dependent variable, as well as using the change in extra seed from 1984 to 1985 (EXTRAΔ).

It was hypothesized that farmers need a minimum acreage of maize and beans for subsistence, but once this requirement is met, extra seed may be planted if there is response to high prices. Two regressions were run to test this hypothesis. In the first equation, EXTRA85 was used as the dependent variable with PRICE84 and PRICE85 as the independent variables. In the second equation, EXTRAΔ was used as the dependent variable with PRICEΔ as the independent variable. The results are presented in Table VII.5. Here it can be seen that price is more important for group 1 than for the other groups. When the relationship is expressed as a change, both groups 1 and 2 show very similar response of production to prices, as can be seen in Table VII.6.

**Summary of Results of the Relationship Between Production and Prices**

The results seem to support the division of the sample into three groups, based on the potato relationship. The new evidence supports the contention that farmers in groups 2 and 3 consider potatoes and beans s complementary outputs and farmers in group 1 consider these two crops as substitute crops. The reason why they may be complements or substitutes has already been mentioned in the first part of this chapter.

For the price-quantity relationships, the low R's show that prices are of little use in the explanation of total seed or changes in production decisions. The change in the sign of the price coefficient from 1984 to 1985 may point at the great price uncertainty in the area.

Farm size, bean seed 84 and potato acreage are consistently the best explanatory var[illegible] the planting decision but they show less explanatory power when plantings are c[illegible] a change. The larger the land base, the more a farmer can grow of any crop or [illegible] crops, if he so wishes. A larger land base, however, may also mean that commercial bean producers are associated with larger farmers. When the sample is divided in three groups, the farm size variable and the BEAN84 variables show less explanatory power for the farmers in group 1. This indicates that there are other factors besides farm size and habit which are more important to farmers in group 1.

Comparison of group regressions and pooled regressions seem to indicate different planting criterion of farmers in the area. For some farmers prices are more important, for others it is a habit factor which may be reflected in the availability of resources, mainly the land base. For all farmers other crops to be grown have a strong influence in their decision but in a different way.

**Discussion of Results of Variables Affecting Bean Planting Decisions**

The underlying assumption for using price of sale as the price variable was that farmers' planting decision is based on the price at which they sold their crop, rather than the price of beans at the time of planting. The reason for this assumption is that there is some seasonality of bean prices, corresponding to harves[illegible] and seeding times. So farmers usually mention that what the price is today has no bearing (or relationship) with the price at which beans will sell in the next harvest season.

It was believed, then, that farmers would look more at the trend in prices with respect to the prices at which they sold the previous year. Even though there has been an upward trend in bean prices up to the end of 1984 (see figure V..1), there was a sharp decrease in prices after that peak which made farmers uneasy and insecure about what to expect next season. Furthermore, the monthly and even weekly price variability instills a great deal of price uncertainty in the region.

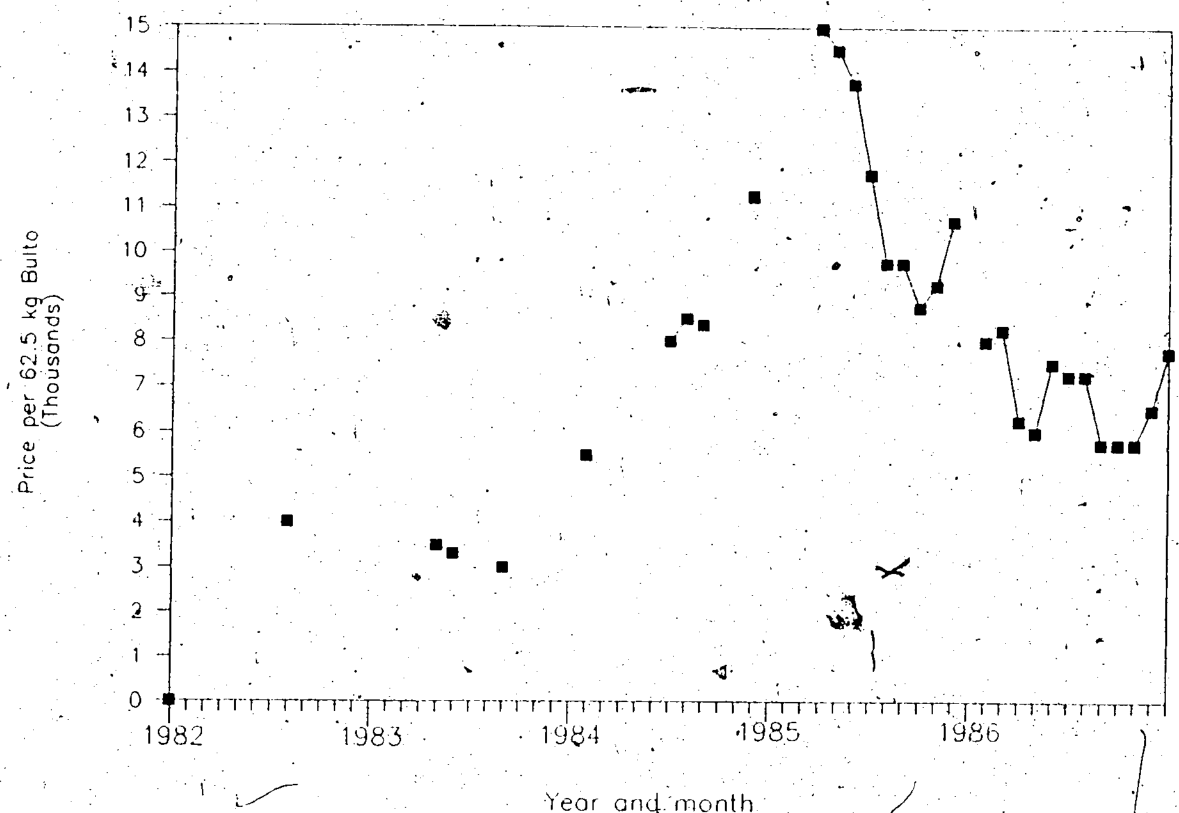
The great day-to-day variability shows how it is a buyer's market in Nariño, not because of the concentration of buyers, but because Nariño is a small producer and relies on other provinces for purchases of their beans. As well bean production is characterized by many small producers with no price-setting power. It was mentioned in chapter IV that farmers in Southern Nariño are not big consumers of beans, neither are urban dwellers in this area. The main bean consumers are located in Colombia's "Paisa" region, in the central part of the country, which is also the largest bean producing region, and in Colombia's three main cities, which have high migrant populations: Bogota, Cali and Medellin.

The price and the demand for beans in Nariño is dependent on the harvests in the Paisa provinces as well as the stocks in the cities. For example, if there is a large demand for beans in Cali, or any other large city, wholesalers know of this by constant telephone communication. These wholesalers can dispatch the stock from their warehouses and ship them in trucks to the city at a short notice.

It is no wonder, then, that prices and production show no correlation and that beans seeded in 1985 are most heavily influenced by beans seeded in 1984. It is not merely a strong habit factor which overlooks prices, it only shows the great market uncertainties which make farmers stick to a pattern which they think works for them and which is probably highly determined by a minimum maize subsistence requirement and a space restriction: available farm land. This hypothesis, however, could not be corroborated, given the available data.

Other forms of farmers' response to prices are by planting early or planting late, or by growing beans in monoculture. All of these measures increase the agronomic risk but may improve the odds on the market risks: low prices at harvest time and higher yields from growing beans in monoculture. Late plantings may be less related to response, since they may be a result of late decisions, late rains, late harvesting of the previous crop, or a symptom of re-seeding after drought or frost. Nevertheless, some farmers mentioned the fact that if they planted late enough they could sell their crops at higher prices.

## Figure V.1 Monthly Farm Gate Prices, Southern Narino, 1982 – 1986




Source: CIAT's Bean Program Records.

## C. Tests of Hypotheses of Factors Affecting Response

### Procedure

Two variables are used as proxies for response. The difference in the MRPS's (MRPSΔ), is used since it shows a change in preference or value of beans as a price change occurs. To compare and corroborate our results, a variable derived from actual data on production and prices is also used as a dependent variable. This variable, ARCELAST, measures the flexibility of farmers' ability to respond to prices in two time periods. It must be emphasized that ARCELAST shows response under uncertainty, while MRPSΔ shows response under near-perfect certainty.

As was hypothesized before, there are four main categories of variables affecting response, those representing level of commercialization, attitudes, biographic characteristics and importance of some crops in the system.

Since only 26 farmers were able to respond to the Frisch interview, the analysis will concentrate on these 26 farmers. The process of choosing variables was a difficult one since all the correlations with the dependent variables were weak. Furthermore, some variables affected one group of farmers but not the other and one dependent variable but not the other dependent variable. The results seem to indicate that there is some difference between the responses represented by each of the dependent variables, in the sense that they are affected in different ways. See tables VII.7 and VII.8 in the Appendix.

As an intermediate step in the search for a behavioral function explaining response, individual variables were used in regressions with both dependent variables. However, given the cross-sectional nature of the data, applied to a small region, some collinearity was detected. This made the use of combinations of variables together a difficult task. Uncorrelated variables were chosen in combinations. Dummy variables were used for potato related variables, since one group had an inverse relationship while the other one had a direct relationship with this variable. A combination of two variables was used at one time with a dummy variable for intercept and interaction terms, as required by the particular variable.

The matrix of correlation coefficients can be found in table V. 3. From this matrix we can make various observations.

a)Farm size is strongly correlated with the commercial variables as well as with the value of animals owned. It is also somewhat correlated with education. This tells us that farm size is an indication of commercialization; with a larger land base, excess production, above consumption requirements, can be achieved and therefore more sales. A larger land base allows more space for animal grazing and more stubble from the crops to feed the livestock.

b)The income variables are strongly correlated with education, especially income from beans; income allows farmers to get more education, or more education allows farmers to acquire more land and wealth. The bean income variable shows the strongest correlation with GRADEA. It must be remembered that the technology variables were related only to the maize/bean crop combination. That is, the farmers were asked what inputs they used and how they used them for these two crops. This indicates that a higher and better use of inputs can be related to income obtained from this crop. So it may be that more sales allow the farmer to buy more inputs, or that the use of better inputs allows him to have better yields, and therefore more sales.

c) All the potato-related variables are negatively, though weakly, correlated with the bean technology variable, which may indicate some degree of specialization of commercial producers in bean rather than potato production. The potato-related variables are also highly correlated with the labor equivalents in the farm, which shows the labor-intensive nature of potato cultivation. Thus a family with high labor equivalents can cultivate a larger area of potatoes. Potatoes are a labor and chemical-input intensive crop. Bean cultivation, on the other hand, is not as labor intensive, so labor available in the farm is not such a strong constraint for this crop.

Taking account of these correlations, combinations of variables were chosen in an attempt to find a behavioural equation with high explanatory power. From the individual-variable regressions, we were able to discern that some variables should be used with a dummy term because they sometimes are positively correlated with one group but

Table V.3: Pearson Correlation Coefficients for the Independent Variables

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 FARM SIZE | 1 | -0.06 | 0.17 | 0.58*** | 0.69*** | 0.32 | 0.30 | 0.22 | 0.25 | 0.19 | -0.19 |
| 2 MAIZFARM | | 1 | -0.48** | -0.09 | -0.06 | -0.24 | -0.10 | -0.12 | -0.19 | 0.22 | -0.27 |
| 3 POTATOFARM | | | 1 | -0.17 | -0.06 | 0.23 | 0.32 | 0.22 | 0.25 | -0.20 | -0.02 |
| 4 ADDANIM | | | | 1 | 0.43** | 0.26 | 0.01 | 0.30 | 0.25 | 0.20 | 0.07 |
| 5 INGFRIJ | | | | | 1 | 0.42** | 0.16 | -0.02 | 0.50*** | 0.27 | 0.14 |
| 6 INPAPAYC | | | | | | 1 | 0.62*** | 0.14 | 0.37* | -0.17 | 0.17 |
| 7 FAMLABOR | | | | | | | 1 | 0.26 | 0.14 | -0.05 | -0.19 |
| 8 AGE | | | | | | | | 1 | -0.01 | 0.12 | 0.03 |
| 9 EDUCATION | | | | | | | | | 1 | 0.22 | 0.40** |
| 10 GRADE A | | | | | | | | | | 1 | -0.15 |
| 11 OWNFARM | | | | | | | | | | | 1 |

Source: Survey results.
Significance level indicated by *(10%), **(5%) and ***(1%).

negatively correlated with the other.

**Behavioral Functions**

For ARCELAST, it was mentioned that heteroscedasticity was detected with some variables, especially with farm size. Weighted least squares was applied, but this procedure significantly reduced the $R^2$ of the equation. According to Koutsoyiannis, the consequences of heteroscedasticity are that one cannot conduct tests of significance or construct confidence intervals, the estimators are inefficient and there is a high variance in prediction. However, the coefficient estimates are still unbiased[14]. The heteroscedasticity present in this study seems to indicate that the variance of the error term of ARCELAST varies systematically with farm size, among other variables. It is possible, then, that a larger land base does allow for more flexibility in changes in production. Heteroscedasticity did not seem to be a major factor for MRPSΔ, when analysing the residuals.

Since the $R^2$ decreased considerably when applying weighted least squares, the OLS results will be reported here, with the warning of the presence of heteroscedasticity in the models where ARCELAST and farm size appear together. The main consequences will be the difficulty of prediction and the inefficient estimators in the models.

The results presented in this section are for groups 1 and 2 pooled together. The groups were not stratified given the small sample sizes. For ARCELAST, the use of dummy variables for group did not improve the models considerably. Consequently, the best equations found are as follow:

ARCELAST = -.157 + .041 FARM SIZE*** + .220 MAIZFARM**,

where $R^2$ = .55 and F = 12.29***

Significance levels are indicated by *(10%), **(5%), ***(1%).

This equation shows the importance of farm size in allowing flexibility in response, the importance of the crop in the farm is also a significant factor affecting flexibility of response. As the farmer concentrates his efforts in maize-bean production, he must be aware

[14] A. Koutsoyiannis, Theory of Econometrics, 2nd. ed. (Hong Kong: Mac Millan, 1977)

of changing prices and able to respond. It must be remembered that MAIZFARM refers to acreage of beans and maize in the farm. The relative importance of other crops in the system is also exemplified by another equation:

ARCELAST = -.001 + .036 FARM SIZE*** - .209 PAPAFARM

where $R^2$ = .43 and F = 7.52***

This equation again shows the importance of farm size in explaining flexibility of response of production and the importance of other crops on the system. The equation indicates an inverse relationship between specialization in potato production and flexibility of response to prices. This denotes a relationship as expected from economic theory. It was hypothesized that substitution characteristics among crops in a system are associated with commercial agriculture. The relationship found above shows some support to this contention; farmers specializing in bean-maize production respond more positively to bean price changes. The larger the farm area in potato cultivation, the smaller the area in cultivation of other crops, including beans, so the smaller PAPAFARM, the more responsive (larger ARCELAST) the farmer is.

These two equations seem to support our hypothesis about the influence of level of commercialization on response. As well, the results support Mellor's thinking and Askari and Cummings' findings with respect to the importance of size of holding on response.

The influence of attitudinal variables and predominant form of tenancy are not as clear. However, one equation gives an indication of the influence of these variables in response:

ARCELAST = .14 + .04 D1 - .37 OWNFARM** + .75 D1*OWNFARM +
.05 EDUC - .14D1*EDUC**

where D1 is the dummy variable for group and

$R^2$ = .45 and F = 2.98**

and:

ARCELAST = .02 + .01 D1 - .00002 POTATOΔ + .01 GRADEA + .0002 D1*POTATOΔ

where $R^2$ = .42 and F = 3.66**

Notice that the $R^2$s are lower now than without the use of dummies and that the sign changes for the interaction term, so it is difficult to interpret. The high significance of the dummy variables for the potato change variable show what was pointed out before, that the groups have a different relationship with this variable. GRADEA and EDUCATION are positively correlated with ARCELAST, while OWNFARM is negatively correlated with ARCELAST, indicating more risk aversion of farmers who own most of their land base. Table A. 8 shows that these variables are more strongly related with one group than with the other. Since only around 40 percent of the variance could be explained with these equations with five variables, the concept of parsimony seems to indicate that the models containing farm size and relative importance of other crops in the system are better models since they explain a greater part of the variance with less independent variables. However, remember the presence of heteroscedasticity. Remember also the distinction between FARM SIZE AND OWNFARM. FARM SIZE refers to total cropping area, while OWNFARM refers to that part of the total cropping area actually owned by the farmer.

For MRPSΔ, in general it was found that, without the use of dummy variables it was difficult to find variables with strong predictive power. The best behavioral equations, that is, those with higher $R^2$s and siginificance levels seemed to include variables for level of commercialization, attitudes and those showing the importance of other crops in the system, specifically potatoes.

The models which accounted for the greatest variation in response are the following:

$$MRPS\Delta = 22.50^{***} - 23.68\ D1^{***} - .0000005\ INGFRIJ + .000002\ D1{*}INGFRIJ - .52\ AGE^{***} + .56\ D1{*}AGE^{***}$$

where $R^2 = .63$ and $F = 3.35^{**}$

and

$$MRPS\Delta = 1.16 - 1.78\ D1 - 23.27\ PAPAFARM + 26.26\ D1{*}PAPAFARM + .35\ GRADEA - .30D1{*}GRADEA$$

where $R^2 = .66$ and $F = 3.85^{**}$

## Summary of Behavioral Equation Results

The results from the behavioral equations may be summarized as follows:

Firstly, the relative importance of the crop and other crops in the farm is paramount in determining farmers' response to price changes.

Secondly, the groups differ in their responsiveness to prices and in the factors affecting their response, as can be seen by the coefficients of the dummy variables and interaction terms.

Thirdly, GRADEA and AGE are also contributing factors in the explanation of the degree of responsiveness to prices. These variables represent the attitudinal component of response.

Finally, by comparing the independent variables which affect total planting decisions, change in plantings, and degree of response to price changes, it was apparent that the EDUCATION and AGE variables became more important when the dependent variable was expressed as a change either in production or in MRPS.

## Discussion of Behavioral Equations

The hypothesis of form of land tenancy influencing response is supported by the results. The less area of the farm that the farmer owns, the more willing he is to incur risks and change his production of beans. This indicates that crop sharing arrangements in the area are useful in the minimization of risks and maximization of resources. It does not mean that landless peasants are more responsive to price changes under all systems and circumstances.

It was argued that level of specialization of the farm enterprises and income from sales were an indication of level of commercialization of the farmer. From the behavioral functions, it was apparent that level of commercialization is very influential in explaining the magnitude of response of farmers to prices. In combination with farm size, it is most helpful in explaining ARCELAST, while in combination with attitudinal variables it is most helpful in explaining MRPSΔ. This supports the hypothesis that more commercialized farmers are more price responsive since they depend so much on the market for their subsistence.

The fact that EDUCATION and AGE become important variables in the explanation of changes in response, rather than in total response, seems to show that perception of prices is important and that an inelastic response is associated to some degree with a low level of perception or of awareness.

Once a change in the market is perceived, attitudes determine whether the farmer wants to change his production or not. The available land base determines whether he can change or adjust his production or not.

The presence of the technology variable, GRADEA, in the behavioral equations for both dependent variables, ARCELAST and MRPSΔ, seem to confirm the hypothesis that there is a positive relationship between use of new technology and price responsiveness. This result also supports the assertion that as a system becomes more commercialized, it must rely more and more in new improved inputs to mitigate the environmental effects which occur as a result of moving to a greater degree of specialization.

Finally, by comparing the results obtained from using these two dependent variables, it can be seen that the results are quite similar. The main exception being the importance of FARM SIZE in explaining variation of ARCELAST but not of MRPSΔ. One of the advantages of the Frisch Interview Technique, though being hypothetical, is that it assures farmers of certain price increases, though it was hard to convince farmers of this possibility. That is, we are measuring price response in the face of total, or close to total price certainty. This may seem unrealistic, especially in Colombia, after having described the great price variability in the area. However, this response in the absence of price uncertainty is very relevant for policy makers because it gives them a guideline to what would happen if a policy of price incentives was set and effectively implemented.

# VI. SUMMARY, LIMITATIONS, AND CONCLUSIONS

## A. Summary

The effects of prices on production in a semi-subsistence farming system were explored in this work. The characteristics of responsive versus non-responsive farmers were explored. The bean farmers of the Colombian Andes provided the scenario and sample frame for the research. The farmers in this area are typical of small farmers in many developing countries. Beans, (*Phaseolus Vulgaris*), are an important small-farmer crop and low-cost protein source in various parts of the world.

The farming system of Southern Nariño is characterized by both subsistence and commercial characteristics. Food self-sufficiency and the production of a surplus for the market are both objectives of the system. Farmers try to achieve these objectives through the use of technological inputs to ameliorate the bio-physical effects of the environment and increase yields. This increased dependency in purchased inputs increases the system's susceptibility to economic environmental effects, such as sudden price changes for inputs and outputs. Beans and maize are intercropped and hold the largest cropping area in the region. Potatoes are the other main crop in the system and are considered the main food crop.

An interview technique for obtaining an estimate of production response to prices was developed and tested in the field. This interview technique is based on the premise that production decisions of semi-subsistence farmers can be analyzed within a theory of choice. The producer is simultaneously reflecting his consumption choices, and other factors, when deciding how much to produce of which crops. An elasticity estimate could not be obtained but it was believed that by applying the game two times to each farmer, each time with a different price for beans, the change in the choices would indicate the response to price changes.

The results obtained from this interview technique revealed three kinds of response by farmers in the area. One group of farmers showed that production decisions for beans were tied in a complementary fashion to production decisions of potatoes, the other main crop in the system. The second kind of response by farmers showed that beans and potatoes were substitute crops, competing for resources in production. The third response was an inability to recognize any price influence on production decisions.

Statistical tests were done to assure that indeed the classification of responses resulted in distinct groups. The tests showed significant differences with respect to the age, knowledge of technology, specialization in crops and income variables, the main difference between the groups being the level of commercialization. An estimate of supply response was not obtained but a useful basis for division of farmers into target groups for policy was achieved.

Linear regression was applied to test the influence of product prices on bean production. The dependent variable was acreage response while the independent variables were the prices at which farmers sold their crops in the preceding two years. Alternatively, in another regression, acreage response was also defined as the change in planned production between the years 1984 and 1985. The independent variable in this case was also specified as the change in bean price between 1984 and 1985. The low explanatory power of the regressions and the low significance of the price coefficients provided support to the hypothesis that absolute prices are a minor determinant of production in semi commercial farming systems. To test if the relationship was not linear, the data was transformed to a semi-logarithmic and log-log form. Neither specification of the equations significantly improved the fit.

It was hypothesized that a surplus of production above subsistence requirements may be more influenced by bean prices than total quantity produced. The results of the regressions do not support this hypothesis.

Variables which were most useful in the explanation of bean production decisions were the size of farm, the potato acreage and the bean acreage of the year before. The change in potato acreage and farm size were useful explanatory variables of the variation in bean acreage between two years. For the substitute response group, the change in potato acreage was inversely related to change in bean acreage at $\alpha = .01$. For the complementary response group, on the other hand, the change in potato acreage was directly related to the change in bean acreage though the F statistic was not significant. These results support the division of the groups as was done from the results obtained in the Frisch Interview.

Multivariate equations were difficult to obtain given the small number of observations for each group and the correlation of the independent variables. The behavioral functions developed to explain differences in price response of farmers included variables for level of commercialization, attitudes, technology and farm size. Fifty five percent of the variation response under uncertainty, calculated as the percentage change in production over the percentage change in price, was explained by the combination of farm size and relative importance of the crop in the system. A model including income from beans, age, and a dummy variable for group explained sixty six percent of the variation of response under certainty, which was the change in response obtained in the Frisch interview.

The two proxies for response, MRPSΔ and ARCELAST, though obtained through different methods, show that there are important factors within the system determining the magnitude of response to prices. This is the case either under uncertainty or under hypothesized stability.

## B. Limitations of the Research

The main limitations of this research lie in the data constraints and the application of the Frisch interview. It was difficult for many farmers to understand the objectives of the game and to respond to it. It is believed that with the use of flashcards with drawings of the crops in question the farmers may have been better able to answer. In any case the ability to respond to the questionnaire also seemed to give an indication of other characteristics describing the farmers. The results from this interview may be reflecting more a level of appreciation by farmers of prices in cropping decisions than an actual production response. As the interview technique involves crop combinations, other crops are highly correlated with the outcome. The tests of hypotheses using other variables as proxies for response, however, seemed to support our contention that the Frisch results are a good proxy for response. More work should be done in this area for the obtention of an elasticity or any other measure of response. It is possible that by applying the game more times for different prices of both crops, a curve can be obtained which will provide a better idea of the response of the farmers. Unfortunately only two points were obtained on the field, given the limited resources and the experimental nature of doing the game for the first time.

The linear regression approach of the relationship between absolute prices and production is recognized to be simplistic and naive, but the main conclusion of this research is the heterogeneity of response. Furthermore, the Frisch Interview does take into account relative prices when comparing beans and potatoes at a given price level.

The small number of observations in each group presented a fundamental problem in the testing of the hypotheses. The original sample design did not anticipate the classification. When testing each group separately, only one variable could be used at a time to keep the degrees of freedom at an acceptable level. It is also possible that since the area was very homogeneous, the cross sectional data did not provide enough variation.

## C. Conclusions

One of the objectives of this research was to achieve an understanding of the role of prices and new technologies on changes in production through a wholistic systems approach. It can be concluded that the farming system of Southern Nariño is a very complex system with both subsistence and commercial goals. In general, farmers showed little response to price. However, within this system, various stages of development can be distinguished as three distinct groups of farmers were identified on the basis of statistical differences in eleven different variables. Farmers who have progressed in this process of commercialization show openness and some response to prices. Those who have not progressed show a more closed system to the economic environment and low and even perverse response to price. Farmers who are in an intermediate position with respect to commercial and subsistence groups, show perverse response but increased reliance in the market. This response was measured in terms of the degree of substitution between the two main crops in the system.

The development of an alternative method of measuring price response was another objective of this research. A quantitative estimate of response was not obtained but a proxy for response was achieved. The fact that half of the sampled farmers were not able to answer to this interview indicates that improvements to the method of interviewing should be pursued in corroborative research. However, the results are a strong suggestion that other variables are more important than prices in production decisions in this economy in transition. As well, the results point at different response of farmers, or groups of farmers despite apparent agroclimatic and cultural homogeneity of the region.

These results apparently contradict the current views of response in less developed agricultures. A landmark of this debate was Shultz's work, after which a general notion of the rationality of the peasant farmer was established[85]. It is not argued here that non-price responsiveness is irrational behavior. Within the present economic system, there are rational explanations of substitute and complementary characteristics of output production. What is apparent from this research is that average estimates of elasticities hide actual important behavioral characteristics and motivations of small farmers. Statistical analysis of secondary data may be biased by the overwhelming response of a few large or very commercialized farmers within a region. Time series data for emerging commercial farming systems are unavailable or hidden within national aggregates.

The results from the Frisch Interview technique while enabling the tests of hypotheses of factors influencing supply response, also demonstrated the heterogeneity of farmers in the area. The main distinguishing characteristics of the farmers lay in their level of commercialization and relationship of the two main crops in the system as complementary or substitute. The division of the sample into groups was supported by analysis of variance tests. The characteristics of the groups could allow decision makers a basis for stratifying the population into target groups for policy direction.

Other forms of response of farmers to prices are the time of planting, early or late, and the switch to monoculture practices. This switch to monoculture would require increased use of inputs and new varieties, as new problems develop with the new methods of cultivation. This aspect of response was not investigated here but it would shed some light on

[85] T. W. Schultz, Transforming Traditional Agriculture, (New Haven: Yale University Press, 1964)

the issue of farmers' response to price. The development of technologies must take account of farmers' individual characteristics as well as the farming system's characteristics. The use that the farmer gives to the crop, the cultivation methods, etc, are important determinants of whether the technologies, especially new varieties will be adopted.

From the results of the behavioral equations, it can be concluded that of the factors affecting supply response, the land base seemed to be a major determinant of total production and of changes in production. Education is highly correlated with income and response, indicating a problem of price perception in the area. In summary, linkages with new technologies and education determine whether farmers perceive market signals. Their use of technology allows them to increase yields and produce a surplus, however, the land base is a major constraint to production not withstanding the farmers' desire to respond. Policy makers cannot centralize their attention only on technical research, extension and/or only on price supports. These three areas of policy are closely related and the success of one rests upon the success of the other one. However, the closed nature of the farming system for up to half of the farmers in this research suggests that careful targetting and design of recommendation domains for farming systems in terms of the specific social and economic requirements seems essential to broad technological advance, speeding up the commercialization process.

The evolution of the system towards commercialization, which is related to greater price perception and response sets the question of whether commercialization is a precondition for development or whether it is the result of development. Nevertheless, policy makers must be aware of the possible negative side effects of developing to a more commercialized agriculture. For example, commercialization requires specialization. If farmers in the area specialize in a few crops they will become more susceptible to market fluctuations. If farmers no longer produce their food requirements, and prices fluctuate very much, as is the case of beans in Colombia, farmers may not be able to maintain an adequate level of food consumption. Policies of price stabilization would decrease market risks for farmers who are moving towards commercialization.

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# APPENDIX

Table VII.1:Price-quantity Regressions for all Observations. Dependent Variable: Bean Seed in 1985.

| Form of model | Constant | Independent Variables Price84 | Price85 | R square | F value |
|---|---|---|---|---|---|
| Linear | 16.82<br>(11.55) | -0.007<br>(0.056) | 0.052<br>(0.051) | 0.04 | 1.15 |
| Log-linear | 2.24<br>(0.64) | -0.004<br>(0.35) | 0.003<br>(0.002) | 0.05 | 1.20 |
| Log-log | 1.06<br>(2.90) | -0.458<br>(0.349) | 0.656<br>(0.510) | 0.05 | 1.39 |

Source: This study. Figures in parentheses are standard errors. No variables are statistically significant.

Table VII.2:Price-quantity Regressions. Dependent Variable: SEED85.

| Group | Intercept | Value of the Cofficient for: Price 84 | price 85 | R square | F value |
|---|---|---|---|---|---|
| 1 | 23.18<br>(30.29) | -.238<br>(.182) | .130<br>(.108) | .2593 | 1.4 |
| 2 | 18.918<br>(33.67) | -.109<br>(.123) | .077<br>(.127) | .08 | 0.526 |
| 3 | 24.01<br>(14.43) | -.018<br>(.07) | -.036<br>(.07) | .0208 | 0.245 |

Source: This study.
Note: Figures in parentheses are standard errors. No variables are statistically significant.

Table VII.3: Selected Variables Explaining Total Bean Acreage. Dependent Variable: —SEED85.

| Group | Independent Variable | Intercept | Estimate | R square | F value |
|---|---|---|---|---|---|
| 1 | Farm size | -1.54<br>(7.09) | 6.928***<br>(2.06) | .5554 | 11.245*** |
| 2 | " | -.14<br>(5.16) | 7.37***<br>(1.29) | .713 | 32.291*** |
| 3 | " | -3.01<br>(2.56) | 10.33***<br>(1.1290) | .7771 | 83.674*** |
| All farmers | " | -0.91<br>(2.39) | 7.89***<br>(0.74) | 0.69 | 112.31*** |
| 1 | Bean seed 84 | 10.31<br>(8.3) | .649<br>(.506) | .1547 | 1.648 |
| 2 | " | 6.23<br>(7.1) | 1.16***<br>(.38) | .4129 | 9.143*** |
| 3 | " | 4.86<br>(3.75) | -.887***<br>(.22) | .3867 | 15.135*** |
| All farmers | " | -6.13**<br>(3.08) | 0.95***<br>(0.88) | 0.36 | 27.94*** |
| 1 | Potato seed 85 | 21.4**<br>(7.02) | -.003<br>(.005) | .04 | .376 |
| 2 | " | 15.99**<br>(6.77) | .011<br>(.006) | .1830 | 2.91 |
| 3 | " | 9.23**<br>(4.62) | .016<br>(.010) | .08 | 2.15 |
| All farmers | " | 15.37***<br>(3.199) | 0.005<br>(0.003) | 0.0374 | 1.941 |

Source: This study.
Note: Figures in parentheses are standard errors, with significance level indicated by *(10%), **(5%), and ***(1%).

Table VII.4: Selected Variables Explaining the Variation in Bean Supply. Dependent Variable: Change in Bean Acreage 1984-1985

| Group | Independent Variable | Intercept | Estimate | R square | F value |
|---|---|---|---|---|---|
| 1 | Price change 84 - 85 | 2.25 (8.43) | .11 (.09) | .13 | 1.377 |
| 2 | " | 1.21 (9.16) | .095 (.07) | .12 | 1.606 |
| 3 | " | -4.63 (4.61) | -.013 (.047) | .003 | .074 |
| All farmers | " | -1.82 (3.69) | 0.044 (0.036) | 0.03 | 1.56 |
| 1 | Potato change 84 - 85 | (11.95)** (3.76) | -.017*** (.004) | .5936 | 13.146*** |
| 2 | " | 5.22 (5.08) | .0097 (.006) | .1454 | 2.042 |
| 3 | " | -3.929 (2.77) | -.011 (.008) | .07 | 1.811 |
| All farmers | " | -6.208*** (2.294) | -0.003 (0.003) | 0.013 | 0.693 |
| 1 | Farm size | 4.98 (9.11) | -3.68 (2.65) | .18 | 1.934 |
| 2 | " | 5.25 (5.75) | -4.504*** (1.44) | .45 | 9.686*** |
| 3 | " | 5.82* (3.38) | -5.62*** (1.49) | .37 | 14.23*** |
| All farmers | " | 5.06* (2.73) | -4.51*** (0.88) | 0.35 | 26.12*** |

Source : This study.
Note 1 : Figures in parentheses are standard errors, with significance level indicated by *(10%), **(5%), and ***(1%).
Note 2 : The negative coefficients of the independent variables signify a positive correlation with seed change. The dependent variable is calculated as seed planted in 1984 minus seed planted in 1985, so if there was a production increase, there is a negative value of change in production.

Table VII.5: Price-quantity Regressions
Dependent Variable: EXTRA85.

| Group | Constant | PRICE84 | PRICE85 | R square | F value |
|---|---|---|---|---|---|
| | Parameter Estimates | | | | |
| 1 | 19.33<br>(25.84) | -0.21<br>(0.15) | 0.10<br>(0.09) | 0.25 | 1.36 |
| 2 | 5.70<br>(32.50) | -0.07<br>(0.12) | 0.10<br>(0.13) | 0.07 | 0.42 |
| 3 | 17.50<br>(14.27) | -0.02<br>(0.07) | -0.02<br>(0.08) | 0.02 | 0.18 |
| All farmers | 9.42<br>(10.80) | -0.06<br>(0.05) | 0.06<br>0.05 | 0.04 | 1.09 |

Source : This study.
Note: Figures in parentheses are standard errors.

Table VII.6: Price-quantity Regressions
Dependent Variable: EXTRA.Δ

| Group | Constant | PRICEΔ | R square | F value |
|---|---|---|---|---|
| | Parameter Estimates | | | |
| 1 | 2.21<br>(8.44) | 0.11<br>(0.09) | 0.13 | 1.36 |
| 2 | 0.49<br>(4.23) | 0.09<br>(0.08) | 0.11 | 1.52 |
| 3 | -4.34<br>(4.60) | -0.01<br>(0.05) | 0.003 | 0.06 |
| All farmers | -1.72<br>(3.70) | 0.05<br>(0.04) | 0.04 | 1.75 |

Source : This study.
Figures in parentheses are standard errors.

Table VII.7: Explanatory Power of Selected Independent Variables for ARCELAS [illegible]

| Variable | R square, Level of Significance, and sign of coeff [illegible] | | |
|---|---|---|---|
| —— | Group 1 | Group 2 | Groups 1 & 2 Pooled |
| FARMSIZE | 0.006 | 0.37 | 0.19** |
| MAIZFARM | 0.21 | 0.10 | 0.14* |
| PAPAFARM | -0.41** | 0.06 | 0.14* |
| ADDANIM | 0.06 | 0.09 | 0.16* |
| INGFRIJ | 0.008 | 0.03 | 0.03 |
| INPAPAYL | 0.51** | 0.008 | 0.001 |
| FAMLABOR | 0.13(-) | 0.004(+) | 0.03(-) |
| AGE | 0.0003 | 0.006 | 0.04 |
| EDUCATION | 0.11 | 0.001 | 0.00 |
| GRADEA | 0.20 | 0.001 | 0.06 |
| OWNFARM | 0.03(+) | 0.33**(-) | 0.05(-) |

Source : This study.
Significance levels indicated by *(10%), **(5%), and ***(1%).

Table VII.8: Explanatory Power of Selected Independent Variables for MRPS.Δ

| Variable | R square, Level of Significance, and sign of coeff. for: Group 1 | Group 2 | Groups 1 & 2 Pooled |
|---|---|---|---|
| FARMSIZE | 0.04 | 0.06 | 0.04 |
| MAIZFARM | 0.11 | 0.009 | 0.0001 |
| PAPAFARM | -0.14 | 0.09 | 0.41 |
| ADDANIM | 0.009 | 0.01 | 0.001 |
| INGFRM | 0.14 | 0.02 | 0.02 |
| INPAPAYL | 0.18 | 0.0009 | 0.003 |
| FAMLABOR | 0.005(-) | 0.0001(+) | 0.00(+) |
| AGE | 0.03 | 0.26 | 0.08 |
| EDUCATION | 0.02 | 0.31 | 0.07 |
| GRADEA | 0.01 | 0.009 | 0.002 |
| OWNFARM | 0.09 | 0.26 | 0.09 |

Source : This study.
Significance levels indicated by *(10%), **(5%), and ***(1%).