# FARM PROBLEMS, SOLUTIONS, AND EXTENSION PROGRAMS FOR SMALL FARMERS IN CAÑETE, LIMA, PERU.

By

VICTOR E. CABRERA

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

1999

To my father

ACKNOWLEDGMENTS

I gratefully acknowledge the support of the Kellogg Foundation for the awarded fellowship that allowed my enrollment in the Graduate School at the University of Florida. I want to thank to Dr. Heliodoro Díaz, Dr. Robert A. DeVries, and Dr. Rebecca Hernandez for making possible the grant. I also want to thank to Dr. Marcos Kisil and Dr. Marc D. Carnersi for their excellent guidance during my fellowship and to Denise Alvarado for her permanent help.

I want to thank to the Valle Grande Rural Institute for agreeing with my graduate studies and for helping me in the field phase of this investigation. I am very thankful to David Baumann and Oscar Sebastiani for conferring me confidence. Appreciation is extended to the *sondeo* team members: Juan M. Carrillo, Jorge Bernaola, Sabino Julián, Polo Echacaya, and Willy Pinedo for their disinterested labor in the first phase of this study.

I would like to express my profound gratitude to the Cañete community in general and especially to the small farmers for their willingness to participate in this research.

I wish to thank to the University of Florida and the Agricultural Education and Communication department for allowing me to complete my master's degree and this thesis. I am especially grateful to the members of my supervisory committee for their guidance and assistance during the elaboration of this research: Dr. Mathew T. Baker, Dr. Peter E. Hildebrand, and Dr. Edward Osborne. Recognition is expressed to Dr. Matthew T. Baker, my adviser, for his patience, advice, and contributions in all the aspects of this study. My special thanks go to Dr. Peter E. Hildebrand who empowered my sensibility toward the more deprived small farmers, awakened in me abilities for Farming Systems analysis, provided substantial contributions, and helped in all phases of this research.

I wish to express my immense gratitude to my wife, Milagritos, for her permanent support, encouragement, dedication, and help.

I would like to express my eternal gratitude to my mother, Rosa, who is, since always, one of my greatest supporters. My sincere thanks go to my brothers and sisters who, although far away, are my permanent encouragement: Pedro & Chuza, Abelardo & Ana, María Silvia & Toño, Juan Carlos & Friné, and Rosita.

Thanks are extended to all my friends who have given me support, confidence, and encouragement. They deserve special recognition for their help. These include: Abib Araújo, Karla Rocha, Paul Litow, Amy Sullivan, Patricio Moya, Olanda Bata, Marcos Freire, Noelle Connor, Carl Pomeroy, Andrea Snyder, Abdullah Al-Shankiti, Paulanco Thangata, Raphael Pierre, Guillermo Zanelli, Manuel Bedoya, Pablo Puertas, Justino Llanque, Jorge Hurtado, and Elenea Acurio.

Gracias a los amigos que me acompañan, de cerca o de lejos, en todos los momentos importantes de mi vida. Sería imposible mencionarlos a todos.

TABLE OF CONTENTS

LIST OF TABLES

## LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science

FARM PROBLEMS, SOLUTIONS, AND EXTENSION PROGRAMS FOR SMALL FARMERS IN CAÑETE, LIMA, PERU.

By

Victor E. Cabrera

August of 1999

Chairman: Mathew T. Baker
Major Department: Agricultural Education and Communication

This was a study about ways of improving the Cañete small farmer community (4,800 households, 18,080 ha) through agricultural extension. The study framework focused on Farming Systems Research and Extension, which was complemented with Targeting Outcomes of Programs, Participatory Rural Appraisal, and extension programming approaches.

Several procedures were used to gather data. A *sondeo* (qualitative data collection technique or rapid appraisal survey) was conducted to obtain a general understanding of the community and to support the research procedures, especially in constructing a formal questionnaire. A survey of 60 random household interviews was also conducted to obtain information of the community to be used in further analyses.

*Ex post facto* or secondary data were also gathered. These data came from records maintained by the Valle Grande Rural Institute (local extension agency with which the

investigation was coordinated), from records maintained by the city government, and from records of Peru's Ministry of Agriculture.

The analyses included production functions, linear programming, and extension programming. Production functions for seven geographical zones were generated based upon multiple regression of cotton yield as a function of fertilization and environmental factors.

Linear programming was used to simulate and better understand the current situation of individual households. Following statistical validation, a projection of future production, income, and consumption was undertaken at the household level. These simulation models are “interactive working models.”

Based upon the sondeo, survey, production functions, linear programming, and secondary data a list of nine extension programs was proposed. These programs were based upon priority needs as identified by small farmers.

# CHAPTER 1
# INTRODUCTION

## Cañete: Agricultural Valley

Cañete is a Valley in the central coast of Peru. It is located between 12°54’ and 13°30’ south latitude and between 76°00’ and 76°24’ west longitude (Figure 1-1), it covers about 22,600 ha of agricultural land and its elevation varies from 0 to 700 meters (Figure 1-2). The Valley is irrigated by Cañete River water. The river flows east to west, and it runs continuously all year long. The weather is desert-like; there is little rain. The temperature varies from 12°C in the winter to 32°C in the summer, with an average of 18°C. There are 152,379 people living in Cañete; 41,000 of them constitute the rural population, who are directly engaged in agricultural production. Agricultural production constitutes the main source of income of the whole province.

## Study Justification

Cañete has 4,800 small farmers with 12 ha or less (80% of the 22,600 ha). In general, the environmental conditions in Cañete including soils, climate, and water resources are not agricultural constraints. Compared to other regions of the country, these agro-climatic conditions are perceived as being very favorable. The Cañete Valley is an influential agricultural production area in Peru.


Figure 1-1: Cañete location

Despite the favorable agro-climatic advantages, on average, households (7 members) have an annual income of US$ 1,420, and many Cañete residents live below international standards for nutrition, health, housing, services, and other basic needs (Valle Grande Rural Institute, 1997). In this context, it is highly relevant to find ways to alleviate the present conditions. The researcher believes that the Farming Systems Research and Extension approach is a very appropriate theoretical framework to use in developing interventions to improve the current situation. These research findings will provide information for extension programs to address the needs of Cañete's small farmers.


Figure 1-2: Cañete Valley

This research is specially needed in the long-term programming efforts of [1]"Valle Grande Rural Institute."

## Purpose and Objectives

The overall purpose of this study was to identify problems and needs and to design extension programs to improve the livelihood of limited resource farmers in the Cañete Valley. The specific objectives of the study were to:

---

[1] A non-government organization which works with Cañete's small farmers and with which this thesis was coordinated.

(1) Develop production functions that explain the current cotton production enterprise and use the production functions to predict future yields of small farmers in the Cañete Valley.
(2) Use linear programming to simulate individual household's livelihood systems and to explore production alternatives in different scenarios of the small farmers in the Cañete Valley.
(3) Propose a priority list of future extension programs to meet the needs of small farmers in the Cañete Valley.

## The Valle Grande Rural Institute

Valle Grande is a development institution that has been in existence for more than 30 years in the Cañete Valley promoting rural improvement through extension and education programs designed for low income farmers. Valle Grande reaches more than 1,000 small farmers in different programs annually. The headquarters is located in Lima, the capital, and it is a non-profit foundation, which has the responsibility to raise the needed funding for programming. Its budget comes from different sources; approximately one-third of it is from local resources (services have a minimum charge), another one-third is raised through local and national donations, and the additional funds are provided from international institutions.

Valle Grande currently runs a coastal extension office, a mountain extension office, an entrepreneurial development office, a soil laboratory, and an agricultural college. With the exception of the mountain extension office, the offices, laboratory, and college collaborate in serving the needs of the Cañete Valley farmers. Undoubtedly Valle Grande (Figure 1-3) has an excellent reputation as an extension agency in Cañete Valley and perhaps in the whole middle coastal region of Peru.

Among other development agencies in the Valley is *CECOACAM* (Cooperative Headquarters of Cañete and Mala), which may reach as many as one-half of the total small farmers in the Valley (2,400) but it has a poor reputation due to a number of questionable experiences. Most of the farmers work with *CECOACAM* seeking credit and low-cost machinery. *CECOACAM* collaborates to a small extent with the government, however it is not an official agency.

Figure 1-3: The Valle Grande Rural Institute

## Significance

The significance of the present study is two-fold. First, there are 34,000 direct beneficiaries (farmers), and about 7,000 indirect beneficiaries (laborers) who might obtain some benefit from extension programming. Second, the Cañete Valley is a highly prestigious agricultural zone in Peru and any methodological success could be diffused quickly throughout the country.

## Background Information of the Cañete Community

In an analysis, including the elements of Cañete's social system, one could observe that in general, the majority of Cañete's community members practice the Roman Catholic Religion; they strongly believe in God. Many family-related decisions (i.e.

number of children) are based upon church doctrine. Community members are also fervent participants in religious festivals and attend mass regularly.

Cañete's farmers are aware of the importance of education, especially formal education. Currently the percent of young people enrolled in primary or secondary school is about 95%. The educational conditions in the community are summarized in Tables 1-1 and 1-2. Table 1-1 indicates the educational institutions in  the Cañete community. The state schools are funded directly by the government. Although these institutions offer free services, they are perceived to be of low quality, with a few exceptions. The private schools charge a fee for their services and generally provide a good quality education.

The private and state schools as well as the church schools receive part of their funding from the government. These are perceived as the best schools in the zone because they offer an excellent quality education at low cost, although admittance is very difficult. More than 90% of the Valle Grande targeted audience with some formal education attended state schools.

Table 1-2 reveals the conditions of the current Cañete student community regarding formal education (people currently enrolled), stratified by age, gender, and level. Most of the population is young people (40% between 5 and 10 years, and 78 % between 5 and 14 years) and they are mainly kindergarten, elementary or high school students. Some students younger than 14, who attend high school, also enroll in college (technical degree of three years duration), while others are not enrolled in school at all.

Table 1-1: Educational institutions in Cañete

| Education Level | Total | State School | Private School | Private & State school | Church School |
|---|---|---|---|---|---|
| 1. Kindergarten | 116 | 53 | 52 | 10 | 1 |
| 2. Elementary | 184 | 110 | 55 | 17 | 2 |
| 3. Adult elementary* | 8 | 5 | 8 | -- | -- |
| 4. High school | 68 | 38 | 23 | 4 | 3 |
| 5. Adult high school* | 15 | 9 | 6 | -- | -- |
| 6. College | 23 | 6 | 17 | -- | -- |
| 7. Special school** | 5 | 5 | -- | -- | -- |
| Total | 419 | 226 | 156 | 31 | 6 |

Source: Peru's Education Ministry, 1998.
Note: Ages of the students, (1) four to six years, (2) six to twelve, (4) twelve to seventeen, (6) eighteen to twenty-one.
* Adult students. ** Schools for special populations.

Less than seven percent (2,961) continue for post secondary studies (college, technical degree or university, BS degree). The number of people who complete higher education programs is considerably fewer, only 0.4% obtain a technical degree, and only 0.3% obtain a BS degree. Little difference exists in education levels based upon gender.

On the other hand, the perception of the adult towards informal education or continuing education is not so good. Although the attendance in informal programs is good, in many cases, the participants' expectations are to obtain easy solutions to their often-complex problems. Such high expectations create conflicts between the local development agencies and the clientele. It is difficult to communicate to clients that the problem-solution process is often slow and complex.

Table 1-2: Formal education stratification in Cañete

| | | Age | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | 5 to 9 | 10 to 14 | 15 to 19 | 20 to 29 | 30 to 39 | 40 to 64 | > 65 |
| Total | 46,792 | 18,745 | 17,720 | 9,101 | 2,561 | 685 | 368 | 112 |
| No education | 332 | 304 | 10 | 11 | 7 | -- | -- | -- |
| Kindergarten | 3,769 | 3,651 | 37 | 39 | 19 | 5 | 18 | -- |
| Elementary | 25,138 | 12,302 | 11,538 | 738 | 187 | 168 | 137 | 6,666 |
| High school | 13,326 | -- | 5,191 | 7,067 | 727 | 212 | 104 | 2,020 |
| Some College | 1,770 | -- | 747 | 400 | 890 | 110 | 28 | 88 |
| College complete | 165 | -- | -- | 15 | 102 | 41 | 7 | -- |
| Some University | 888 | -- | -- | 267 | 513 | 73 | 28 | 7 |
| University complete | 138 | -- | -- | -- | 66 | 58 | 14 | -- |
| Not specified | 1,266 | 488 | 444 | 224 | 50 | 18 | 32 | 11 |
| Males | 23,496 | 8,353 | 8,668 | 4,600 | 1,302 | 344 | 176 | 80 |
| Females | 23,296 | 8,392 | 8,552 | 4,501 | 1,259 | 341 | 192 | 50 |

Source: Peru’s Education Ministry, 1998.

A recent survey of Valle Grande (1997) showed that young people are more interested in careers such as military, police, and the like. Many young people do not want to study agriculture or related careers because these careers are not as prestigious as others. Currently, the recruitment of young people for agrarian careers presents a major challenge to educators.

Almost all small farmers are "born farmers,” most of them have always lived in Cañete, and others are recent settlers who had practiced agriculture in other regions of the country before relocating. In addition, the Valley has an agricultural economic base. Consequently, the farmers have a great deal of practical and empirical knowledge of farming. It is not a surprise that in many cases, the farmers possess agricultural knowledge beyond the knowledge of the change agent.

In terms of environmental conditions, the soils where these farmers work are classified as fair or good. The weather conditions normally do not present barriers for agricultural activities. Despite dry weather conditions, the whole valley is crossed by an important river (Cañete River) that supplies water for irrigation all year long. Four paved main roads and many secondary dirt roads traverse the Valley; almost all the farmers have easy access. For agricultural practices, farmers have access to inputs, such as pesticides, fertilizers, and herbicides. In addition to that, they use tractors and trucks for production and transportation. Most of the farmers' houses have services such as water and electricity. Telephones are uncommon. The Valley has a geographic advantage due to its location near Lima, which is Peru's largest market (eight million people).

Farmers, business people, and authorities define the social context of the Cañete Valley. Farmers are in charge of agricultural production, which is the principal activity of the community. Although the business people provide services for the main activity, they do not give a great deal back to the community. Business people serve as middlemen who usually benefit most from the production-based economy.

The major authorities recognized in each district include the priest, the mayor, and city commissioners. The priest exercises a powerful position. The people seek his advice frequently, but the role of the priest does not include political affairs, just spiritual concerns.

The community's income stratification is shown in the Table 1-3. Farmers are stratified into four categories. The medium and large farmers have more than 12 ha of land, an average annual income of US$ 6,090, and control 20% of the land in the Valley. These farmers are not the target of Valle Grande but they could be collaborative leader farmers to help in programming.

The small farmers constitute the very small, small and parcel categories, and they are the target of the agency. They have less than 12 ha of land, an average income of US$ 1,220, and control 80% of the lands of the Cañete Valley. However, some small farmers with less than 12 ha that have higher incomes (more than US$ 5,000) and are not clients of Valle Grande Rural Institute.

Table 1-3 includes a column about "optimum income" for each farmer classification. This information was generated in Valle Grande based upon the leader farmers in each category and economic projections.

Table 1-3: Land and income in Cañete

| Farmer | Area (ha) | Number farmers | Total (ha) | Average (ha) | Total land (%) | Actual income (US$/farmer) | "Optimum income" (US$/farmer) |
|---|---|---|---|---|---|---|---|
| Medium & Large | >12 | 260 | 4,530 | 17.42 | 20.00 | 6,090 | 35,235 |
| Parcel* | 3.5-12 | 2,002 | 10,362 | 5.18 | 45.70 | 1,820 | 10,530 |
| Small | <12 | 2,482 | 7,273 | 2.93 | 32.10 | 1,015 | 5,866 |
| Very small | < 1 | 715 | 491 | 0.69 | 2.20 | 245 | 418 |
| Total | | 5,495 | 22,656 | 6.55 | 100.00 | | |

Source: Valle Grande Rural Institute, 1997.
* Small farmers resulting from Peru's Agrarian Reform (1969-1985)

Medium and large farmers are mostly white Hispanic. Small farmers have an ethnic background called "mestizo" (Figure 1-4, Appendix A) that represents a racial mix between Hispanic and natives. In the last twenty years, natives have migrated from the highlands to Cañete Valley. These immigrants are mainly small marginal farmers.

Figure 1-4: Small farmers planting potatoes

There is a small group of black people, few of whom own land. Some segments of medium farmers are “Nikkei" (Japanese ascendance). They are usually hard and efficient workers and maintain strong economic networks.

# CHAPTER 2
# LITERATURE REVIEW AND METHODOLOGY

## Literature Review

### Introduction

The present chapter schematizes the theoretical framework for this study. Farming Systems Research & Extension (FSR&E), the spinal column, was complemented by other approaches: Targeting Outcomes Programs (TOP), Participatory Rural Appraisal (PRA), and Extension Programming (EP). These other frameworks were used not to contrast with FSR&E, but to enrich the research process.

### Farming Systems Research & Extension

FSR&E represents a unique approach to agricultural research and extension; it was formulated in response to the complex and diverse production methods encountered on small often-mixed farms in the developing world. (Zandstra, 1983).

According to Hildebrand and Waugh, 1982, *FSR&E,*

> Deals mostly with conditions inside the farm gate. It is concerned with technology generation, evaluation, and delivery. It emphasizes on-farm biological research, and it is applied, farmer-oriented, agro-biological research, supported by the social sciences in a team effort, which includes extension responsibilities. The principal product is the technology and the primary clients are the farmers (p. 13).

According to D.W. Norman (1982):

> A Farming System is the result of a complex interaction of a number of interdependent components. At the center of this interaction is the farmer,

> who is the central figure. Moreover, both farm production and household decisions of small farmers are intimately linked and should be analyzed in Farming Systems research. A specific farming system arises from the decisions made by small farmers or farming families with respect to allocating different quantities and qualities of land, labor, capital and management to crop, livestock, and off-farm enterprises in a manner which, given the knowledge the household possesses, will maximize the attainment of the family goals (p. 8-9).

The farming systems perspective is especially appropriate for such a process-oriented approach to gender analysis, which includes a focus on small farm households and on the participation of farmers in the research and extension process (Poats, Schmink, & Spring, 1988). The same authors believe that a farming systems emphasis on reaching low-income groups can illuminate women's roles in agricultural development, and there is a high and growing proportion of female-headed households emphasizing the economic importance of decisions made by women in poor populations.

Stages in Farming Systems Research & Extension

Norman (1982, p. 10) proposed four stages in Farming Systems Research & Extension. Norman stated the following regarding the first stage:

> The descriptive or diagnostic, in which the actual farming system is examined in the context of the total environment to identify constraints farmers face and to ascertain the potential flexibility in the farming system in terms of timing, slack resources, etc. An effort is also made to understand goals and motivation of farmers that may affect their efforts to improve the farming system.

In this first stage, the researcher looked for *needs and/or problems* that Cañete small farmers' currently face.

*Need* can be defined as a deficiency, imbalance, lack of adjustment, or gap between the present situation and a set of societal norms believed to be more desirable (Boone, 1985). The first sub-process of Boone's Extension Programming, *planning,* includes: linking the organizations to its publics, in which he discusses the identification of the publics to be served with effective mapping, as well as identification and interfacing with the leaders. He concludes that the most important task is the collaborative effort to identify needs of the publics.

Participatory Rural Appraisal (PRA) describes a growing family of approaches and methods to enable local people to share, enhance and analyze their knowledge of life and conditions, to plan and to act. (Chambers, 1992). PRA is shared and owned by local people; the behavior and attitudes of outside facilitators are crucial, including relaxing not rushing, showing respect, “handing over the stick,” and being self-critically aware.

The same author posits that the PRA has been used in natural resource management, agriculture, programs for the poor, and health and food security. Evidence to date shows high validity and reliability in information shared by rural people through PRA.

Targeting Outcomes of Programs (TOP) developed by Bennett and Rockwell (1995) proposes that program planning first targets *SEEC* –social, economic, and environmental conditions- then the *practices* necessary to achieve the targeted conditions, and the *KASA* –knowledge, attitudes, skills, and aspirations- needed to realize adoption of the practices.

The second FSR&E stage is the design stage. According to Norman:

> The design stage, in which a range of strategies is identified, is thought to be relevant in dealing with the constraints delineated in the descriptive or diagnostic stage. Heavy reliance at this stage is placed on obtaining information from the "body of knowledge."

In this second stage, the researcher analyzed different alternatives in different scenarios through linear programming simulation of individual households. Production functions were also used to analyze the cotton production enterprise in the Cañete Valley.

The second sub-process of Boone's Extension Programming, *design & implementation*, includes: Plans of action, where he devotes great attention to develop specific educational strategies and learning experiences based in the planned program and action strategies, which are devoted to develop the plans of action through marketing techniques and using leader resources.

Targeting Outcomes of Programs (TOP) proposes that the program targets the *reactions* needed to ensure sufficient *participation* in program *activities* that enable learning the intended *KASA*. Finally, the *resources* necessary to support the activities are acquired. (Figure 2-1).

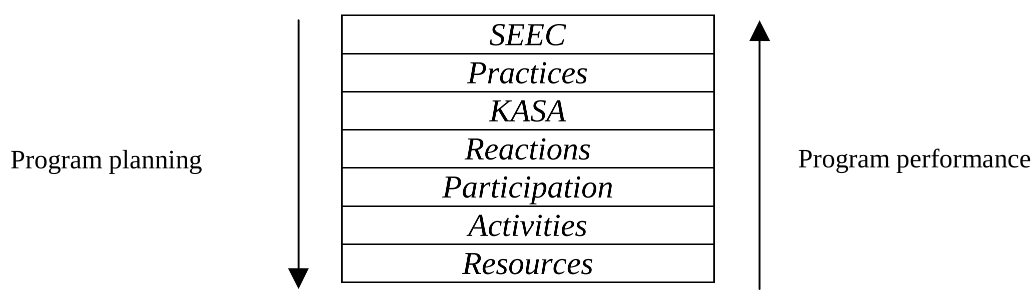



Figure 2-1: Hierarchy in programming.

The third FSR&E stage is the testing stage. Norman revealed the following regarding this stage:

> The testing stage, in which a few promising strategies arising from the design stage are examined and evaluated under farm conditions to ascertain their sustainability for producing desirable and acceptable changes in the existing farming system.

The FSR&E approach lies strongly in that the limited resource farm households live and work on farms characterized by a high degree of both biophysical and socioeconomic diversity. Technologies developed solely under the conditions common on experiment stations are rarely transferable directly to small scale limited resource farmers (Hildebrand & Russell, 1996). Adaptability of experimental treatments to particular environmental conditions must be identified and incorporated into a specific experimental design *ex ante*, that is, before the trial is put in the field.

The fourth stage in the FSR&E model is the extension stage. According to Norman:

> The extension stage is the last stage in which the strategies that were identified and screened during the design and testing stages are implemented.

Boone (1985) defines Extension Programming as:

> A comprehensive, systematic, and proactive process encompassing the total planned, collaborative efforts of the adult education organization, the adult educator in the roles of change agent and programmer, representatives of the learners, and the learners themselves in a purposive manner and designed to facilitate desirable changes in the behavior of learners and the environment in which they live (p. 41).

In objective three of this study, the researcher proposes a priority list of future extension programs for the Valle Grande development agency for the low resource farmers in Cañete Valley, Peru.

The TOP model suggests that program performance expends targeted *resources* to conduct the program *activities* intended and obtain targeted *participation* with positive *reactions*.

Affirmative reactions help program participants acquire targeted *KASA* leading to the adoption of targeted *practices*. Use of such *practices* helps achieve the targeted *SEEC* changes, according to Bennett and Rockwell (1995).

De los Santos and Norland (1990) used Bennett's theoretical framework to study extension programming in the Dominican Republic. They found that the farmers gained mostly knowledge and skills toward the program and that older farmers tended to hold negative attitudes toward information provided by extensionists.

The third and final sub-process of Boone’s extension programming is *evaluation and accountability*. Evaluation and accountability include determining and measuring the program outputs, assessment of program inputs, and, using evaluation findings for accountability purposes.

After extension programs are initiated, there is a need to monitor the programs. According to Rossi and Freeman (1985) there are several reasons monitoring of programs is required. First, monitoring provides judgment information. Second, monitoring is required for accountability purposes. Third, it is adjunct to impact assessment. Fourth, monitoring evaluations often are instrumental in decisions to continue, expand, or terminate ongoing programs. The authors mention that the monitoring of programs is directed at two key questions: (1) whether or not the program is reaching the appropriate target population, and (2) whether or not the delivery of service is consistent with program design specifications.

The social sciences provide reliable, useful information to biological scientists. Social science research is useful in making suggestions concerning the consequences of technology change (DeWalt, 1985).

Sociological and economic variables play complementary roles in the innovation decision process; the sociological variables had more impact in the *adoption* stage, while the economical factors were more predictive in the *implementation-confirmation* stages (Sapp & Jensen, 1997).

It was found that farmers preferred neighbors as sources of agricultural information. The rate of early *adoption* was influenced by the farmers' level of education for attaining knowledge and land holding. Organizational assistance and communication showed a higher correlation with adoption of farming innovation (Sandhu & Allen, 1974; Pfeffer & Gilbert, 1989).

## Methodology

### Population and Sample

The population and sample differed based upon the multiple data collection methods used by the researcher. For example, in order to develop the cotton production functions, the researcher used a population of small farmers who borrowed money through the Valle Grande Rural Institute during the period 1992 through 1998 (N= 1,860). A purposeful sample (n= 622) consisting of farmers with complete records was used to develop the production functions.

In terms of the linear programming model, the researcher used data from numerous sources including a sondeo, survey, and selected secondary data. First, the researcher conducted a sondeo consisting of a sample of 22 farmers in the area. A sondeo is an open-ended, non-structured interview technique (Hildebrand, 1976).

Second, the researcher conducted a survey consisting of structured questions developed based upon personal knowledge of the Cañete Valley, and the sondeo results. A questionnaire consisting of 70 items was developed by the researcher (Appendix B). The instrument contained three sections. The first section had three subsections: (1) household information, (2) agricultural factors; and (3) economic information. The second section consisted of seven open-ended needs assessment questions. The final section included 13 open-ended questions regarding farm problems and concerns.

The population for the survey consisted of limited resource farmers in the Cañete Valley (N=4,800). A random sample of 60 farmers was selected for participation in the survey; the raw data can be found in Appendix C. In an effort to collect information that was reflective of the population, the researcher took a map of the Cañete Valley and divided the area into 60 zones. One zone was then randomly selected at a time by a computer. The researcher subsequently randomly selected a limited resource household to interview in each zone. Any small farm household had the same chance to be selected. Sometimes the interviews were accomplished in the farms and other times in the houses. Survey data were collected from a broad cross section of valley residents and the study area was completely covered, Figure 2-2.

For both the sondeo and survey, households had to meet the following criteria (1) farm less than 12 ha of land, (2) have a net annual income less than US$ 5,000, and (3) generate the majority of the household's income from agricultural production.


Figure 2-2: Survey interview locations.

## Data Collection and Design

### Production function

A production function describes the technical relationship that transforms inputs (resources) into outputs (commodities). Mathematically, a function is a rule for assigning to each value in one set of variables (the domain of the function) a single value in another set of variables (the range of the function). A general way of writing a production function is y= f (x), where *y* is an output and *x* an input (Debertin, 1986).

Regression analysis is the way to transform data representing an existing phenomenon (physical, socioeconomic or biological) into a mathematical expression to help understand the relationships among the dependent and independent variables (Hildebrand, 1997). The production function data were gathered from records maintained by the Valle Grande Rural Institute.

Linear programming

Linear Programming (LP) is a method for simulating and analyzing family farm livelihood systems by determining a combination of farm and non-farm activities that is feasible, given a set of fixed farm constraints. It maximizes (or minimizes) a particular objective or family goal. The model, according to Hildebrand and Araújo (1997), requires the following in each farm family situation:

> (1) The farm and non-farm activities and options with their respective resource requirements and any constraints on their production, (2) the fixed resources and other maximum or minimum constraints that limit farm and family production, (3) cash costs and returns of each activity; and (4) a defined objective or objectives. (p. 3).

In a first approximation to a linear programming methodology in Cañete, a family livelihood system with real data was selected. Using data that are accurate on various types of households will reveal ways to improve the complex farming systems in Cañete. (Cabrera, 1997).

In terms of the linear programming data, numerous sources of data were utilized. A sondeo was coordinated by the researcher between May 11 and May 15, 1998. A sondeo is a qualitative data collection technique, also referred to as a reconnaissance survey, informal survey, and exploratory survey. The sondeo is an important needs assessment tool used in FSR&E (Hildebrand, 1976). A properly conducted informal survey can provide accurate and comprehensive information on the ecology of farming and related practices (Rhoades & Bidegaray, 1987). According to Franzel (1984), the sondeo has the following four distinguishing characteristics:

> (1) Farmer interviews are conducted by researchers themselves, (2) interviews are essentially unstructured and semidirected, with emphasis on dialogue and probing for information (questionnaires are never used), (3) informal random and purposive sampling procedures are used, and (4) the data collection process is dynamic. (p. 1).

The researcher used an interdisciplinary team consisting of six professionals with expertise in extension, economics, and technical agriculture. The sondeo or rapid rural appraisal team spent one day driving through the valley making general observations. Next, the six researchers split up into two teams and interviewed selected household representatives. Finally, the six pooled their findings and wrote a final report.

The survey information was collected through personal interviews conducted by the researcher between May 18 and July 17, 1998. Each interview lasted between one and two hours. At least one adult household member was interviewed. In addition to the interviews, the researcher made and recorded personal observations regarding each household.

The researcher also collected information for the linear programming model from Valle Grande Rural Institute records, records maintained by the city government located in Cañete, and Peru's Ministry of Agriculture.

## Data Analysis

The data were analyzed using Microsoft® Access 97 SR-1, Microsoft® Excel 97 SR-1 Microsoft® Visual Basic, and Microsoft® Visual Basic.

# CHAPTER 3
# COTTON PRODUCTION FUNCTIONS

## Introduction

The purpose of this analysis was to generate production functions based upon multiple regression of cotton yield based upon fertilization and environmental factors.

Table 3-2 shows the summary of the data used in the production functions. All the raw data can be found in Appendix D.

The dependent variable in all cases was the cotton per ha yield in quintals (100 lb). The independent variables tested were: nitrogen (N) in kilograms, phosphorus (P) in kilograms, potassium (K) in kilograms, annual environmental index (average production per ha for the specific year) (EI) in quintals, and the interaction between the fertilizers and the annual environmental indexes, EIxN, EIxP, EIxK.

## Analysis

The fertilization rates used by the farmers in the cotton crop were the amounts recommended by Valle Grande Rural Institute. These amounts had little variation within zones (Table 3-1, Figure 3-1), and consequently the subsequent analyses are only on a small data range. Therefore, it is recommended to complement these results with the results of on-farm trials, in which the independent fertilization variables will have greater ranges. It would also be desirable to include more zones in other analyses to generate more complete production curves.

Table 3-1: Range of fertilization factors by geographic zone, kg/ha

| | Cerro Alegre | La Quebrada | San Benito | San Francisco | Santa Bárbara | Palo Isla | Quilmaná |
|---|---|---|---|---|---|---|---|
| N | 170-240 | 180-230 | 190-245 | 200-250 | 110-229 | 200-240 | 200-240 |
| P | 46-110 | 46-120 | 46-120 | 30-103 | 46-100 | 80-100 | 80-100 |
| K | 40-100 | 50-100 | 50-100 | 40-90 | 25-95 | 90-100 | 90-100 |

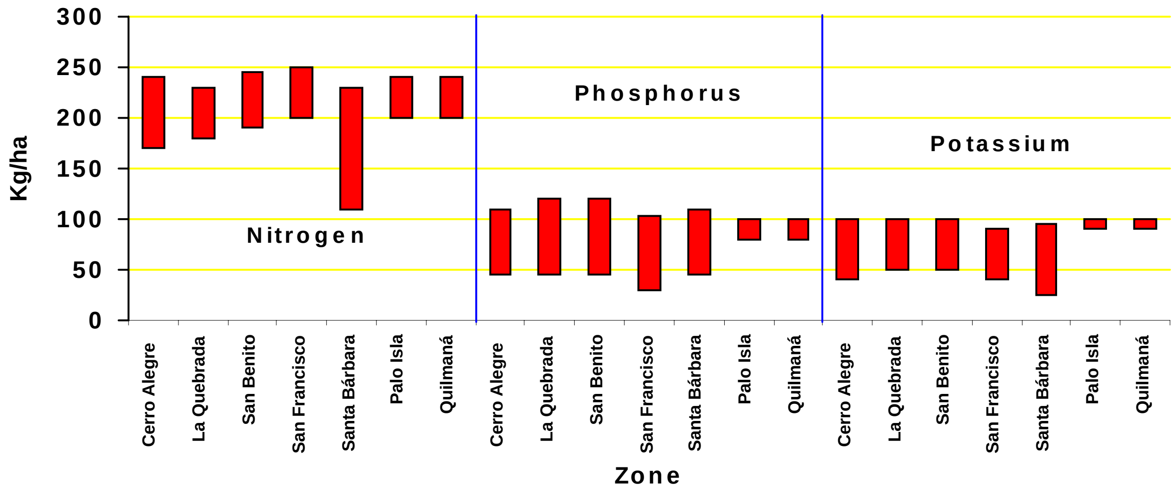



Figure 3-1: Range of fertilization factors by geographic zone, kg/ha

The following is an analysis of seven multiple linear regressions (one for each association or geographic zone) of the following form:

$$Y' = a + b_1X_1 + b_2X_2 + \ldots b_kX_k$$

Where:

| | |
|---|---|
| $Y'$ | is the estimated value of cotton yield in one zone in quintals (100 lb), |
| $X_1, X_2, \ldots X_k$ | are the independent variables, |
| a | is the intercept, and |
| $b_1, b_2, \ldots b_k$ | are the partial regression coefficients. |

The hypotheses tested in each case were:

*F test* for the whole regression equation:

Ho: $R^2$ = 0 in the population.

H1: $R^2$ > 0 in the population, and

*t-test* for the independent variables:

Ho: $b_k = 0$ in the population

H1: $b_k <> 0$ in the population

The coefficients that were statistically significant at 95% confidence level ($\alpha$ = 0.05) are the only independent variables reported in each specific equation because they can be used for prediction purposes. Although curvilinear variables ($x^2$) were included in the regression analyses, none were significant at this level of confidence.

The annual environmental index (EI) is the result of calculating the average of all available production data for each year. As seen in Figure 3-2, the annual environmental conditions are responsible for drastic changes in the yield variable of the cotton crop. For analyses and recommendation purposes the production years are divided into good (more than 60 qq/ha), fair (more than 45 but less or equal to 60 qq/ha), and poor (less or equal to 45 qq/ha).

The interactions of the environmental index variable (EI) and the macronutrient variables (N, P, K) were the result of multiplying both values creating the interaction variables (EIxN, EIxP, EIxK).

Table 3-2: Data used in production functions

| Production Season | Association | Number of Farmers |
|---|---|---|
| 92/93 | | **37** |
| | Cerro Alegre | 14 |
| | San Benito | 23 |
| 93/94 | | **110** |
| | Cerro Alegre | 19 |
| | La Quebrada | 3 |
| | Santa Bárbara | 28 |
| | San Benito | 51 |
| | San Francisco | 9 |
| 94/95 | | **72** |
| | Cerro Alegre | 16 |
| | Santa Bárbara | 2 |
| | San Benito | 46 |
| | San Francisco | 8 |
| 95/96 | | **138** |
| | Cerro Alegre | 13 |
| | La Quebrada | 18 |
| | Palo Isla | 19 |
| | Quilmaná | 22 |
| | Santa Bárbara | 24 |
| | San Benito | 41 |
| | San Francisco | 1 |
| 96/97 | | **124** |
| | Cerro Alegre | 8 |
| | La Quebrada | 22 |
| | Quilmaná | 19 |
| | Santa Bárbara | 18 |
| | San Benito | 44 |
| | San Francisco | 13 |
| 97/98 | | **141** |
| | Cerro Alegre | 25 |
| | La Quebrada | 15 |
| | Palo Isla | 4 |
| | Quilmaná | 18 |
| | Santa Bárbara | 23 |
| | San Benito | 38 |
| | San Francisco | 18 |
| Total | Seven associations | 622 |

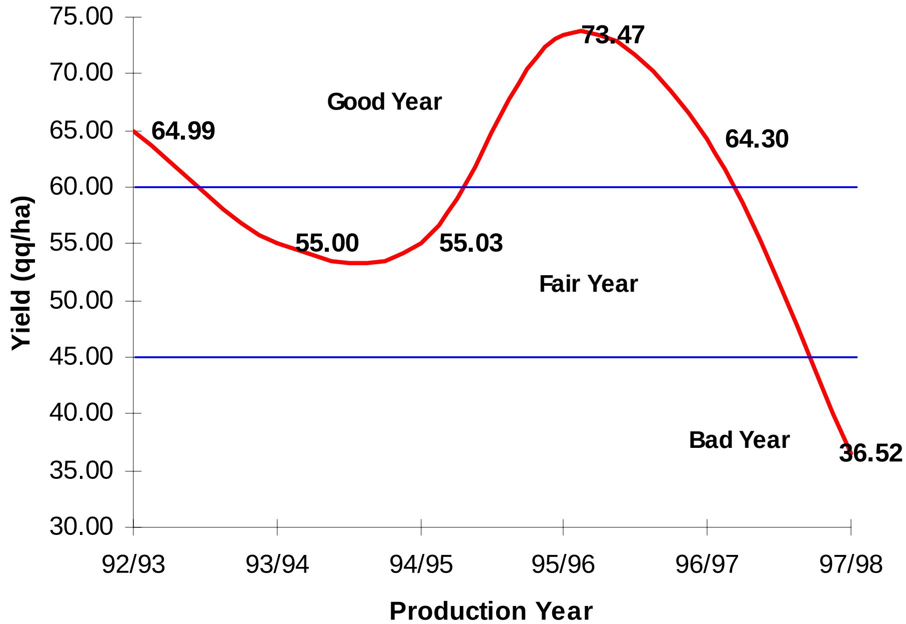



Figure 3-2: Annual environmental index for cotton yield in Cañete

Cerro Alegre

The cotton production function for Cerro Alegre is presented in Table 3-3. Fifty-one percent of the variance in cotton production was accounted for by four factors: phosphorus (P), potassium (K), annual environmental index (EI), and the interaction of phosphorus by the annual environmental index (EIxP). A statistically significant proportion of the variance in final cotton production in Cerro Alegre was explained by those factors ($F = 23.89$, $p < 0.001$), with a [2]*very high* multiple correlation ($R = 0.72$).

[2] Interpreting strength correlations according to Davis (1971)

Table 3-3: Cotton production function in Cerro Alegre

| Variables | Standard error | b | t | p |
|---|---|---|---|---|
| Phosphorus (P) | 0.89 | -4.01 | -4.50 | <0.001 |
| Potassium (K) | 0.14 | -0.34 | -2.45 | 0.016 |
| Environmental Index (EI) | 1.51 | -6.16 | -4.09 | <0.001 |
| Interaction (EIxP) | 0.02 | 0.071 | 4.62 | <0.001 |
| Intercept | 88.79 | 430.43 | 4.85 | <0.001 |

$R^2 = 0.51$ R = 0.72 F = 23.89
Adjusted $R^2 = .49$ p < 0.001
Standard error = 12.99 Observations = 96

Y’ in Cerro Alegre = 430.43 - 4.01P - 0.34K - 6.16 EI + 0.071EIxP

## La Quebrada

Table 3-4 summarizes the cotton production function for the La Quebrada zone. Fifty one percent of the variance of the cotton production was explained by two factors: phosphorus (P) and the interaction of phosphorus and the annual environmental index (EIxP). A statistically significant proportion of the variance in final cotton production in La Quebrada was explained by those factors (F = 28.87, p < 0.001) with a *very high* multiple correlation (R = 0.72).

Table 3-4: Cotton production function in La Quebrada

| Variables | Standard error | b | t | p |
|---|---|---|---|---|
| Phosphorus (P) | 0.21 | -0.91 | -4.44 | <0.001 |
| Interaction (EIxP) | 0.00 | 0.014 | 7.60 | <0.001 |
| Intercept | 15.08 | 77.69 | 5.15 | <0.001 |

$R^2 = 0.51$ R = 0.72 F = 28.87
Adjusted $R^2 = .49$ p < 0.001
Standard error = 18.39 Observations = 58

Y’ in La Quebrada = 77.69 – 0.91P + 0.014EIxP

## Palo Isla

Table 3-5 summarizes the cotton production function in Palo Isla. As indicated, eighty-four percent of the variance of the cotton production was explained by three factors, potassium (K), nitrogen (N), and the interaction of nitrogen by the annual environmental index (EIxN). A statistically significant proportion of the variance in final cotton production in Palo Isla was explained by those factors (F = 34.42, p < 0.001) with a *very high* multiple correlation (R = 0.92).

Table 3-5: Cotton production function in Palo Isla

| Variables | Standard error | b | t | p |
|---|---|---|---|---|
| Potassium (K) | 0.82 | 3.58 | 4.35 | <0.001 |
| Nitrogen (N) | 0.32 | -1.72 | -5.44 | <0.001 |
| Interaction (EIxN) | 0.00 | 0.012 | 9.19 | 0.010 |
| Intercept | 72.57 | -81.50 | -1.12 | 0.280 |

$R^2$ = 0.84 R = 0.92 F = 34.42
Adjusted $R^2$ = .82 p < 0.001
Standard error = 11.91 Observations = 23

$$Y' \text{ in Palo Isla} = -81.50 + 3.58K - 1.72N + 0.012EIxN$$

## Santa Bárbara

Table 3-6 summarizes the cotton production function for the Santa Bárbara zone. Thirty percent of the variance of the cotton production was explained by three factors, potassium (K), the interaction of potassium by the environmental index (EIxK), and the interaction of phosphorus by the annual environmental index (EIxP). A statistically significant proportion of the variance in final cotton production in Cerro Alegre was explained by those factors ($F = 13.02$, $p < 0.001$) with a *substantial* multiple correlation ($R = 0.55$).

Table 3-6: Cotton production function in Santa Bárbara

| Variables | Standard error | b | t | p |
| --- | --- | --- | --- | --- |
| Potassium (K) | 0.29 | -1.66 | -5.72 | <0.001 |
| Interaction (EIxK) | 0.00 | 0.02 | 4.32 | <0.001 |
| Interaction (EIxP) | 0.00 | -0.006 | -2.19 | 0.003 |
| Intercept | 17.12 | 119.45 | 6.98 | <0.001 |

$R^2 = 0.30$ R = 0.55 F = 13.02
Adjusted $R^2 = .28$ p < 0.001
Standard error = 22.37 Observations = 95

Y' in Santa Bárbara = 119.45 – 1.66K + 0.02EIxK – 0.006EIxP

## San Benito

Table 3-7 shows the cotton production function for San Benito. Thirty six percent of the variance of the cotton production was explained by four factors, potassium (K), the interaction of potassium by the annual environmental index (EIxK), nitrogen (N), and the interaction of nitrogen by the annual environmental index (EIxN). A statistically significant proportion of the variance in final cotton production in San Benito was explained by those factors ($F = 33.46$, $p < 0.001$) with a *substantial* multiple correlation ($R = 0.60$).

Table 3-7: Cotton production function in San Benito

| Variables | Standard error | b | t | p |
|---|---|---|---|---|
| Potassium (K) | 0.42 | 1.58 | 3.74 | 0.000 |
| Interaction (EIxK) | 0.00 | -0.025 | -3.37 | 0.000 |
| Nitrogen (N) | 0.22 | -0.87 | -4.03 | 0.000 |
| Interaction (EIxN) | 0.00 | 0.016 | 4.92 | 0.000 |
| Intercept | 27.08 | 44.57 | 1.65 | 0.101 |

$R^2 = 0.36$ R = 0.60 F = 33.46
Adjusted $R^2 = .35$ p < .000
Standard error = 15.90 Observations = 243

Y' San Benito = 44.57 + 1.58K – 0.025EIxK – 0.87N + 0.016EIxN

## San Francisco

Table 3-8 shows the cotton production function for the San Francisco zone. Seventy seven percent of the variance of the cotton production was explained by five factors, nitrogen (N), phosphorus (P), potassium (K), the interaction of phosphorus by the annual environmental index (EIxP), and the interaction of potassium by the annual environmental index (EIxK). A statistically significant proportion of the variance in final cotton production in San Francisco was explained by those factors (F = 29.54, p < 0.001) with a *very high* multiple correlation (R = 0.88).

## Quilmaná

Table 3-9 reports the cotton production function for Quilmaná. Fifty-four percent of the variance of the cotton production in Quilmaná was explained by two factors, potassium (K) and the interaction of potassium by the annual environmental index (EIxK). A statistically significant proportion of the variance in final cotton production in

Quilmaná was explained by those factors ($F = 32.28$, $p < 0.001$) with a *very high* multiple correlation ($R = 0.73$).

Table 3-8: Cotton production function in San Francisco

| Variables | Standard error | b | t | p |
|---|---|---|---|---|
| Nitrogen (N) | 0.15 | 0.46 | 3.09 | 0.003 |
| Phosphorus (P) | 1.38 | 4.90 | 3.55 | <0.001 |
| Potassium (K) | 1.36 | -5.57 | -4.08 | <0.001 |
| Interaction (EIxP) | 0.02 | -0.088 | -3.51 | <0.001 |
| Interaction (EIxK) | 0.02 | 0.103 | 4.17 | <0.001 |
| Intercept | 34.62 | -63.01 | -1.82 | 0.075 |

$R^2 = 0.77$ $R = 0.88$ $F = 29.54$
Adjusted $R^2 = .74$ $p < 0.001$
Standard error = 11.18 Observations = 49

Y' in San Francisco = -63.01 + 0.46N + 4.90P – 5.57K – 0.088EIxP + 0.103EIxK

Table 3-9: Cotton production function in Quilmaná

| Variables | Standard error | b | t | p |
|---|---|---|---|---|
| Potassium (K) | 0.31 | -0.84 | -2.75 | 0.008 |
| Interaction (EIxK) | 0.00 | 0.01 | 6.89 | <0.001 |
| Intercept | 29.63 | 52.06 | 1.76 | 0.084 |

$R^2 = 0.54$ $R = 0.73$ $F = 32.28$
Adjusted $R^2 = .52$ $p < 0.001$
Standard error = 18.27 Observations = 59

Y' in Quilmaná = 52.06 – 0.84K + 0.01EIxK

## Cotton Yield Analysis Based on Production Functions

Based on the function equations, the fertilization ranges, and the environmental indexes, an analysis of the estimated cotton yields is presented for all and each one of the different zones. Three levels of each fertilizer factor were used, lowest, medium, and highest, according to the range of the data of each zone (Table 3-1). Three levels of environmental conditions were also included as proposed in Figure 3-2: good year (65 qq/ha), fair year (52.5 qq/ha), and poor year (37.5 qq/ha) in each particular analysis. Sixty quintals of cotton per ha is considered the acceptable, good, or objective yield in each case. The fertilizer factors reported were those with statistical significance and therefore those that can be used in predictions with confidence.

Figure 3-3 shows the estimated cotton yield in Cerro Alegre in function of phosphorus and potassium fertilization rates in different environmental conditions.

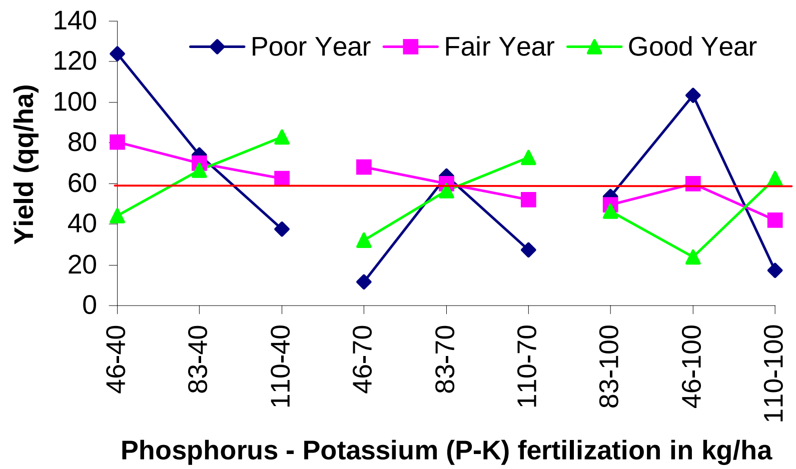



Figure 3-3: Estimated cotton yield in response to phosphorus and potassium fertilization rates, Cerro Alegre

A poor year as previously defined might become a good year for this zone because the best yields are found over that curve with lowest rates of both phosphorus and potassium. Drastic changes in the yield curves would indicate phenomena of synergism and antagonism among the fertilizers and the soil, which enhance or deplete the productivity. In a good year, Cerro Alegre could obtain reasonable yields with highest phosphorus and lowest potassium. In a fair year, lowest rates of fertilizers would be appropriate to obtain the best yields.

Figure 3-4 shows the curves of La Quebrada production functions. The explaining factors are the phosphorus fertilizer and the interaction of phosphorus with the environmental conditions.

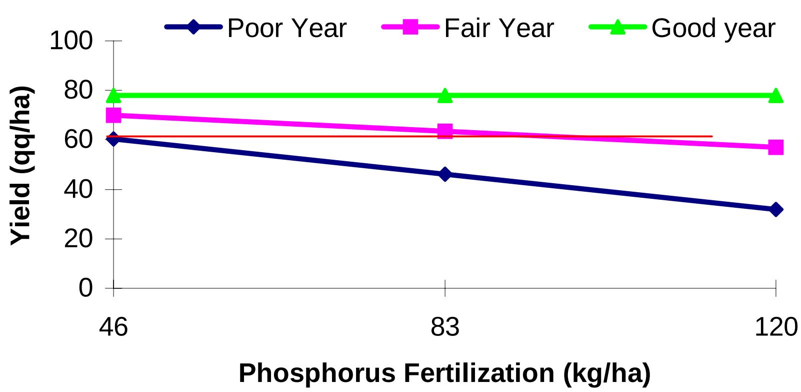



Figure 3-4: Estimated cotton yield in response to phosphorus fertilization rates, La Quebrada

In all cases, poor, fair, and good year, there is no reason to apply more than 46 kg/ha of phosphorus because it would not increment the yield of cotton. Indeed, applying more phosphorus, in poor or fair years, would decrease the yields. This negative effect of the phosphorus fertilizer could be explained in this zone for two reasons. First, these small portions of curves are part of major curves of production, what are conceived as curvilinears, in which they might be located in the top or decreasing segments. Second, La Quebrada is a zone with pest problems. These problems would become more severe in presence of more phosphorus fertilizer. It is probably better not to recommend cotton production in poor years because the yields would not reach the acceptable limit.

Figure 3-5 shows the Palo Isla production functions explained by nitrogen and potassium fertilizers and the interaction of nitrogen with the environmental index.

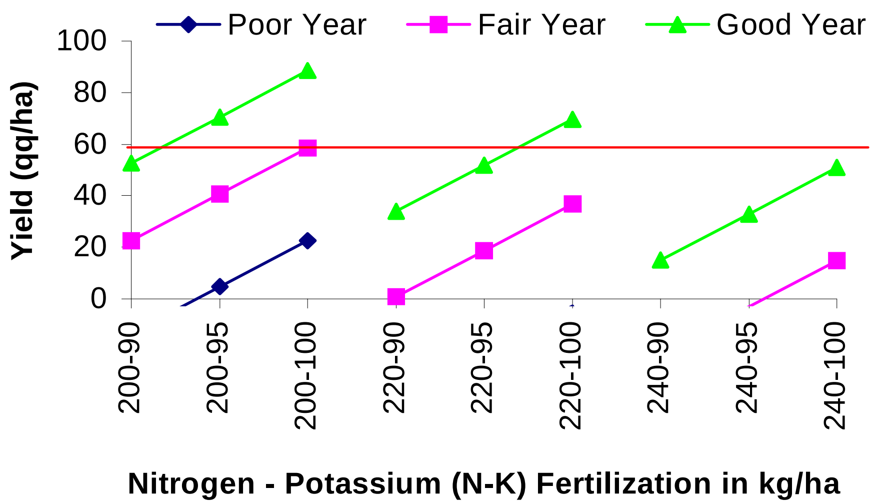



Figure 3-5: Estimated cotton yield in response to nitrogen and potassium fertilization rates, Palo Isla

Palo Isla is not a good zone for cotton production. In poor years, it is difficult to obtain any cotton yield. In fair years, there is also a great chance of failure unless there would be minimum nitrogen (200) and maximum potassium (100). The same rates of fertilizers would be recommended in a good year to obtain the best yields.

Figure 3-6 shows the curves of the cotton production functions in Santa Bárbara. The curves indicate higher yields with lower fertilizer application, especially with lower potassium. The Santa Bárbara soils are saline and this problem could be aggravated with potassium applications. On the other hand, cotton is a crop adapted to saline soils and it could result in good yields even in poor years if fertilization is balanced. In all years, the lowest rates of phosphorus and potassium would be recommended.

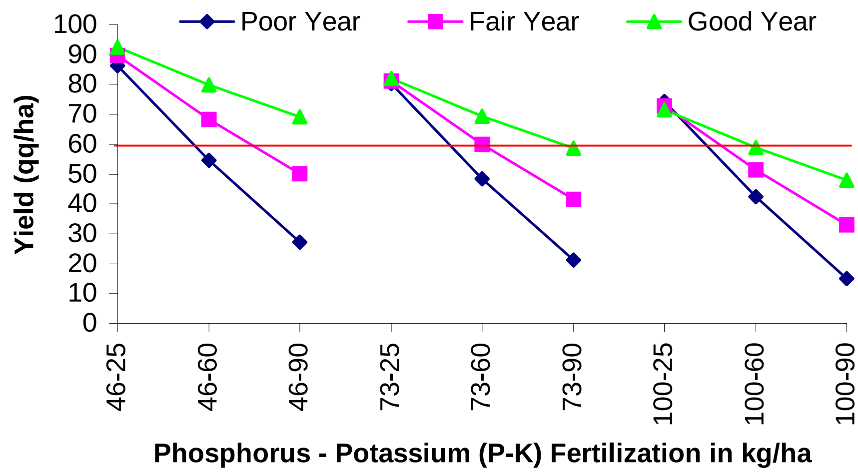
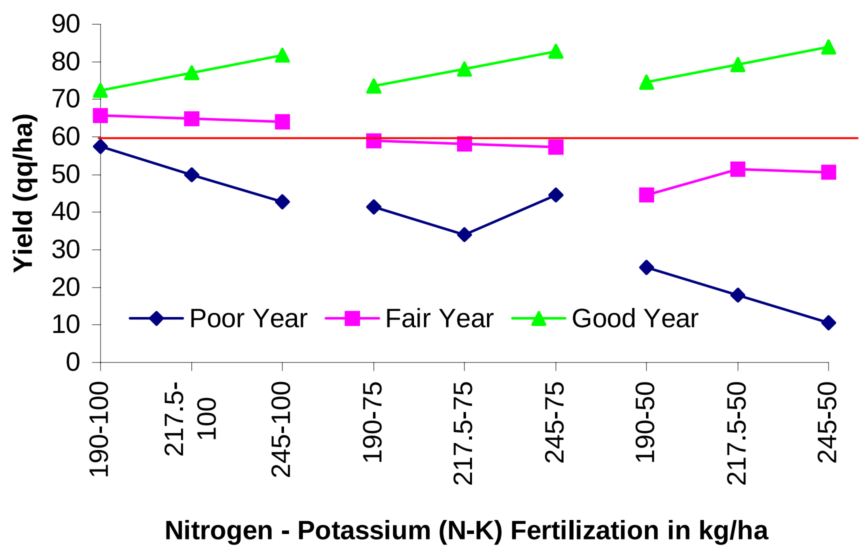



Figure 3-6: Estimated cotton yield in response to phosphorus and potassium fertilization rates, Santa Bárbara

Figure 3-7 presents the curves of cotton production for San Benito. As seen in the curves, San Benito is a good cotton zone in good years. In a good year, good cotton yields are expected with almost all fertilization N-K combinations, although best results could be obtained with highest rates of nitrogen and lowest rates of potassium. In fair years, best yields are predicted with maximum amount of potassium (100 kg/ha) and minimum amount of nitrogen (190 kg/ha). In poor years, it would be better not to produce cotton in San Benito.

Figure 3-8 shows the curves of the cotton production functions for San Francisco zone based on nitrogen, phosphorus, potassium, and environmental factors.

In good years, the yield is enhanced with the highest rates of nitrogen (250 kg/ha) and potassium (90 kg/ha) and lowest rate of phosphorus (30 kg/ha). The amount of potassium has more effect than nitrogen and phosphorus: the peaks in the curve are determined by this factor. In the fair years, the curve increases with more nitrogen and phosphorus, but decreases slightly with more potassium. The best yields in fair years could be obtained with highest rates of nitrogen (250 kg/ha) and phosphorus (103 kg/ha) and lowest rate of potassium (40 kg/ha). In San Francisco, as it was in Cerro Alegre, the poor years might become good years. The best yields are found over this curve. In poor years, the best yields could be reached with the same fertilizer rates as fair years. In fair and poor years, the peaks in the curves are determined with the lowest amounts of potassium.




`Figure 3-7: Estimated cotton yield in response to nitrogen and potassium fertilization rates, San Benito

Poor years and, in to a lesser extent, fair years are characterized by the presence of major pest problems that could be the reason that potassium becomes a deleterious factor because it increases the chance of pest infestation.

Figure 3-9 shows the production functions in Quilmaná based on potassium fertilization and environmental factors. As seen in the curves, Quilmaná is not a good cotton zone, the yields are low. The potassium fertilizer negatively affects yield for the three types of years. The least affected is the curve of the good year. Probably, it is better not to raise cotton in Quilmaná.

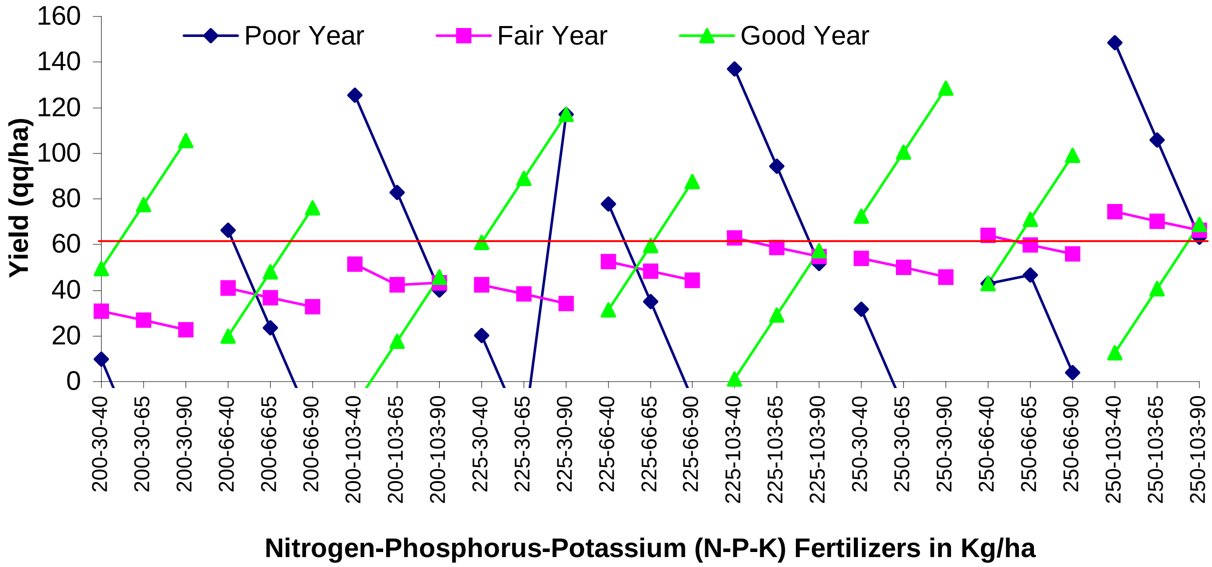



Figure 3-8: Estimated cotton yield in response to nitrogen, phosphorus, and potassium fertilization rates, San Francisco

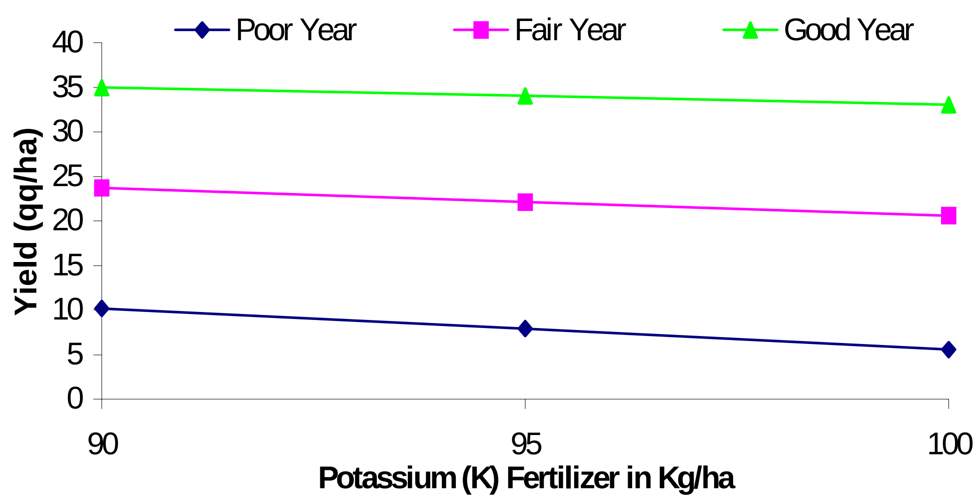



Figure 3-9: Estimated cotton yield in response to potassium fertilization rates, Quilmaná

# CHAPTER 4
# LINEAR PROGRAMMING

## Introduction

The purpose of this analysis was to study the various farming systems in the Cañete Valley community in order to evaluate different scenarios. Linear programming was used first to simulate the households' current situation and after statistical validation, predict different farmer's responses to various scenarios.

The simulation of the Cañete community was done using the 60-household survey sample. Independent linear programming models –one for each household- were developed. That fact was critical for analyzing the overall community while maintaining the diversity of the systems. In all cases, there was a one-year model and a six-year model.

The simulation results were statistically compared with the real data to validate the models. The validation process resulted in verifying that the models represented the same population as the sample, and consequently would allow an extensionist to use the models with confidence in the Cañete community. The simulation results were aggregated, grouped, and analyzed at the community level in different scenarios.

The simulation models are "interactive-working models," which, even though satisfactorily simulating the community, should be updated and reviewed frequently. The prices and production conditions could change through time; different technologies can be available; new activities could be added, and ultimately, the models can be used with each specific household, after updating with appropriate data. Use of Visual Basic, embedded programming language of Microsoft® Excel 97 SR-1, allowed the researcher to make the interactive process quick and efficient. Appendix E contains two interactive-working Excel files, the one-year and the six-year linear programming models of the Cañete community.

## Assumptions for Linear Programming

Based on the data gathered in the survey, the situation was simulated by a linear programming model that maximizes discretionary cash at the end of the year after satisfying all basic family needs (Table 4-1). The linear models include the following activities and constraints:

1. There are two well-known production seasons in Cañete. The matrix was divided into these: First season, August 15th to April 14th, and second season, April 15th to August 14th.
2. Land is a limited resource in the Cañete Valley. Its use is intensive.
3. Renting land from both the owners' perspective and the renters' perspective is a common practice in the community that was included in the models. The farmers have the opportunity to rent out their lands or take or rent in other farmers' lands for a reasonable price. The cash received when renting land is less than the cash needed to take or rent in others' land because of some fixed costs (i.e. irrigation fee, municipality tax). The commercial transaction requires in both cases five units of household management (explained in number 7 below).

4. Labor is a limited resource. It is determined by the number, age and gender of the household members (Table 4-5). Each child younger than five years *requires* 0.75 day-labor per day, each child between 5 to 14 years *contributes* 0.5 day-labor per day as well as the males older than 65 years and the females older than 75 years. The males between 14 and 65 and the females between 14 and 75 years *contribute* 1.00 day-labor per day to the household. The female labor is more limited than the male because they attend the children, the house, and most of the livestock.

5. The household has the opportunity to hire people in labor intensive-seasons (labor is available in the community). It is also common that the household members work for others (off-farm labor) to supplement household income. The cost to hire someone is S/. 10.00 per day, however the cash contribution to the household income when working for another is only S/. 8.00 per day because the member keeps 20% for his/her own. At least 50% of the total household labor is provided by its members. The house and livestock activities do not use hired people.

6. Water is not a limited resource in the first semester, but it is, in some cases, in the second semester. The availability of water is determined by the frequency, time, and flow of water received in each household. The house and the livestock consume the same irrigation water.

7. Management is an aggregate index computed by summing the total years of education of all members in each particular household (the following values were utilized in the index: 1= illiterate, 3= primary, 7= secondary, 10=

superior). Management is not a limited resource in the basic one-year model. It becomes a serious limiting factor in the six-year model because the new activities (asparagus and grapes) require more management skills than traditional crops and because in this simulation many households would be able to rent in or rent out land, activities that require management resources.

8. Credit is an available resource for cotton and maize in the first semester and for maize in the second semester (development agencies, industry). This is a limited resource, mostly in the second season. The interest is 10% in the first semester and 8% in the second. The farmers may get cash credit (retailer, intermediaries, pesticides shop, etc.), and may be assessed as much as 100% interest for just one season of credit. Credit is also available for activities such as asparagus and grapes in the six-year model.

9. Each household has some cash at the beginning of each season. This money is used for household expenses, livestock, and production activities. The quantity was computed based upon family activities, and production records as well as previous debts. The household cash is a limited resource in both semesters.

10. The basic activities of the household in the first semester are general household expenses (food, services, etc.), livestock (mainly poultry, but also rabbits, Guinea pigs, or sheep), cotton, maize, and sweet potato. In the second semester, there is no cotton production. The production and prices vary in maize and sweet potato according to semesters (Tables 4-2 & 4-4).

11. The family and livestock consume maize and sweet potato produced on the farm. The family requires a certain amount of livestock produced by the household (Table 4-3). These quantities are computed according to the number, age, and gender of the household members.
12. The cash, if not used in the first semester, can be transferred to the second semester. If the cash in the second semester is not used, it is transferred to the end of the year cash. The needed cash is transferred to the first semester of the next year, in the six-year model.
13. The cash at the end of the year could be negative in the one-year and in the six-year models. Negative cash at the end of the year indicates a non-sustainable system.
14. In the six-year model, the perennial crops –asparagus and grapes- have different resource needs and production rates through the years, Tables 4-5, 4-6, & 4-7. The land used by these crops is not available for others crops during the six years.
15. The traditional crops (cotton, maize, and sweet potato) require one unit of management per enterprise. Similarly, the house and livestock activities require one unit of management each per semester. The new activities, such as asparagus and grapes, require more management resources estimated at five units per semester per crop.

Table 4-1: Resources and constraints for linear programming, average household

| Resources and Constraints | Sign | Unit | Amount |
|---|---|---|---|
| Land I | <= | ha | 4.72 |
| Land II | <= | ha | 4.72 |
| Male labor I | <= | days | 449.00 |
| Male labor II | <= | days | 224.00 |
| Female labor I | <= | days | 466.00 |
| Female labor II | <= | days | 233.00 |
| Male hired I | <= | days | 449.00 |
| Male hired II | <= | days | 224.00 |
| Female hired I | <= | days | 464.00 |
| Female hired II | <= | days | 230.00 |
| Water I | <= | $m^3$ | 64,076.88 |
| Water II | <= | $m^3$ | 32,038.44 |
| Management I | <= | unit | 31.48 |
| Management II | <= | unit | 31.48 |
| Credit for cotton and/or maize I | <= | Soles | 9,700.58 |
| Credit for maize II | <= | Soles | 3152.69 |
| Household cash I | <= | Soles | 4,999.99 |
| Household cash II | <= | Soles | 3300.00 |
| Livestock consumption I | = | unit | 8.00 |
| Livestock consumption II | = | unit | 4.00 |
| Maize consumption (house) I | = | Kg | 543.11 |
| Maize consumption (house) II | = | Kg | 273.46 |
| Maize consumption (livestock) I | = | Kg | 960.89 |
| Maize consumption (livestock) II | = | Kg | 478.55 |
| Sweet potato consumption (house) I | = | Kg | 497.07 |
| Sweet potato consumption (house) II | = | Kg | 900.13 |
| Sweet potato consumption (livestock) I | = | Kg | 900.13 |
| Sweet potato consumption (livestock) II | = | Kg | 600.08 |

Note: I is first semester: August 15$^{th}$ to April 14$^{th}$.
II is second semester: April 15$^{th}$ to August 14$^{th}$.
Average of the 60 sample households. Specific information for each household can be found in Appendix D.

The one-year model maximizes the cash available for discretionary spending at the end of the year for each household after meeting all households needs. The six-year model maximizes the sum of the end of the year cash for all six years. In both cases, the maximization is after meeting the family needs.

Table 4-2: Crop activities and resource use for linear programming, per ha

| Resource | Cotton | Maize I | Sweet Potato I | Maize II | Sweet Potato II |
|---|---|---|---|---|---|
| Male labor I (days) | 75 | 70 | 77 | -- | -- |
| Male labor II (days) | -- | -- | -- | 70 | 60 |
| Female labor I (days) | 50 | 55 | 70 | -- | -- |
| Female labor II (days) | -- | -- | -- | 55 | 50 |
| Water I ($m^3$) | 8,000 | 9,500 | 6,500 | -- | -- |
| Water II ($m^3$) | -- | -- | -- | 7,500 | 5,000 |
| Management I (unit) | 1 | 1 | 1 | -- | -- |
| Management II (unit) | -- | -- | -- | 1 | 1 |
| Credit I (Soles) | 3,128 | 1,986 | -- | -- | -- |
| Credit II (Soles) | -- | -- | -- | 1,500 | -- |
| Household cash I (Soles) | -- | -- | 1,848 | -- | -- |
| Household cash II (Soles) | -- | -- | -- | 386 | 1,534 |

There are two non-elective activities in the models: 1) household activities –cash for food, health, education, transportation, etc., and farm products -and 2) livestock (the livestock activity is mainly for consumption).

Table 4-3: Resource use for house and livestock activities, average household

| Resource | House | Livestock |
|---|---|---|
| Male labor I (days) | 25 | 40 |
| Male labor II (days) | 12.5 | 20 |
| Female labor I (days) | 126 | 64 |
| Female labor II (days) | 42 | 32 |
| Water I ($m^3$) | 1,519.20 | 1,000.00 |
| Water II ($m^3$) | 1,000.14 | 500.00 |
| Management I (unit) | 1 | 1 |
| Management II (unit) | 1 | 1 |
| Household cash I (Soles) | 5,367.84 | 800.00 |
| Household cash II (Soles) | 2,638.92 | 400.00 |

Note: Average of the 60 sample households. Specific information for each household can be found in Appendix D.

Table 4-4: Income from traditional activities, per ha

| Activity | Unit | Yield | Below Average Price | Average Price | Above Average Price |
|---|---|---|---|---|---|
| Cotton | Quintal | 60.83 | 68.00 | 103.50 | 121.50 |
| Maize I | Kg | 5607.28 | 0.43 | 0.48 | 0.58 |
| Sweet potato I | Kg | 19845 | 0.15 | 0.25 | 0.35 |
| Maize II | Kg | 7300.14 | 0.45 | 0.85 | 0.90 |
| Sweet Potato II | Kg | 24630.4 | 0.08 | 0.20 | 0.45 |
| **Rate of price change (average)** | | | **-36.62 %** | | **+41.80 %** |

Asparagus and grapes are two introduced crops in the Cañete Valley. They are perceived as complex but profitable. Currently, the development agencies are recommending these crops for the small farmers as alternatives to improve their livelihood. Indeed, development agencies are financing these crops. The six-year model was used to test the viability of these alternatives from the small farmers' perspectives. In the case of the asparagus, the development agency requires that the small farmer be able to plant at least one hectare due to harvesting and marketing concerns.

Table 4-5: Asparagus resource needs in six-year model, per ha

| | Years | | | | | |
|---|---|---|---|---|---|---|
| Resource | 1 | 2 | 3 | 4 | 5 | 6 |
| Male labor I (days) | 15 | 15 | 45 | 30 | 30 | 30 |
| Male labor II (days) | 15 | 15 | 45 | 30 | 30 | 30 |
| Female labor I (days) | 2 | 4 | 15 | 12 | 12 | 12 |
| Female labor II (days) | 2 | 4 | 15 | 12 | 12 | 12 |
| Water I ($m^3$) | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 |
| Water II ($m^3$) | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 |
| Management I (unit) | 5 | 5 | 5 | 5 | 5 | 5 |
| Management II (unit) | 5 | 5 | 5 | 5 | 5 | 5 |
| Credit I (Soles) | 2500 | 2500 | 2500 | 2000 | 500 | 2500 |
| Credit II (Soles) | 1500 | 1500 | 1500 | 1500 | 500 | 2000 |
| Household cash I (Soles) | -- | 500 | 500 | 500 | 500 | 500 |
| Household cash II (Soles) | -- | 500 | 500 | 500 | 500 | 500 |

Table 4-6: Grape resource needs in six-year model, per ha

| | Years | | | | | |
|---|---|---|---|---|---|---|
| Resource | 1 | 2 | 3 | 4 | 5 | 6 |
| Male labor I (days) | 20 | 15 | 30 | 30 | 30 | 30 |
| Male labor II (days) | 20 | 15 | 30 | 30 | 30 | 30 |
| Female labor I (days) | 5 | 5 | 30 | 30 | 40 | 40 |
| Female labor II (days) | 5 | 5 | 30 | 30 | 40 | 40 |
| Water I ($m^3$) | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| Water II ($m^3$) | 1500 | 1000 | 1000 | 1500 | 2500 | 1000 |
| Management I (unit) | 5 | 5 | 5 | 5 | 5 | 5 |
| Management II (unit) | 5 | 5 | 5 | 5 | 5 | 5 |
| Credit I (Soles) | 3000 | 3000 | 3000 | 2500 | 1000 | 2500 |
| Credit II (Soles) | 1500 | 2000 | 2000 | 2000 | 500 | 2500 |
| Household cash I (Soles) | -- | 1000 | 1000 | 1000 | 500 | 500 |
| Household cash II (Soles) | -- | 500 | 500 | 500 | 1000 | 1000 |

Table 4-7: Asparagus & grape income, per year per ha

| | Years | | | | | |
|---|---|---|---|---|---|---|
| Perennial crop | 1 | 2 | 3 | 4 | 5 | 6 |
| Asparagus | -- | 12000 | 20000 | 26000 | 35000 | 48220 |
| Grape | -- | 2000 | 10000 | 22000 | 28000 | 35000 |

Analyses were conducted from different perspectives. The researcher attempted to explain the overall household system dynamics. After the aggregation of the sixty model solutions, they were compared with the original data to understand “why” the simulation selected some activities over others. Without losing the system diversity, there were some naturally occurring household groupings. As suspected, family composition: number of members, ages and gender were critical characteristics as well as the land resource. A summary of those characteristics for the 60 households is shown in Table 4-8.

Table 4-8: Household composition and land for each farm

| | Members, gender, and age | | | | | | Land |
|---|---|---|---|---|---|---|---|
| N° | <5 | 5-14 | 15-65male | 14-75female | >65male | >75female | (ha) |
| 01 | 1 | 3 | 2 | 3 | 0 | 0 | 3.00 |
| 02 | 0 | 2 | 1 | 1 | 1 | 0 | 1.00 |
| 03 | 0 | 1 | 4 | 2 | 0 | 1 | 4.50 |
| 04 | 0 | 0 | 2 | 1 | 0 | 0 | 2.84 |
| 05 | 2 | 1 | 3 | 2 | 0 | 0 | 4.00 |
| 06 | 0 | 0 | 1 | 1 | 1 | 0 | 4.50 |
| 07 | 1 | 3 | 4 | 1 | 0 | 0 | 0.70 |
| 08 | 0 | 0 | 1 | 1 | 0 | 0 | 7.50 |
| 09 | 1 | 1 | 2 | 4 | 1 | 0 | 6.00 |
| 10 | 1 | 2 | 2 | 2 | 0 | 0 | 3.00 |
| 11 | 0 | 0 | 3 | 2 | 0 | 0 | 6.00 |
| 12 | 0 | 0 | 1 | 1 | 0 | 0 | 5.07 |
| 13 | 0 | 2 | 3 | 2 | 0 | 0 | 3.45 |
| 14 | 0 | 0 | 0 | 2 | 1 | 0 | 1.50 |
| 15 | 0 | 0 | 2 | 4 | 0 | 0 | 5.70 |
| 16 | 0 | 0 | 4 | 2 | 0 | 0 | 7.00 |
| 17 | 0 | 0 | 2 | 4 | 1 | 0 | 4.00 |
| 18 | 0 | 0 | 2 | 2 | 1 | 0 | 4.25 |
| 19 | 0 | 2 | 4 | 3 | 0 | 0 | 4.70 |
| 20 | 0 | 1 | 1 | 1 | 0 | 0 | 4.68 |
| 21 | 1 | 1 | 3 | 2 | 0 | 0 | 3.50 |
| 22 | 0 | 0 | 2 | 2 | 0 | 0 | 4.37 |
| 23 | 0 | 1 | 3 | 3 | 0 | 0 | 6.00 |
| 24 | 0 | 0 | 4 | 1 | 0 | 0 | 5.75 |
| 25 | 2 | 0 | 4 | 2 | 0 | 0 | 8.33 |
| 26 | 0 | 2 | 3 | 5 | 0 | 0 | 6.77 |
| 27 | 0 | 0 | 1 | 2 | 0 | 0 | 4.50 |
| 28 | 0 | 0 | 5 | 1 | 0 | 0 | 4.40 |
| 29 | 0 | 0 | 4 | 2 | 0 | 0 | 6.70 |
| 30 | 0 | 1 | 2 | 5 | 0 | 0 | 6.13 |
| 31 | 0 | 1 | 2 | 3 | 0 | 0 | 5.10 |
| 32 | 1 | 1 | 1 | 1 | 0 | 0 | 3.00 |
| 33 | 0 | 0 | 0 | 2 | 0 | 1 | 3.00 |
| 34 | 0 | 0 | 5 | 3 | 0 | 0 | 4.70 |
| 35 | 0 | 2 | 3 | 3 | 0 | 0 | 4.20 |
| 36 | 0 | 0 | 3 | 1 | 0 | 0 | 3.00 |
| 37 | 1 | 0 | 3 | 3 | 0 | 1 | 5.40 |
| 38 | 1 | 0 | 1 | 1 | 0 | 0 | 2.25 |
| 39 | 0 | 0 | 2 | 1 | 0 | 0 | 3.20 |
| 40 | 0 | 2 | 3 | 2 | 0 | 0 | 3.00 |
| 41 | 0 | 0 | 0 | 2 | 0 | 1 | 3.25 |
| 42 | 0 | 0 | 2 | 2 | 0 | 1 | 1.00 |
| 43 | 0 | 0 | 3 | 1 | 1 | 0 | 7.00 |
| 44 | 0 | 2 | 1 | 1 | 0 | 0 | 3.00 |
| 45 | 0 | 0 | 3 | 4 | 0 | 0 | 5.10 |

(Continued in next page)

Table 4-8: Continued

| | Members, gender, and age | | | | | | Land |
|---|---|---|---|---|---|---|---|
| N° | <5 | 5-14 | 15-65male | 14-75female | >65male | >75female | (ha) |
| 46 | 0 | 0 | 1 | 1 | 1 | 0 | 5.00 |
| 47 | 0 | 1 | 1 | 3 | 0 | 0 | 6.84 |
| 48 | 0 | 0 | 5 | 3 | 0 | 0 | 11.00 |
| 49 | 0 | 0 | 1 | 1 | 1 | 1 | 8.70 |
| 50 | 0 | 0 | 0 | 1 | 1 | 0 | 2.00 |
| 51 | 0 | 0 | 1 | 1 | 0 | 0 | 10.00 |
| 52 | 0 | 0 | 3 | 3 | 1 | 0 | 6.00 |
| 53 | 0 | 3 | 2 | 2 | 0 | 0 | 2.75 |
| 54 | 0 | 0 | 0 | 3 | 0 | 0 | 11.75 |
| 55 | 0 | 1 | 3 | 4 | 0 | 0 | 5.00 |
| 56 | 1 | 0 | 1 | 2 | 0 | 0 | 3.50 |
| 57 | 0 | 0 | 4 | 6 | 0 | 0 | 3.00 |
| 58 | 0 | 0 | 2 | 3 | 0 | 0 | 2.00 |
| 59 | 0 | 3 | 2 | 2 | 0 | 0 | 1.00 |
| 60 | 0 | 0 | 2 | 2 | 0 | 0 | 9.00 |

## Linear Programming Model Validation

Before continuing with further analyses, the researcher examined the 60 one-year models to determine the degree to which they represent the same population as the sample of 60 households. The results of the 60 individual simulation models were statistically compared with the data from the household survey. Three items were used for this analysis: total land used in the second semester, land planted with maize and land planted with sweet potato in the second semester because they were the most accurate data from the survey.

Both an F-test and a t-test were used to test the models. The F-test compared the data variances in order to determine if both sets of data had equal variances. The t-test compared the means (with equal or unequal variances) in order to determine if significant differences existed between the two sets of data: simulated and survey. Both tests were based on probability level of 0.05.

The null hypothesis in each case was that variances and means were not equal:

F-test:

Var (solution data) = Var (real data)
Var (solution data) <> Var (real data)

t-test:

Mean (solution data) = Mean (real data)
Mean (solution data) <> Mean (real data)

Table 4-9 shows the analysis for the total land used in each household in the second semester. The null hypothesis for variance is rejected (F = 1.50, p = 0.062) indicating that we can accept that the variances are not different. The t-test, assuming equal variances, leads us to reject the null hypothesis and accept that the sample and the results of the simulated models represent the same population. (t = 0.135, p = 0.893).

Table 4-9: Total land used (t-test assuming equal variances)

| Land used | n | Mean | Variance | t | p |
|---|---|---|---|---|---|
| Model simulation | 60 | 3.68 | 3.71 | 0.135 | 0.893 |
| Real data | 60 | 3.73 | 5.55 | | |

(F = 1.500, p = 0.062)

Table 4-10 analyzes the maize land planted in the second semester. The F-test indicated unequal variances (F = 2.967, p = 0.004). The t-test for unequal variances indicated that both sets of data –simulation & real- have approximately equal means and therefore the sample and the simulated models represent the same population. (t = 1.684, p = 0.122).

Table 4-10: Maize land used (t-test assuming unequal variances)

| Land used | n | Mean | Variance | t | p |
|---|---|---|---|---|---|
| Model simulation | 26 | 2.00 | 0.75 | 1.684 | 0.122 |
| Real data | 26 | 2.54 | 2.22 | | |

(F = 2.967, p = 0.004)

Table 4-11 shows results for sweet potato land planted in the second semester. The F-test for the simulation and the real data indicated equal variances (F = 0.674, p = 0.176). The t-test, assuming equal variances, revealed no significant differences in means indicating that the sample and the simulated models represent the same population. (t = -1.408, p = 0.166).

Table 4-11: Sweet potato land used (t-test assuming equal variances)

| Land used | n | Mean | Variance | t | p |
|---|---|---|---|---|---|
| Model simulation | 24 | 2.65 | 2.46 | -1.408 | 0.166 |
| Real data | 24 | 2.06 | 1.66 | | |

(F = 0.674, p = 0.176)

Based on this validation analysis, we conclude that the linear programming models adequately simulate the population sampled: Cañete’s small farmers. These models can be used with confidence to project production, income, and consumption in different scenarios for any Cañete’s small farmer household.

## Prices, Alternative Crops, and Discount Analyses Based on Validated Model

The following section presents analyses with the results of the solutions of the different models (60 solutions –one for each household- in each scenario). The specific numerical results can be reviewed in Appendix D.

### One Year Model

A one-year model was run for three different scenarios in all the 60 households: average, below average, and above average product prices. The average scenario model represents the most current information, the normal or average prices in all crops and it is the same as the simulation used in the validation. The below average and above average scenarios estimate responses to external extreme price changes (Table 4-4).

#### Average Price Scenario

In this scenario, with the most common prices, cotton is produced by almost all the households, in variable quantities. Seven households that do not produce any cotton have land, labor, and cash constraints. In all households, more sweet potatoes than maize are produced in the first semester, and more maize than sweet potato is produced in the second semester. The maize in the first semester and the sweet potato in the second are produced primarily to cover the family and livestock consumption needs.

Female labor is more limited in the second semester than in the first. In both semesters, female labor is more binding than male labor. There is more male off-farm labor than female and more in the first semester. All of the farmers in the model, with exception of three households, rent out a portion of their land in both semesters. The three households that chose not to rent out land (N° 42, 50, and 59) have very little land (two ha or less) and plenty of labor available. One of them (N° 50) has very low management resources as well. Little land is rented in by the farmers in either semester.

Water is a constraint only in four households in the first semester. It is a constraint in about 50% of households in the second semester. The management resource is a constraint in twelve households.

Fifty households (83.33%) have credit constraints, mostly in the second semester. The ten households without a credit constraint have no characteristics in common. Six of them have plenty of labor resources; the other four have low labor resources but cash available. Five of these households have small farms (two ha or less), the others have medium or large farms (3 to 8.7 ha). Four households have management resources below 25 units; the others have plenty of this resource.

Cash at the end of the year varies greatly. There is one negative (S/. -2,823, household N° 7). This household is characterized by having very little land (0.7 hectares) and large number of family members in the household (including many small children). All other households have positive year end cash, with a maximum of S/. +57,013 (household N° 60). The cash at the end of the year is highly related to factors such as farm size and household demographics (size, age, and sex composition). All of the households require a certain amount of credit for agricultural production. This is generally in the form of credit for seed, fertilizer, or pesticides. However, nine households borrow cash in addition, from retailers, intermediaries, and/or pesticides shops.

Below Average Price Scenario

In difficult economic times (Table 4-4), farmers would tend to plant more hectares of cotton (Figure 4-1), and subsequently fewer hectares of sweet potatoes and maize. The sweet potato and maize production would be primarily for household consumption.

In the below average scenario, farmers would be financially unable to hire labor, and would more likely seek off-farm employment to subsidize cash income. In addition, more land would be rented out, and less land would be rented in by these small farmers. What little land that is rented, would be rented in the first semester only.

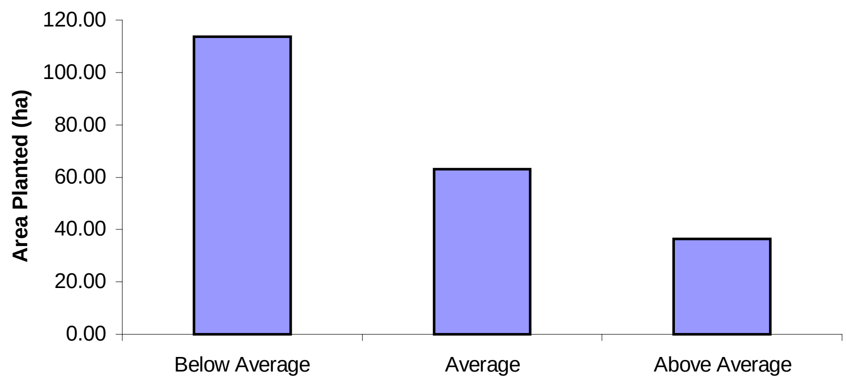



Figure 4-1: Total area planted in cotton for different price scenarios

In terms of water, it would be a constraint only in six of the households for the first semester. It would not be a constraint in any of the households during the second semester (Figure 4-2). Eighteen households would experience management constraints during both semesters.

There would be three households with negative cash holdings at the end of the year (Households N° 7, 25, and 26). The maximum cash holding at the end of the year would be S/. +39,971 (Figure 4-3). End of the year cash is related to farm size and household demographics.

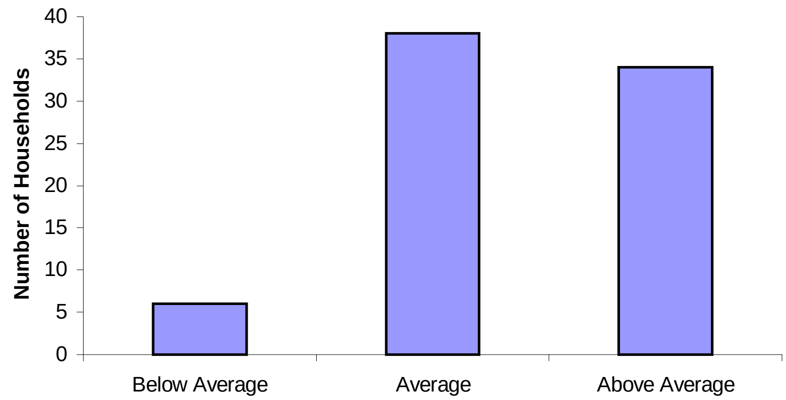



Figure 4-2: Households with water constraints in different price scenarios

Only four households use expensive cash credits. On average, the prices included in this model are 36.62% less than the prices included in the previous model. The end of the year cash in this model is 27.40% less than the end of the year cash in the average model.

<u>Above Average Price Scenario</u>

The most optimistic prices were utilized in this model. Only about one-half of the average hectares would be planted of cotton. Maize production in both semesters would be only for household consumption. However, sweet potato would become the major cash crop.

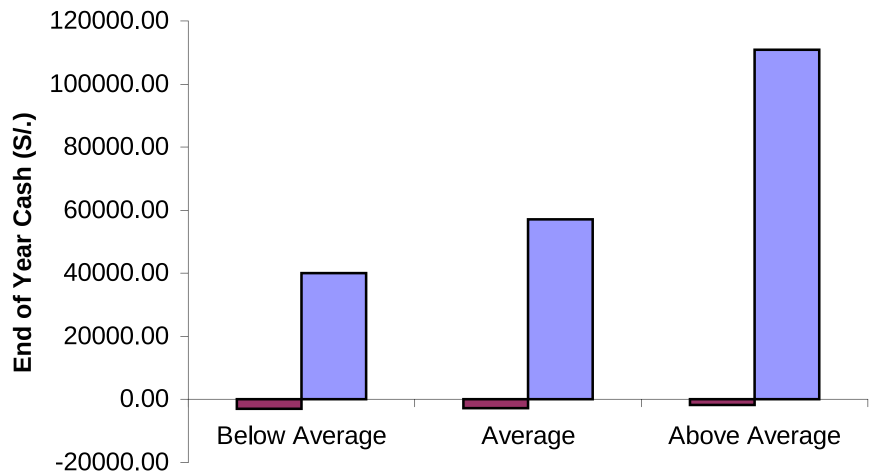



Figure 4-3: Range of cash at the end of the year in different price scenarios

In this model, there would be more cash available to employ labor (Figure 4-4). Consequently, there would be less income brought into the household from off-farm labor. In an effort to maximize hectares, more land would be rented in (50% of the households) than in the average model (Figure 4-5). The land expansion (by renting) would be mostly in the second semester.

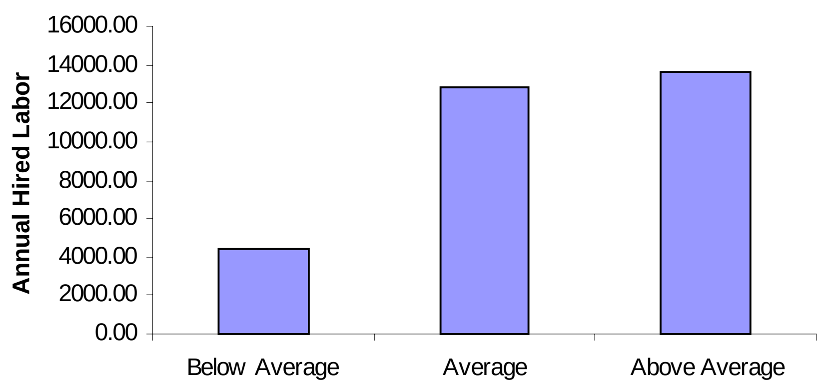



Figure 4-4: Hired labor in different price scenarios

Water constraints in this model would be very similar to the water constraints in the average model. Management constraints were only slightly higher in this model. The household with a negative cash income in the average model still would experience a negative cash income in this model.

The maximum end of year cash would be S/. +110,869 (household N° 60). In this scenario, the product prices are, on average, 41.80% higher than in the average model and the end of year cash in all households is 52.46% higher than in the average model.

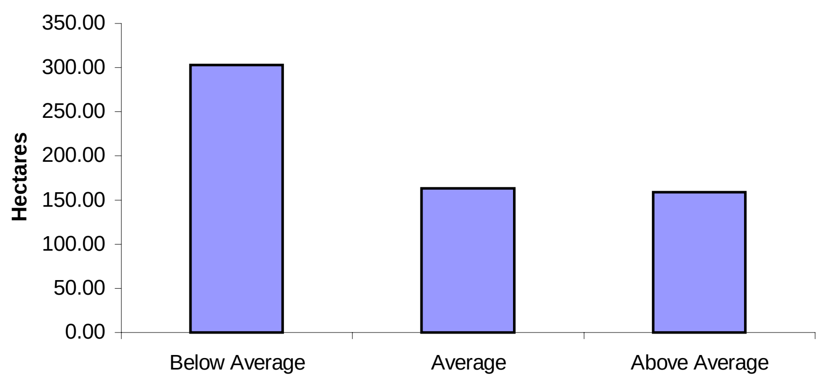



Figure 4-5: Land rented out in different price scenarios

An inspection of Table 4-12 reveals that households were differently affected by prices changes. Some households were highly affected, while others were slightly affected. According to Table 4-12, 26.67% of the households experience a high degree of economic variability and 20.00% of the households experience a low degree of economic variability. The other households (53.33%) experience a moderate economic variability in the three price scenarios. In an attempt to assess potential risk or potential windfall for a general price decrease or increase, the researcher calculated a land to person (number of people in the household) index.

Table 4-12: Cash at the end of the year in different scenarios, economic variability

| Economic Variability | n | Below Average Price | Average Price | Above Average Price | Range | Land/Person Index* |
|---|---|---|---|---|---|---|
| Low | 12 | 13,382 | 16,237 | 25,856 | 12,474 | 0.57 ha/person |
| Moderate | 32 | 17,673 | 24,355 | 46,546 | 28,873 | 1.08 ha/person |
| High | 16 | 25,480 | 36,857 | 74,153 | 48,313 | 1.36 ha/person |

*Land/Person index –land in hectares and number of people in household- is proposed to explain the household economic variability characteristics in different price scenarios.

Households with more land per person experience more economic variability than households with less land per person. (Figure 4-6).

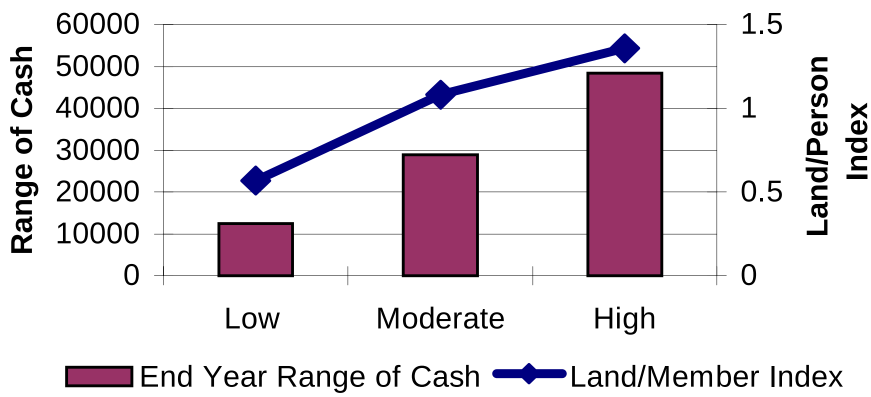



Figure 4-6: Different economic variability and land to person index.

Households with high land per person index (large area or few family members) experience more potential risk or potential windfall in any enterprise than any of the other groups. They would obtain very high incomes in “good” price years, but they would obtain very low incomes in “bad” price years. While the incomes obtained in “good” price years would be almost double than family needs, the incomes in “bad” years would be not enough to cover household needs.

Households with a low land per person index (little area or many family members) experience less potential risk or potential windfall. This last group of households would obtain acceptable incomes in “good” price years and in “bad” price years. These incomes would be enough for the household needs.

## Six Year Model

The six-year model was run in the same three different scenarios: Average, below average and above average cotton, maize, and sweet potato product prices. In the average or normal scenario the two new alternative crops were included (grapes and asparagus) as well as an analysis using discount rates.

### Average Price Scenario

Seventy-five percent of the households do not produce cotton in this scenario. Of the 15 households that do produce cotton, they added the crop in the sixth year, but produce no cotton during the first five years. All of the households produce maize for household consumption. However, during the final two years they also produce maize for the market. Sweet potato production increases each year. Sweet potato is grown for both household consumption and as a cash crop.

Every year in this six-year model, less land is rented out. Those that rent in land for expansion tend to have more land to begin with and a higher degree of management capability. Households with greater labor resources rent out less land. In terms of land expansion, more land is rented in for production each year.

Eight households do not hire any labor during the six-year period. They have less land to care for and more family members to care for their land. The end of the year cash increases every year with one exception (household N° 7).

Grape and asparagus activities analysis

In this average price scenario, no household is financially capable of investing in grape production. However, 46 households would be able to raise some asparagus, twenty-five of which could produce over one hectare (Table 4-13).

Table 4-13: Analysis of the asparagus activity regarding household characteristics

| Grouping | Members, Age, and Gender 1 | 2 | 3 | 4 | Land ha | Zone* | Management or Education |
|---|---|---|---|---|---|---|---|
| No Asparagus 14 out of 60 (13.33%) | 0.50 | 0.79 | 1.71 | 1.64 | 4.35 | 43% high<br>43% medium<br>14% low | 20.69 |
| < 1 ha Asparagus 21 out of 60 (35.00%) | 0.19 | 0.67 | 2.24 | 2.14 | 4.11 | 48% high<br>38% medium<br>14% low | 31.90 |
| >=1 ha Asparagus 25 out of 60 (41.67%) | 0.08 | 0.56 | 2.56 | 2.60 | 5.45 | 20% high<br>48% medium<br>32% low | 38.19 |
| Solution for "Average" Household **0.84 ha Asparagus** | 0.21 | 0.65 | 2.25 | 2.22 | 0.18 | -------- | 31.48 |

Note: 1, males and females of less than five years.
2, males and females between five and fourteen years of age.
3, males between fourteen and sixty-five years of age.
4, females between fourteen and seventy-five years of age.
*The Cañete Valley can be divided in three well-known zones: low, medium, and high, according to elevation differences.

Those households that could devote a greater amount of land to asparagus production are characterized as having fewer children living at home (Figure 4-7), and having more available adult labor (Figure 4-8).

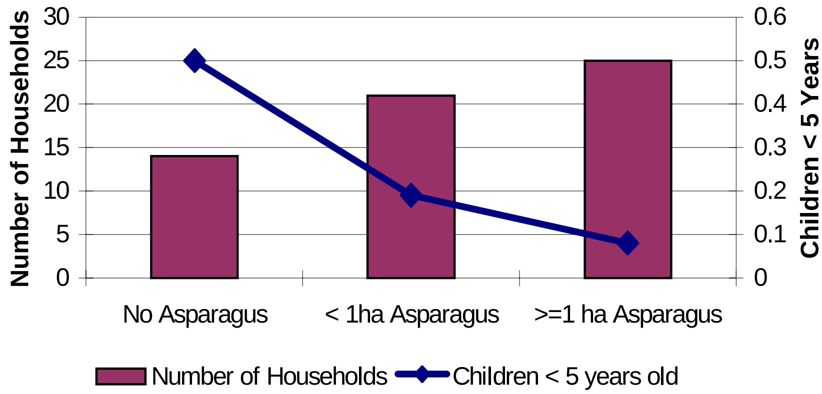



Figure 4-7: Capability of planting asparagus and number of children in household

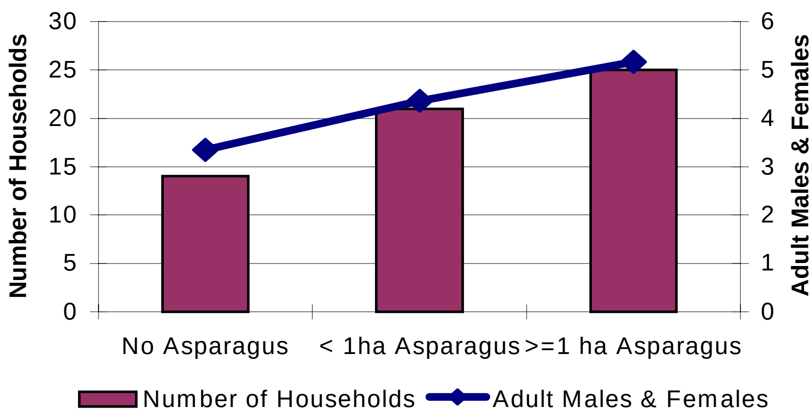



Figure 4-8: Capability of planting asparagus and number of adult members in household

In addition, the households that could devote a greater amount of land to asparagus have larger farms to begin with (Figure 4-9). They tend to have more land in the lower to middle valley range (probably the most productive lands in the valley). They are also more highly educated (Figure 4-10).

Discount rate analysis

Three levels of discount rate were analyzed: low (50%), medium (100%), and high (150%). These discount rates reflect the degree of *stress* (necessity to produce food in the short run) that any household could perceive at any time. The higher the *stress*, the higher the discount rate.

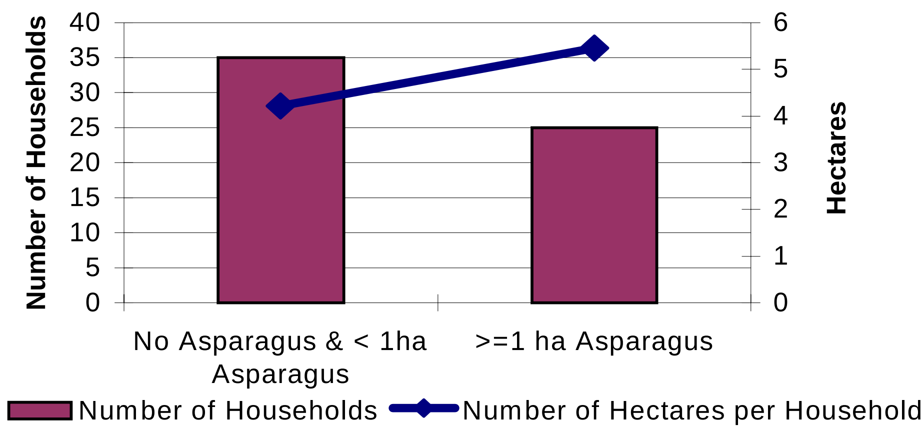



Figure 4-9: Capability of planting asparagus and farm size

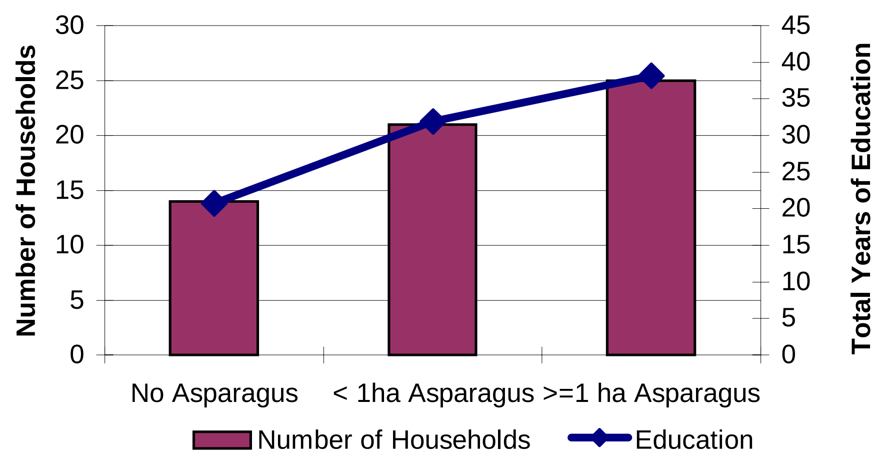



Figure 4-10: Capability of planting asparagus and household education

The total or general findings pointed out that no grapes would be produced at any discount rate. At a relatively low 50% discount rate, asparagus would increase from 48.83

ha (no discount) to 60.39 ha. With a medium discount rate of 100%, asparagus area planted would decrease back to 48.85 ha and at a high discount rate of 150%, asparagus would decrease to only 14.41 ha planted. (Table 4-14, Figure 4-11).

Cotton and maize would increase in area planted at all discount rates. Cotton would increase from 30.27 ha (with no discount) to 31.25 ha with 50% discount, while it would increase to 32.45 ha at 100% and to 45.36 ha at a 150% rate. Maize would increase from 46.20 ha to 47.30 ha, to 51.94 ha, and to 63.63 ha at the highest discount rate.

Sweet potato would vary less than the other crops. It would decrease from 507.37 ha to 491.82 ha, to 505.42 ha, and to 503.93 ha at the highest discount rate.

With a zero discount rate, 25 households would produce asparagus. With the highest discount rate reflecting a strong preference for short term gain, only five households would produce asparagus.

Table 4-14: Analysis of discount and crops

| | Rate of Discount | | | |
|---|---|---|---|---|
| Crop | (0%) | (50%) | (100%) | (150%) |
| **Asparagus** | | | | |
| ha Planted | 48.83 | 60.39 | 48.45 | 14.41 |
| Households (%) | 25 (42.67) | 30 (50.00) | 23 (38.33) | 5 (8.33) |
| **Cotton** | | | | |
| ha Panted | 30.27 | 31.25 | 34.45 | 45.36 |
| Households (%) | 15 (25) | 17 (28.33) | 16 (26.67) | 21 (35.00) |
| **Maize** | | | | |
| ha Planted | 46.20 | 47.30 | 51.94 | 63.63 |
| Household (%) | 60 (100) | 60 (100) | 60 (100) | 60 (100) |
| **Sweet Potato** | | | | |
| ha Planted | 507.37 | 491.82 | 505.42 | 503.93 |
| Household (%) | 60 (100) | 60 (100) | 60 (100) | 60 (100) |

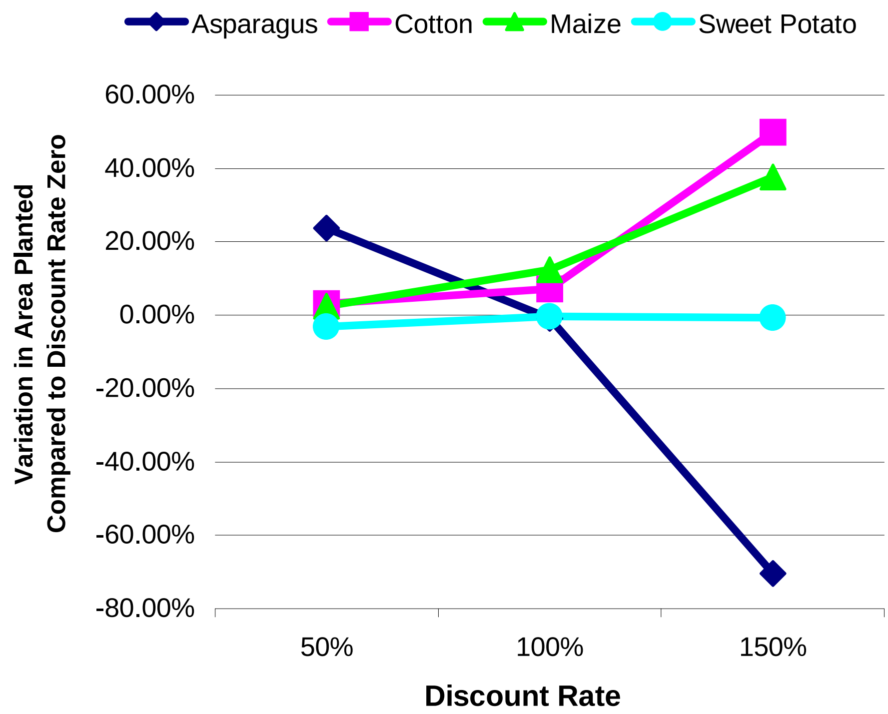



Figure 4-11: Area of crops planted in different stress levels

The discount rates affect to all crops beginning the second year. One difference is that the asparagus starts generating income in the second year (and income increases until the sixth year). The others generate income from the first year, but the amount is the same through the years. Therefore, the other crops (cotton, maize, and sweet potato) would have a priority of resource use in the first year, when these are able to generate income. However, the high profitability of the asparagus makes this crop competitive even at low or medium discount rates.

Another difference is that the asparagus requires a set of fixed resources during the six years, which would not be available to the other activities, and the other crops only need resources in the season of production. This gives the household more flexibility in resource use. For example, the cotton, although not very profitable, requires very small amounts of resources. This explains the fact that this crop would increase in area planted when the asparagus would decrease at medium or high rates of discount.

Finally, other differences among these crops are that the asparagus and the cotton are cash crops and the maize and the sweet potato are mostly food crops, required for the family and livestock consumption. This explains the fact that the priority of resource use at medium or high discount rates would go to the sweet potato and maize. However, this situation varies in each household according to composition, available resources, and activities.

Below Average Price Scenario

In this scenario, cotton would be produced in the sixth year by 30 of the households. This is compared with only 15 of the households producing cotton in the average scenario. Maize that would be produced is only for household consumption. The quantity of sweet potato produced would be drastically decreased in this model. Sweet potato would be only produced for household consumption. Asparagus production would increase from 48.83 ha in the average model to 86.92 in this model. Only two households would not produce asparagus in this model (households N° 7 & 5). Both households are large in terms of family members, have limited hectares, and little available cash. Sixty-five percent of the households would produce more than one ha of asparagus. No one in this model would produce grapes.

In this scenario, the farmers would tend to rent more land out to maximize cash coming into the household. Only one household would expand production by renting in land (household N° 42). This household has limited land, and more available labor, management resources, and cash. In this model, only nine households would have the resources to hire labor. Two households would have negative year end cash for each of the six years model (households N° 7 & 5).

Above Average Price Scenario

In this scenario, only 14 households would produce cotton in the sixth year, compared to 15 in the average model. Maize would be produced only for household consumption. More land would be used for sweet potato production following a similar trend observed in the average scenario. Less asparagus would be produced in this scenario. A total of 43.71 hectares would be devoted to asparagus production by the 60 households. Twenty-three households would produce more than one hectare of asparagus. As in the other scenarios, grapes would not be produced.

More land would be rented in this scenario and less land would be rented out, especially after the third year. Similarly, little difference would be observed in hired labor and the increasing trend of greater amounts of end of year cash. The amount of end of year cash would be greater in this model, as one would have anticipated.

# CHAPTER 5
# CONCLUSIONS AND RECOMMENDATIONS

## Production Functions

1. The analysis of cotton production functions demonstrated enormous variability among geographic zones in relation to yield and its response to fertilizers and environmental factors. This fact points out the need to make fertilization recommendations on an individual basis (geographic zone) using the production functions, according to the anticipated environmental factors. It is also recommended to complement the production function results with on-farm trials.
2. The production functions demonstrated that, contrary to common belief, higher yields are not necessarily reached with higher amounts of fertilizers. Actual recommended fertiliz0er amounts are mostly too high; they are probably based upon trails conducted on the very best soils in good years. It is suggested to recommend balanced amounts of fertilizers based on annual environmental conditions (good, fair or poor year) for each specific zone using the appropriate production functions. Lower rates could probably be recommended but should be based on on-farm research. It is also recommended to generate more production functions for other zones and other crops.
3. The production functions may become predictor tools. For example, a “poor year” anticipated, would be a “good year” for Cerro Alegre and San Francisco if

fertilized adequately. This opportunity would be much better with an anticipated better cotton price because of less Cañete total production.

4. These equations may also become risk avoidance tools. For example, in Palo Isla it would not be recommendable to raise cotton in a "poor year" or even in a "fair year" because of the low yields expected. In Quilmaná zone, where the worst results were reported, it is perhaps recommendable not to raise cotton, even in "good years."

## Linear Programming

1. Statistical comparisons of the Cañete linear programming models with the real data allowed validation of the models, indicating that the models adequately simulate the population sampled. This statistical validation process is an innovation used for first time in this investigation to the author's knowledge.
2. The diversity of the household systems of Cañete community requires individual approaches. Use of an "average household" or a "representative household" is not appropriate in drawing conclusions for the whole community. The validated Cañete linear programming models can be used to project production, income and consumption in any household in the Cañete small farmer community, maintaining the system diversity, after inputting them with household specific information. Both, the one-year and the six-year models are "interactive working models" and they can be used with confidence and in a quick and efficient manner through Visual Basic embedded programming.
3. The linear programming models (one and six years) could be applied in two different perspectives. First, the small farmer perspective, in which the linear

programming may model any particular household in any price and activity scenario to better assess household possibilities and to generate individual household recommendations. In addition, a community perspective, in which the developing agency may aggregate groups of individual small farmer models to project community responses in different scenarios.

4. Based in the linear programming simulations, household land to person index – land in hectares and number of people in household- can explain the household potential risk or potential windfall characteristics in different price scenarios. Potential risk and potential windfall are understood as the variability in incomes found in a household after simulating it in different price scenarios. Higher indexes determined higher potential risk in “bad” price years as well as higher potential windfall in “good” price years.
5. Grape is a crop recommended to all small farmers by the development agencies. This activity was analyzed in all different scenarios of the six-year linear programming model and it was demonstrated that no small farmer would be able to raise grapes and consequently this activity should not be recommended.
6. Asparagus is also a crop highly recommended to all small farmers by the development agencies. The simulation of the six-year models found out that, according to scenarios, only a relatively small segment of the population would be able to raise asparagus. The recommendation of this crop should be on an individual basis, after solving the appropriate model in the appropriate scenario. Aggregation with market purposes should also be based on the individual models rather than the model taken from the survey “average farm.”

# Extension Programming

## Introduction

The subsequent programming information is proposed as recommendation for Valle Grande Rural Institute extension work. After the previous chapter analyses along with extension analysis, the major needs of the Cañete's small farmers were identified. These needs were the baseline for programming.

## Identifying Target Publics

According to its mission and philosophy, Valle Grande has identified its target public as limited resource farmers, who have less than 12 ha of land. This includes 4,800 families. The average household consists of seven people. In total, the general target public is about 33,600 people. These farmers own 80% of the land in the Valley (18,080 ha). Most of the family members work to support the agricultural production system.

## Collaborative Identification, Assessment, and Analysis of Needs Specific to Target Publics

Based upon data collected by the researcher (sondeo, survey), supplemental data (Valle Grande Rural Institute records, records maintained by the city government of Cañete, and Peru's Ministry of Agriculture), and the researcher's knowledge and experience in the region, the following nine major extension programs are proposed:

1. Traditional Crop Management. Pest control, fertilizer application, weed control, and pesticide applications of traditional crops.
2. Adoption of New or Improved Crops. New crops with some economic advantage, when compared to traditional crops.

3. Credit and Land Ownership. Farmers must know how to obtain credit. In addition, they need to understand the relationship between land credit and ownership.
4. Commercial Marketing. Farmers need to analyze marketing elements to make wiser decisions in order to obtain higher incomes.
5. Farm Management. Farmers need to follow a sequential orderly production process based upon decisions made from clear and accurate records. The farmers must generate such data through record keeping and budgeting.
6. Legal Issues. Small farmers need to know about agricultural policies and tax law.
7. Farming Associations. Small farmers need to know how to organize themselves in associations in order to undertake common goals such as the advantage of purchasing products by scale, labor efficiency, diffusion of information and optimization of financial resources. One critical point of the associations should be to decrease crime related to the theft of crops and assets.
8. Healthy Diets. There is a need to modify the diets of small farmers to include more farm-raised products in their diets.
9. Pesticide Use and Environmental Conservation. Farmers need to decrease their dependence upon chemical pesticides and incorporate Integrated Pest Management (IPM) practices.

Design and Implementation

In order to accomplish the program macrobjectives and to achieve behavioral change it is necessary to create a general plan of work that consists of the following activities: Lectures, workshops, farm trials, formal education, informal education, mass media delivery, bulletins and brochures, seminars, contests, and educational fairs.

The planned program seeks the overall well being of the Cañete community with sustainable development reflecting individual behavior change. More specifically, the outcomes will increase the quantity and quality of the production of the main crops, better farm management practices, and successful introduction of new crops. Farmers will obtain fair prices for their commodities in the market place. The farmers will be able to make informed decisions about investments and returns. They will increase the use of bank loans. The farmers will be able to fulfill rights and responsibilities in commercial and tax aspects. The small farmers will be able to balance better their diet and they will be aware of the current environmental concerns.

Through farmers associations, they will be able to better negotiate costs, prices, obtain technical assistance, fight crime, and receive mutual benefits. They will be able to build a sustainable community through the development of common values, norms, and rules without affecting the freedom to express themselves.

Implementing the Planned Program

The specific planned programs are presented below. For each of them, there is a descriptive title, the program purpose, the program justification, and the program significance. Target audiences and specific objectives are also included.

Developing Plans of Action

Cañete first major program: improvement of traditional crop management (cotton, sweet potato, and maize).

This program will help Cañete's farmers to manage adequately the traditional crops. Annually, according the sondeo and survey, Cañete produces 10,000 ha of cotton, 3,800 ha of sweet potato, and 3,600 ha of maize. About 80% of this production is by small farmers who produce on average 60 cwt. of cotton, 15 ton of sweet potato, and 4 ton of maize per hectare. These yields could greatly be improved by the adoption of more appropriate management practices.

The preferred situation would be higher in both quality and quantity of the traditional crops yields that permit small farmers a fair return. The previous analysis of cotton production function showed the need to make fertilization recommendations on an individual basis (geographic zone) using the production functions, according to the anticipated environmental factors to obtain higher yields. More production function development is proposed to analyze yields in maize and sweet potato and to analyze other zones in cotton.

The traditional crop activities should be recommended in a household after analyzing this, in different scenarios, on an individual basis through linear programming; it will allow optimum resource use in each household.

The diffusion of appropriate crop management practices will allow higher levels of productivity.

The targeted audience includes around 960 growers who have, on average, less than US$ 800 annual income. They represent about 5,000 ha. Eighty percent of them are males and the 20% are females. These farmers are 40 years and older.

The small farmers will reach, in a four-year period, an average production for cotton, 70 cwt., sweet potato, 20 ton, and maize, 5 ton. According to researcher experience, the harvested quality of these three crops could be 10% better. The goal is to provide growers with information about pesticide application, weed control, pest control, and fertilizer application. The following activities are proposed:

a) Weekly radio course for crop management. It will be broadcast, for one hour, every Sunday morning on South Star radio and it will include specific topics in pest control, crop nutrition, weed control, etc.
b) Seminars of cotton management. Two seminars, one in August and the other in February. The first seminar will deal with the planting, irrigation, first stages of pest control, and particular fertilization practices according the cotton production function. The second seminar will deal with *Pectinophora gossipiella* (pink worm) control and harvesting recommendations.
c) Seminars of maize management. There will be two maize seminars, one in summer (January), and the other in winter (June). The summer seminar will refer exclusively to the maize variety *Cargill 404* and the winter seminar will refer to the maize variety *Cargill 606*. The seminars will include soil preparation, planting, pest and disease control, and crop nutrition.
d) Workshops for weed control. Two workshops, one in October, the other in March. The October workshop will emphasize weed identification and mechanical and cultural weed controls. The March seminar will emphasize chemical weed control.
e) Fertilization demonstration in cotton and sweet potato. Follow-up between August and April in three different farms one in the upper zone, another in the middle zone and the last in the lower zone of the Valley. The demonstrations will be held the last Saturday of the month.
f) Course on plant nutrition (cotton, sweet potato, and maize). Sixty hours (twenty per crop) in a course that will include lectures, visits, practices, demonstrations, and laboratory. It will be held any time between May to July.

<u>Cañete second major program: introduce new crops (horticultural, fruits, and annual crops).</u>

This program will promote new crops to Cañete's farmers that will better suit the farmer's environments. Cañete’s traditional crops, cotton, sweet potatoes, and maize may not be the most economical crops for all the small farmers. Cotton is a secure but low profit crop, which requires about nine months to be harvested. Cotton production functions showed for example that in some zones this crop should not be recommended because of very low anticipated yields. Maize and sweet potatoes are high-risk crops because of pests and prices. The small farmers’ income may be greatly improved by the adoption of different crops.

The low resource farmers preferred situation would be to raise new crops in order to obtain higher benefits, but as displayed by the linear programming analysis, such decisions are on an individual basis. Some of the new crops might be asparagus, chilies, broccoli, cabbage, squash, and pumpkin. New varieties of tomato, cotton, maize, and potato should also be considered. Fruits crops such as seedless grapes, *annona cherimolia*, *lucuma*, and avocado are also alternatives. Before recommending any of these new crops, the extension office will analyze the multiple options in each household linear programming model in order to find the best combination for each farmer's conditions.

The new crops to be recommended should be first tested. Local research must be conducted through on-farm trials. The diffusion of new crops will allow production of more diverse commodities in the community that may result in higher profits for all farmers because of less risk in decreasing prices. Decreases in prices are commonly associated with over-production of traditional crops.

The targeted audience includes around 600 farmers who have, on average, more than US$ 3,600 annual income. They represent about 4,500 ha. Seventy-five percent of them are male and the 25% are female. These farmers are 55 years and older.

These small farmers will adopt at least one new crop on their farms within a four-year period. The following activities are proposed:

a) Workshops for new crops. Three workshops –September, February, and May. The first workshop will be about new vegetable crops, the second will deal with annual crops, and the May workshop will be about fruit crops. Each workshop will include guest speakers, lectures, classes, group discussions, and on-farm visits.
b) Field days. Every two months, on the first Saturday of the month, groups of farmers will visit neighboring Valleys (Chincha, Ica) and interview innovative farmers about the introduction of new crops.

c) Newsletters. On a monthly basis, newsletters will be produced with specific information of new crops suitable for the Valley. The newsletters will be delivered directly to the target audience together with invitations to the other activities.
d) Learning trip. Once a year, in the summer, one trip to the third region of Chile will be organized. There should be at least twenty participants and two facilitators. The round trip should take about one week. It will be video-recorded and one week after the trip a meeting will be held with the target audience to discuss the findings.
e) Individual assistance. The office of entrepreneurial development of Valle Grande will analyze each household with the linear programming model before starting any new crop program. This office will be established on a permanent basis.

Cañete third major program: credit administration

The overall program purpose is to increase farm credit for production activities. According to the sondeo and survey, less than 70% of Cañete growers receive formal credit. In many cases the greatest barrier is the lack of property titles (15% of the farmers do not have property title).

The preferred situation would be that 100% of the clientele obtain property titles and at least 90% of the farmers receive credit from banks. One critical limited resource found in the linear programming analysis was the lack of credit. In fact, the simulation showed that eight out of ten small farmers have credit constraints. Credit will improve the farmer’s financial status, increase productivity, and generate more wealth to the whole system.

The targeted audience will be small farmers without farm property title and farmers who do not work with bank credit. This population represents about 3,000 hectares (600 farmers). Of this group, 65% are male and 35% are female, with an average age of 48.

The major program objective (4 years) will be to assist three hundred small farmers in obtaining property titles and the whole targeted audience in obtaining bank loans, resulting in at least 90% of the targeted audience obtaining formal credit.

In order to undertake the program objectives the following activities are proposed:

a) Property title obtainment workshops. On a monthly basis, these workshops will be held at the Valle Grande facilities. They will be programmed for the second Tuesday afternoon of the month and will include both private and governmental legal assistance.
b) Establish an Office of Property Title assistance. It will operate in Cañete one day a week (Fridays). An attorney will be hired to provide legal services for that office.
c) Agricultural credit workshops. Two workshops per year at the start of each crop season (August and April). They will be held in a banking institution and conducted by bank employees. Valle Grande would be only a facilitator.
d) Credit application assistance. Small farmers will be provided assistance in completing credit applications in the office of entrepreneurial development (Valle Grande).

Cañete fourth major program: marketing for Cañete growers

Prices for traditional crops range from, cotton S/. 68 to 121.5 /qq., sweet potato S/. 0.08 to 0.45/kg, and maize S/. 0.43 to 0.90/kg as analyzed in the linear programming, based upon information obtained in the sondeo and survey.

According data gathered in the survey, acceptable prices perceived for the small farmers should be, at least: S/. 90 for a qq of cotton, S/. 0.18 for a kg of sweet potato, and S/. 0.55 for kg of maize to compensate the production costs and obtain reasonable benefits.

In order to obtain fair prices for these products, the farmers must gain marketing skills. Such skills include avoiding high risks by predicting prices, interpreting and managing marketing information, and negotiating with intermediaries.

The targeted audience will be small farmers with an annual income less than US$ 2,000. Growers with this income represent about 11,000 hectares (1,600 farmers). Sixty-five percent is male and 35% female; the average age is 58 years.

The major program objective will be to increase annual income by 15%.

In order to undertake the program objectives the following activities are proposed:

a) Marketing short courses. They will be held four times a year (October, January, April, and July) in the Valle Grande facilities. Each course will deal with a specific topic. The first course will be on price and area planted analysis; the second course will teach the different commercialization chains; the third course will be about the farmer-intermediary negotiation options; and the last course will include commercialization opportunities for the farmers.
b) Visit to marketplaces. Four visits to four markets will be coordinated. These visits will take a day on the following months November, February, May, and August. These visits will be to the horticultural market in Lima, the fruit market in Lima, the market in Ica, and the market in Chincha. In each visit, there will be two lecturers: the market chair and the intermediaries' association president.

<u>Cañete fifth major program: apply farm management techniques</u>

Data from the sondeo and survey revealed that less than 10% of low resource farmers keep records on their daily activities; less than 5% of small farmers make decisions based upon budgeting, and less than 1 % of them analyze their own data for decision-making purposes.

Information is important. For example, more production functions (other crops or cotton in other zones) could have been generated if more information were available. One evaluation objective for this program is that at least 20% of the farmers keep accurate records and make budgeting decisions based upon such records. This program will result in improved participants, who will ultimately benefit the entire valley.

The targeted audience will be all small farmers in the Cañete community. They represent about 22,600 hectares (4,800 farmers). A four-year goal is that a thousand farmers will keep records on their daily labor, and be able to effectively apply budgeting in advance, and two hundred farmers will use management analysis on their farms.

In order to undertake the program objectives the following activities are proposed:

a) Administration workshops. These workshops will be held each Thursday afternoon in the Valle Grande facilities with the participation of the extension and entrepreneurial offices. The workshops will be similar in content and they will emphasize the need to keep daily records for all household activities. The workshops will include group work to apply the knowledge.
b) Publication of daily records. Valle Grande will help the small farmers by publishing real samples of daily records of representative farmers. The publications should include detailed listing of items to include and instructions of how to manage the system.
c) Radio promotion. On the local radio station, South Star, there will be advertisements three times a day to encourage the farmers to keep daily records. These advertisements will emphasize the need to keep records and publicize Valle Grande record keeping services.
d) Billboards. Three strategic billboards will be installed on major roadways. They will show the benefits to keeping records.

Cañete sixth major program: agricultural legal issues

The main purpose is to educate small farmers about government agricultural policies and tax issues. The survey pointed out that only 5% of the small farmers are familiar with essential agricultural policies, and less than 2% are registered taxpayers.

The farmers should understand essential agricultural policies and apply them in their daily work. Small farmers should start the unavoidable process to register as taxpayers. Currently all the farmers are encouraged to register as taxpayers by the government, although they will be exempt from taxes. Farmers who fail to register are not allowed access to certain markets.

The improved knowledge and skills in agricultural policy will permit better decisions along with more adequate commercial transactions. Becoming aware about tax topics will prepare farmers with tools and skills to deal with tax issues that will be critical in the subsequent years.

The targeted audience will include all Cañete small farmers (4800). In four years, 20% of small farmers will make business decisions based on current agricultural policy, and 10% will be registered as taxpayers.

In order to undertake the program objectives the following activities are proposed:

a) Weekly newspaper stories about agricultural policy issues. They will be delivered in the entertainment section of the most diffused newspapers in the community (Day to Day Cañete and Cañete News). They will be multiple-part stories of some fictitious household about its experiences with legal topics. In addition to a legal focus, agricultural policies and tax topics will be discussed.
b) Daily radio program on legal topics. A program called "Smart Farmers" will be produced in a daily basis in the South Star station. It will include interviews with government representatives and it will be interactive with a question and answer segment.
c) Biannual exhibitions at regional fairs. The two major festivities of the Cañete community, Cañete Foundation Celebration (August) and Cañete Christmas (December) will be used to display vast information about agricultural policies, commercial agricultural laws, and tax issues. The fair exhibitions will be coordinated with the official government agencies.
d) Handouts and brochures. These will include a summary of successes in the topics of agricultural policies and tax issues.
e) Monthly newsletters. There will be a database of the small farmers. It will be used to deliver the newsletters. The newsletters will include summary information of the monthly handouts.

Cañete seventh major program: organize farmers in strong associations

The purpose of this program is to promote farmers' associations of cooperation that enhance the well being of their household activities. The survey data revealed that fewer than seven percent of the small farmers participated in organizations or associations of any type in the community. Consequently, the small farmers have very little power in the community decision-making process. Small farmers do not have many organizational groups, although some organizations that do exist are not successful.

Because of that, farmers have to deal individually when purchasing farm inputs or selling farm products.

The establishment of strong community organizations will permit a series of advantages:

1. Obtain low cost of production through scale economies.
2. Better production by mutual help among members.
3. Better prices in commercial transactions.
4. Reduce the amount of theft in the community.

With the establishment of organizations, farmers will obtain stronger positions to influence government policies, deal with intermediaries, purchase commercial services, and the like. The organizations will improve the small farmers' economies and therefore improve the quality of living. In fact, the linear programming analysis found critical binding factors that could be resolved through strong associations.

The targeted audience will be all the small farmers (4,800). The four-year objective of this program is that at least 20% (960 small farmers) of the target audience will participate in at least in one purposive organization.

Farmers will receive information on how to establish an organization. There will be four organizations established to serve as models. Each organization will have at least 20 members. The first group will exist to promote the production of a certain crop. The second organization will be established to prevent crop theft. The third association will exist to bargain for lower production inputs. The last one will negotiate better prices for common products on the market.

In order to undertake the program objectives the following activities are proposed:

a) Workshops about Community Organizations. There will be 12 workshops, one per month. They will be held the first Wednesday morning of each month in the Valle Grande facilities. The topics will include the different organizations' policies, the successful organizations in agriculture, purposes of the organizations, etc. The Extension office will organize and deliver those meetings with some government help.

b) Short courses about community organizations. There will be two short courses, one in February and the other in April. They will be conducted specifically to establish new organizations. The motivated people of the workshops will be invited to participate in these short courses.
c) Monthly demonstration results bulletin. A monthly bulletin will be published containing exclusive information on current organizations.
d) Monthly farmers' newsletters and brochures. They will contain mostly motivational aspects to promote the creation of new organizations.

Cañete eighth major program: learn healthy and affordable nutrition practices

This program will teach Cañete's farmers to practice healthy and affordable nutrition practices. The survey revealed that, in general, the small farmers spend a large part of their budget to purchase food. It is common to consume industrialized products such as wheat derivatives, canned milk, and the like and not their own farm products. These industrialized products are more expensive than farm-produced products. It is common knowledge that they do not eat a balanced diet.

The preferred situation is a higher consumption of farm-produced products, such as maize, sweet potatoes, potatoes, milk, etc. contributing to a more healthy diet.

The targeted audience includes the more deprived small farmers, around 960 growers who have, on average, less than US$ 800 annual income. They all represent about 5,000 ha.

These small farmers will realize a 40% decrease in food household expenses, in a four-year period.

In order to undertake the program objectives the following activities are proposed:

a) Daily advertisement in radio. It will promote Cañete products. The radio will be South Star and the campaign will emphasize in the benefits of the own products. The general idea will be revalue the local products in the minds of farmers.

b) House nutrition counseling. A team of five women, specifically hired for that purpose, will deliver knowledge directly to the households. They will visit four households a day and they will talk mostly with the household women. They will explain and demonstrate how to prepare nutritious meals with local products.

c) Handouts of recipes. The Extension office will publish on a monthly basis a handout of balanced meals with local products. The recipes will be delivered taking advantage of other correspondence of Valle Grande and its clientele to five hundred small farmers each month.

<u>Cañete ninth major program: decrease pesticide use and increase environmental awareness</u>

According to the sondeo and the survey, small farmers control pests primarily by chemical applications. There is a need to make the farmers more environmentally sensitive. There is an overuse of pesticides. Many small farmers expressed a concern with increasing pest resistance to chemical controls. About forty percent of small farmers seek pesticide assistance from chemical retailers.

The preferred situation would be to decrease the dependence of chemical use and adopt Integrated Pest Management (IPM) practices. It is also desirable to promote environmental conservation not only in the pesticide rationale but also in many other aspects such as water management, soil conservation, air pollution, and the like.

To increase the small farmers' awareness of environmental issues is critical in the sustainable development of the whole community. The knowledge, attitude, and behavior toward environmental protection will allow the small farmers to continue in business for subsequent generations.

The targeted audience will be all the small farmers (4,800). A four-year goal is to decrease pesticide use by 25%.

In order to undertake the program objectives the following activities are proposed:

a) Video presentations. On a monthly basis, Valle Grande will present a video of ecological disasters. After the presentations, there will be a discussion and a dramatization of the case applied to the Cañete community. It will be expected that two hundred small farmers will attend each presentation.
b) Television advertisements. They will be coordinated and funded by the government through the Agricultural Ministry in their conservation campaign. The advertisements will encourage the farmers to decrease pesticides use and conserve resources.
c) Integrated pest management program. Valle Grande will create an agreement with the La Molina Agrarian University and the Agricultural Ministry to promote integrated pest management in the Valley. The program will include courses, workshops, demonstrations, and direct counseling.

APPENDIX A
CAÑETE VIDEO

There is a short video showing images of the Cañete community and it can be downloaded by clicking.

video.avi, size: 5,828 KB

APPENDIX B
SURVEY QUESTIONNAIRE

The survey questionnaire is a Microsoft ® World 97 SR-1 document. It can be downloaded by clicking.

questionnaire.doc, size: 84 KB

APPENDIX C
SURVEY DATA

The survey data are contained in a Microsoft ® Access 97 SR-1 database. It can be downloaded by clicking.

(Use Microsoft Explorer 4.01 or above).

surveydata.mdb, size: 588 KB

APPENDIX D
PRODUCTION FUNCTION DATA

The production function data are contained in a Microsoft ® Excel 97 SR-1 file. It can be downloaded by clicking.

(Use Microsoft Explorer 4.01 or above).

function.xls, size: 215 KB

## APPENDIX E
## LINEAR PROGRAMMING MODELS

The one-year and six-year linear programming models are contained as Microsoft ® Excel 97 SR-1 files. They can be downloaded by clicking the locations below. (Note: Both files have *Visual Basic* programming. As a consequence, you may need to enable macros if the software asks about it).

(Use Microsoft Explorer 4.01 or above).

oneyear.xls, size: 210 KB

sixyear.xls, size: 337 KB

## LIST OF REFERENCES


Bennett C., & Rockwell K. (1995). Targeting outcomes of programs (TOP): An integrated approach to planning and evaluation. [On-line]. Available: http://www.okstate.edu/ag/agedcm4h/academic/aged6220/6220class/6220class/tops.htm

Boone, E. J. (1985). Developing programs in adult education. Illinois: Waveland Press Inc.

Cabrera, V. E. (1997). Ciprian Melendez farm analysis case. [On-line]. Available: http://www.fortunecity.com/meltingpot/robson/360/cmlp.doc

Chambers, R. (1992). Rural appraisal: Rapid, relaxed and participatory. Brighon, England: Institute of Development Studies at the University of Sussex.

Davis, J. A. (1971). Elementary Survey Analysis. New Jersey: Prentice-Hall, Englewood Cliffs

Debertin, D. L. (1986). Agricultural production economics. New York: MacMillan Press.

De los Santos, S., & Norland, E. V. T. (1990). Use of Bennett's hierarchical model in the evaluation of the extension education program for cacao farmers in the northeast region of the Dominican Republic. [Abstract]. Educational Resources Information Center, 1, 13.

DeWalt, B. R. (1985). Anthropology, sociology, and farming systems research. Human Organization Journal, 44, 2, 106-114.

Franzel, S. C. (1984). Planning an adaptive production research program for small farmers: A case of study of farming systems research in Kirinyaga District, Kenya. Farming Systems Research and Extension Symposium. Manhattan, Kansas.

Hildebrand, P .E. (1976). A multi-disciplinary methodology for generating new technology for small, traditional farmers. Guatemala : Instituto de Ciencia y Tecnologia Agrícolas, ICTA, Sector Público Agrícola.

Hildebrand, P. E. (1997). Graphical display and regression analysis: Draft for discussion. [Mimeograph] Gainesville: University of Florida

Hildebrand, P .E., & Araújo A. A. (1997). Introduction to linear programming. Gainesville, USA: The Florida Book Store.

Hildebrand, P. E., & Russell, J. T. (1996). Adaptability analysis: A method for the design, analysis, and interpretation of on-farm research-extension. Ames, Iowa: Iowa State University Press.

Hildebrand P. E., & Waugh, R. K. (1982). Farming systems research and development. In P. E. Hildebrand (Ed.), Perspectives on farming systems research and extension (pp. 12-15), Boulder, Colorado: Lynne Rienner Publishers.

Instituto Rural Valle Grande (Valle Grande Rural Institute). (1997). Informe anual 1997 (1997 annual inform). Lima, Peru: Latin Graf S.R.L.

Ministerio de Educación del Perú (Peru's Education Ministry). (1998). Estadisticas educativas en Cañete (Educational statistics in Cañete). [Brochure]. Lima, Peru.

Norman, D. W. (1982). The farming systems approach to research. Farming Systems Research and Extension Symposium. Manhattan, Kansas.

Pfeffer, M. J., & Gilbert, J. (1989). Federal farm programs and structural change in the 1980s: A comparison of the Cornbelt and the Mississippi Delta. Rural Sociology Journal, 54, 4, 551-567.

Poats S. V., Schmink M., & Spring A. (Eds.). (1988). Gender issues in farming systems research and extension. Boulder: Westview press.

Rhoades R. E., & Bidegaray P. (1987). The farmers of Yurimaguas : Land use and cropping strategies in the Peruvian jungle. Lima, Peru : International Potato Center.

Rossi, P. H., & Freeman H. E. (1985). Evaluation: A systematic approach. (3rd ed.). London: Beverly Hills.

Sandhu, H. S., & Allen, D. E. (1974). The village influence on Punjabi farm modernization. American Journal of Sociology, 79, 4, 967-980.

Sapp, S. G., & Jensen, H. H. (1997). Socioeconomic impacts on implementation and confirmation decisions: Adoption of U.S. beef in Japan. Rural Sociology Journal, 62, 4, 508-524.

Zandstra, H. G. (1983). An overview of farming systems research. Farming Systems Research and Extension Symposium. Manhattan, Kansas.

## BIOGRAPHICAL SKETCH

Victor E. Cabrera was born on February 9, 1969, in the city of Cusco, Peru. He received his bachelor's degree in agronomy from La Molina Agrarian University, in Lima, Peru, in 1993. The same year he was graduated as Engineer in Agronomy from La Molina Agrarian University, Lima, Peru. In 1995, he received a post-graduate diploma in management of agricultural schools, in Spain and France.

Victor E. Cabrera has been working as Professor and Change Agent in the Valle Grande Rural Institute, Cañete, since February 1994.

http://www.fortunecity.com/meltingpot/robson/360