LINEAR PROGRAMMING: ITS APPLICATION IN THE PHILIPPINES

by

HERMINIGILDO MONTEMAYOR MONTALVO

B.S.C., Philippine College of Commerce, 1973

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Agricultural Economics

Department of Economics

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1979

Approved by:

Major Professor

ACKNOWLEDGEMENTS

Deepest appreciation is expressed to the Integrated Agricultural Production and Marketing Program (IAPMP), a Kansas State University-Philippine government project, for providing me the opportunity to pursue post graduate studies.

Acknowledgements and sincere thanks are due Dr. David W. Norman, major professor, for his advice and assistance during the study.

The author also wishes to express his gratitude to Drs. Orlan H. Buller and John H. McCoy, committee members, for their valuable suggestions and constructive criticisms in the preparation of this manuscript.

My most special gratitude is reserved for my beloved fiancee, Luming, for her constant encouragement and patience.

To my dear parents, the late Dr. Amado A. Montalvo and Mrs. Francisca M. Montalvo, this piece of work is heartily dedicated.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

LIST OF SOLUTIONS

INTRODUCTION

The problem of allocation of resources which is the foremost production economics problem, faces all organizations in one or more forms. For ages, man has been searching for the most effective means of allocating his resources to achieve his goals one of which is to maximize profits out of a set of available resources. In the field of agriculture, the problem of what crop to plant is first in a farmer's list of priorities. In general, net returns or yields are used as basis in making farm decisions about what crops to plant. Of the two, net returns is considered a better gauge since high yield does not always result in high net return.

Most studies and research in the Philippines use net return as basis in comparing the relative performance of one enterprise with another. A good example is the study "Comparative Input, Output and Financial Data for Virginia Tobacco, Palay, Mongo, Corn and Cotton in the Ilocos Region" conducted by the marketing analyst of the Special Studies Division of the former Department of Agriculture (now Ministry of Agriculture). This study was done yearly from 1975-77. Net returns were used to compare the performance of cotton with other dry season crops such as palay (rice), corn, mongo (mungbean), and Virginia tobacco. While the results of this study offer a good ground for comparison, another method like linear programming can be employed to obtain better results. This method provides an efficient mathematical way of determining an optimal strategy when there are numerous alternative methods which may be followed in seeking certain goals and the situation is clouded because various courses of action are interrelated by a number of restrictions and constraints. While it is true that the net return approach and linear programming techniques are similar in purpose, i.e., both are concerned with the economic concept of profit maximization, linear programming allows a more complete analysis than the net return approach.

This paper will deal with the application of linear programming techniques to the study mentioned earlier. Comparisons will be made to determine if linear programming is really better than net return in analyzing such data.

A. Importance of the Study

In the Philippines, net return is generally used as basis in relating performance of two or more enterprises. This approach is limited to the analysis of the contributions made by one resource, which in most cases is land, e.g., net return per unit of land. It is assumed that the only resource fixed in amount is land while others such as labor, capital, etc... can be decreased or increased in unlimited proportions. In this case, the contributions made by capital and labor are being ignored. Moreover, the most profitable organization has been found without considering the possibility of going into a combination of two or more enterprises which allows an efficient use of the available resources and at the same time gives higher return.

The linear programming approach is applicable to situations which have many possible alternatives each with different constraint. The author believes that the use of this method will be very useful in guiding farmers as well as government or private agencies in making sound individual or group farm decisions.

B. Objectives

This report is a study of how linear programming can be used in agriculture. The primary objective is to compare results from using linear programming with that of the net return approach in a study of the most profitable crop on farms in the Philippines. It also proposes applications of linear programming techniques to other similar studies conducted and to be conducted in the future.

The other objectives are as follows:

1. To analyze the data in the cited study,
2. To determine other uses of linear programming techniques on data in the Philippines,
3. To formulate criteria as bases for the collection of data necessary in building a workable and a more realistic linear programming model and to identify problems which may be encountered in collecting such data,
4. To determine the limits of the use of linear programming.

C. Limitations of this Study

This paper is limited to the analysis of data presented in the study "Comparative Input, Output and Financial Data for Virginia Tobacco, Palay, Mongo, Corn and Cotton in the Ilocos Region". Due to the unavailability of some data, assumptions were made to show how linear programming can be used. However, a more realistic application of linear programming is advocated for solving problems in the Philippines.

CHAPTER II

A REVIEW OF THE STUDY[1]

A. Objectives

The "Comparative Input, Output and Financial Data for Virginia Tobacco, Palay, Mongo, Corn and Cotton in the Ilocos Region" is a yearly survey undertaken by the Special Studies Division of the Ministry of Agriculture, Republic of the Philippines, primarily to determine the profitability of growing cotton over other crops such as Virginia tobacco, palay, corn and mongo and to know the crop and situations with which cotton can compete effectively. The results serve as guide to the Philippine Cotton Corporation, a semi-government corporation in charge of overseeing the production of cotton in the country, in planning for the yearly expansion of area for cotton growing.

B. Procedure

Farmers in the Ilocos Region planting any of the five dry season crops such as Virginia tobacco, corn, cotton, rice and mungbean, were randomly selected and interviewed: 300 in 1975, 515 in 1976 and 500 in 1977 (Table 1). Primary areas considered were those located in or near the major cotton producing parts of the region. The same procedure was used each year.

C. Area Covered

The area covered by this study is the Ilocos Region, one of the twelve regions in the Philippines. It is located in the northwestern part of the Luzon Island (Figure 1) and is composed of five provinces

---

[1]All data shown in this analysis have been converted to "per hectare basis" in order to adjust for differences in size of enterprises.

TABLE 1

NUMBER OF FARMS SURVEYED, SSD*
ILOCOS REGION

Year and Farm Classification	Cotton	Tobacco	Corn	Mungbean	Rice	Total
1975						
Low	20	20	20	20	20	100
Medium	20	20	20	20	20	100
High	20	20	20	20	20	100
Total	60	60	60	60	60	300
1976						
Low	34	36	29	35	41	175
Medium	33	34	31	33	40	171
High	33	30	32	33	41	169
Total	100	100	92	101	122	515
1977						
Low	60	27	27	27	27	168
Medium	60	27	28	27	27	169
High	60	26	25	26	26	163
Total	180	80	80	80	80	500

* Special Studies Division, Ministry of Agriculture, Philippines

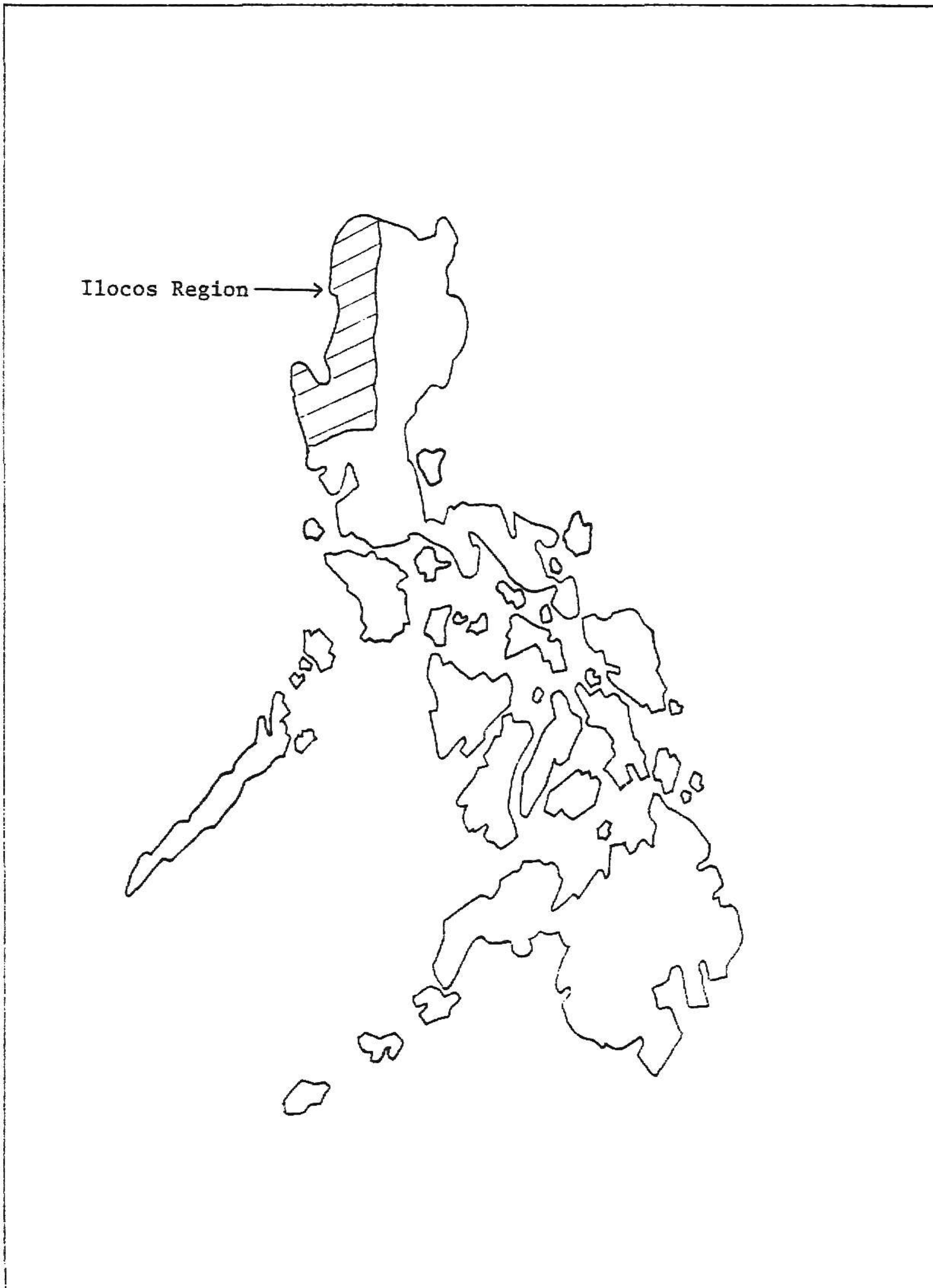


Figure 1 - Map of the Philippines Showing the Ilocos Region

namely, La Union, Pangasinan, Abra, Ilocos Norte and Ilocos Sur. In the crop year 1976-77, 2526[2] hectares of land in this region were planted to cotton which was 90% of the total area planted to this crop in the whole country. Despite the fact that rice is the main staple food in the area, most of the land is utilized in growing cotton and tobacco, making the region the nation's major producer of these crops.

There are two cropping seasons in the area as shown in Table 2, namely, rainy and dry seasons. The rainy season starts in May and ends in October while the dry season begins in November and ends in April. The first crops or those grown during the rainy season are planted from April to September and harvested from July to January. Planting of the second crops or those grown in the dry season takes place from August to March while harvesting is from October to August.

Figure 2 shows the planting calendar of the region for the crops included in this study. Since cotton is a dry season crop and the primary objective of the study is to compare the performance of cotton with other dry season crops, it is imperative that all information regarding crop situation in this study deal with dry season farm operations only so as not to confuse with rainy season crops.

D. Analysis of the Surveys

1. Production

Farms were classified based on yield per hectare as low-, medium-, and high-yield farms (Table 3). Yield varies widely among the crops. Based on the average, the biggest variation was observed in rice while

---

[2]Based on the 1977 Report of the Philippine Cotton Corporation.

TABLE 2

PLANTING AND HARVESTING DATES, 500 FARMS,
ILOCOS REGION, SSD SURVEY, 1975-1977

Crop	Planting Date	Harvesting Date
First Crop		
Irrigated		
Palay	May - August	September - December
Corn	April - September	July - November
Peanuts	May - June	August - October
Rainfed		
Palay	May - September	August - January
Corn	May - August	August - November
Peanuts	May - June	August - September
Vegetables	June - July	August - September
Second Crop		
Irrigated		
Palay	September - January	December - April
Mungbean	November - March	January - May
Corn	October - February	January - May
Tobacco	September - January	January - May
Cotton	October - January	February - May
Vegetables	September - January	July - August
Root Crops	January - February	July - August
Peanuts	November - December	February - April
Rainfed		
Palay	November - December	February - March
Mungbean	August - March	October - May
Corn	October - January	January - April
Tobacco	September - January	January - May
Cotton	August - December	December - May
Vegetables	September - January	November - May
Root Crops	January - February	July - August

DRY SEASON

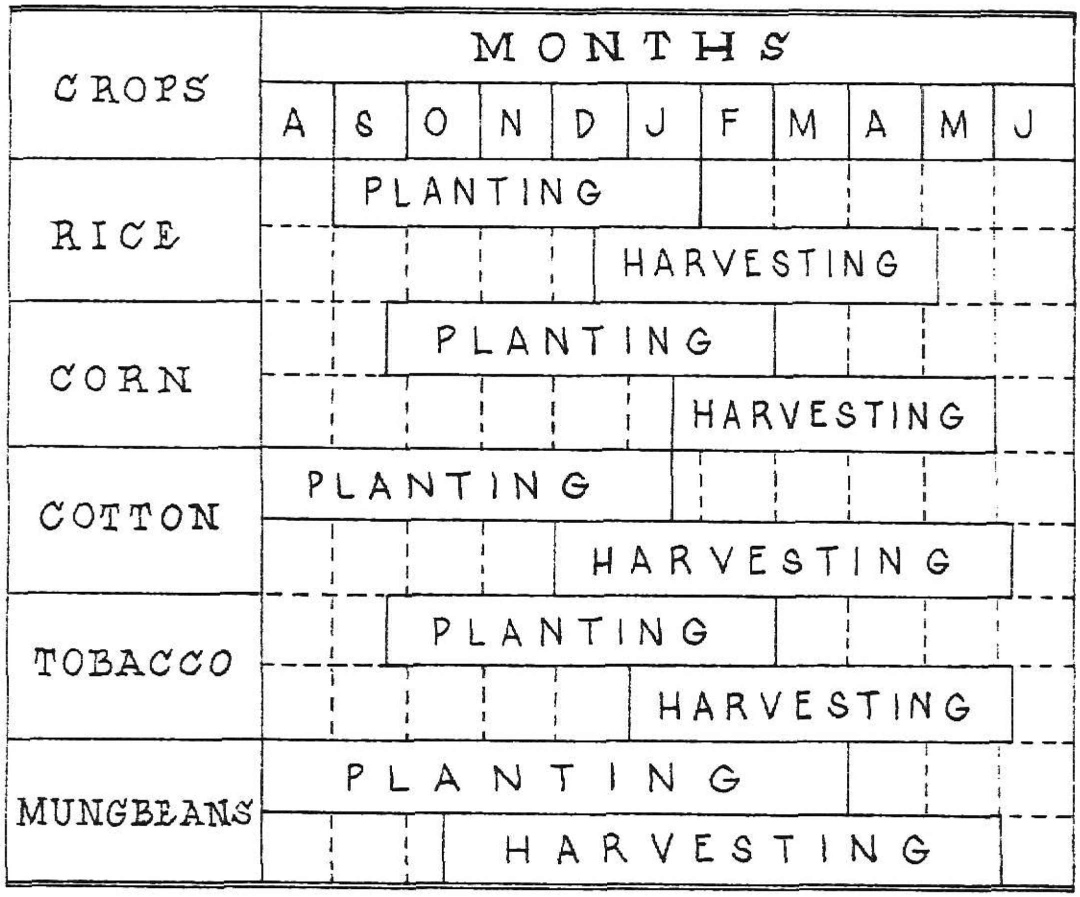


Figure 2. - Planting Calendar of Five Selected Crops in Ilocos Region

TABLE 3

AVERAGE PRODUCTION PER HECTARE
SSD SURVEYS, ILOCOS REGION
(IN KILOGRAMS PER HECTARE)

Year and Farm Classification	Cotton	Corn	Tobacco	Mungbean	Rice
1975					
Low	453.6	330.0	608.3	114.4	1175.0
Medium	977.0	650.0	1053.1	277.7	2335.0
High	1760.4	1205.0	1611.4	559.2	3535.0
Average	998.1	890.0	984.8	332.2	2310.0
1976					
Low	247.8	270.0	373.1	170.9	1400.0
Medium	651.9	640.0	725.6	313.7	2225.0
High	1218.8	1575.0	1234.7	537.4	3690.0
Average	712.9	810.0	670.9	335.0	2325.0
1977					
Low	281.6	290.0	604.6	209.1	1415.0
Medium	712.0	840.0	928.9	337.6	2520.0
High	1437.4	1475.0	1583.4	653.0	4215.0
Average	860.06	808.33	969.23	352.56	2501.11

the smallest was in mungbean. These variations in each crop may be attributed to differences in cultural practices, e.g., proper scheduling of planting, application of fertilizer and insecticide, proper spacing, etc... Climatic and soil conditions may have also contributed to such results.

2. Size of Farms

Among the farms included in the study, the biggest area was planted to rice and the smallest to tobacco (Table 4). As the size of farm increased, the corresponding yield per hectare decreased which shows a negative correlation between farm size and yield except for corn farms. This may imply that smaller farms are better maintained and supervised than bigger ones but availability of labor, capital and other limiting resources may have affected such results.

3. Tenure Status

Most farmers were share-tenants, that is, they paid their landlord a certain percentage of their produce. Others owned their farms while a small percentage were on a leasehold agreement (Table 5).

4. Labor Usage

The amount of labor used on each crop differed each year for each farm class (Table 6). For a better comparison of the amount of labor used for each crop, farm operations were placed under three stages:

Stage 1 - includes all activities before planting, i.e., seedbed preparation, land preparation, basal fertilizer application, etc...

Stage 2 - includes all activities from planting to pre-harvesting such as transplanting, weeding, spraying, etc...

TABLE 4

AVERAGE LAND AREA GROWN TO EACH CROP
SSD SURVEYS, ILOCOS REGION
(IN HECTARES)

Year and Farm Classification	Cotton	Corn	Tobacco	Mungbean	Rice
1975					
Low	.79	.36	.71	.61	.87
Medium	.70	.47	.48	.54	.84
High	.58	1.00	.39	.52	.79
Average	.69	.61	.53	.56	.83
1976					
Low	.53	.74	.67	1.08	.93
Medium	.58	.61	.46	.94	.83
High	.58	.61	.37	1.03	.69
Average	.57	.65	.51	1.02	.82
1977					
Low	.63	.83	.80	.49	.93
Medium	.54	1.18	.67	.47	.80
High	.44	.90	.64	.47	.56
Average	.54	.98	.70	.48	.76
3-year Average					
Low	.65	.64	.73	.73	.91
Medium	.61	.75	.54	.65	.82
High	.53	.84	.40	.67	.68
Average	.60	.74	.56	.68	.80

TABLE 5

TENURE STATUS, SSD SURVEYS, ILOCOS REGION
(IN NUMBER AND PERCENTAGE)

Crop and Tenure	1975		1976		1977	
	No.	%	No.	%	No.	%
Cotton						
Owner	32	53	40	40	65	36
Share-Tenant	27	45	51	51	85	47
Part-Owner	1	2	5	5	16	9
Leasee	-	-	4	4	14	8
Total	60	100	100	100	180	100
Corn						
Owner	19	32	47	51	34	43
Share-Tenant	29	48	36	39	37	46
Part-Owner	12	20	8	9	2	2
Leasee	-	-	1	1	7	9
Total	60	100	92	100	80	100
Tobacco						
Owner	26	43	54	54	19	24
Share-Tenant	28	47	38	38	49	61
Part-Owner	-	-	2	2	8	10
Leasee	6	10	6	6	4	5
Total	60	100	100	100	80	100
Mungbeans						
Owner	20	33	21	21	22	28
Share-Tenant	39	65	77	76	54	67
Part-Owner	-	-	3	3	-	-
Leasee	1	2	-	-	4	5
Total	60	100	101	100	80	100
Rice						
Owner	19	23	37	30	34	43
Share-Tenant	45	75	59	49	37	46
Part-Owner	1	2	15	12	2	2
Leasee	-	-	11	9	7	9
Total	60	100	122	100	80	100

Stage 3 - includes all harvesting and post-harvesting processes like harvesting, bailing, storage, packaging, delivery, etc...

Table 6 shows that in most cases, there is a positive correlation between labor and yield. The average amount of labor used for each crop is presented in Table 7 which shows that tobacco growing required the biggest amount of labor amounting to 215.90 man-days while mungbean needed 46.79 man-days. Cotton, rice and corn growing used 155.71, 106.89 and 54.51 man-days of labor respectively.

Farmers planning to grow any of the five crops included in the study may consider the following information. As Table 7 indicates, more labor is used in cotton farms from November to January; corn too required more labor in November and December. The most critical period in tobacco growing as far as labor is concerned is from November to April. In a mungbean farm, labor is needed most in February and March while November to March is the peak period for labor utilization in rice farms.

a. Percentage of Hired Labor

Although the farm operator and his family are considered to be the major source of labor, the amount they contribute is not sufficient, thus hiring of additional labor is necessary to meet the labor requirements of each crop. Table 8 shows the percentage of hired labor put in for each crop. On the average, rice needed the biggest percentage of hired labor accounting for 54% of the total which cotton required only 18%. Mungbean, corn and tobacco entailed 44, 20 and 19% hired labor respectively. As it has been shown earlier, tobacco is a labor-intensive crop. However, it requires only a small amount of hired labor. This can be attributed to differences in some cultural practices for the crops. For example, harvesting of rice can be done in 1 to 2 weeks while that of tobacco takes 1 to 2 months through a method

TABLE 6

AVERAGE LABOR IN MAN-DAYS USED PER OPERATION
PER HECTARE, SSD SURVEYS, ILOCOS REGION

Crops and Stages	1975 Low	1975 Med.	1975 High	1975 Ave.	1976 Low	1976 Med.	1976 High	1976 Ave.
Stage I								
Cotton	25.82	28.29	35.69	24.92	17.36	20.86	22.41	25.74
Corn	25.83	23.19	14.50	19.02	12.70	14.92	14.26	13.85
Tobacco	30.99	40.00	42.82	34.91	38.06	50.22	73.78	49.22
Mungbeans	10.66	13.52	13.85	12.32	5.00	7.55	4.85	5.39
Rice	27.54	21.31	35.83	27.83	32.58	33.13	36.52	33.54
Stage II								
Cotton	70.76	86.57	109.66	86.81	54.15	72.93	63.76	62.63
Corn	14.44	17.45	11.10	13.61	18.24	24.10	25.25	22.31
Tobacco	30.14	50.00	48.97	41.70	47.61	66.30	91.35	62.75
Mungbeans	11.80	15.00	18.46	14.82	4.03	5.53	5.15	5.00
Rice	20.34	18.81	25.95	21.57	30.22	34.70	40.58	34.63
Stage III								
Cotton	40.38	53.86	82.93	56.95	27.36	38.97	49.66	38.60
Corn	19.17	20.85	16.7	17.37	17.57	23.93	41.15	27.54
Tobacco	60.99	92.50	113.33	83.21	72.54	110.43	128.65	98.06
Mungbeans	16.07	21.49	30.96	21.25	14.45	26.49	148.46	114.12
Rice	22.75	24.76	42.15	29.03	30.97	37.95	48.55	38.05

TABLE 6-Continued

Crops and Stages	1977 Low	1977 Med.	1977 High	1977 Ave.	3 - Year Average Low	3 - Year Average Med.	3 - Year Average High	3 - Year Average Ave.
Stage I								
Cotton	23.33	24.63	31.59	25.74	22.17	24.59	29.90	25.55
Corn	9.88	13.31	8.89	10.92	16.14	17.14	12.55	15.28
Tobacco	40.25	52.39	60.31	50.57	36.43	47.54	58.97	47.65
Mungbeans	12.65	12.13	17.45	13.96	9.44	11.07	12.05	10.85
Rice	49.14	43.63	64.82	51.32	36.42	32.69	45.72	38.28
Stage II								
Cotton	79.52	92.22	106.59	70.74	68.14	83.19	93.34	61.56
Corn	13.73	18.53	13.78	14.80	15.47	19.36	16.71	17.18
Tobacco	77.00	61.94	83.75	74.43	51.58	59.41	74.69	61.89
Mungbeans	15.10	15.11	13.40	14.58	10.51	11.88	12.34	11.58
Rice	47.74	40.00	50.36	46.18	32.77	31.17	38.96	34.40
Stage III								
Cotton	32.24	56.67	79.32	54.07	34.33	49.83	70.64	51.60
Corn	18.19	24.24	29.56	23.98	18.31	23.01	29.91	23.74
Tobacco	109.25	178.21	189.84	156.00	80.93	127.05	143.94	117.31
Mungbeans	25.71	36.60	36.40	31.46	18.74	28.19	29.64	25.52
Rice	30.54	44.38	46.25	39.21	28.09	35.70	42.38	35.39

TABLE 7

AVERAGE MONTHLY UTILIZATION OF LABOR IN MAN-DAYS
SSD SURVEYS, ILOCOS REGION

Crop and Year	MONTHS											
	J	F	M	A	M	J	A	S	O	N	D	Total
Cotton												
1975	27.0	9.0	15.9	20.3	15.9	1.2	2.7	15.1	18.0	22.5	25.6	173.2
1976	10.2	13.5	15.1	13.5	8.4	.7	.6	10.4	11.8	16.5	21.5	122.1
1977	24.0	18.5	16.0	19.0	2.4	-	2.6	13.4	23.5	23.5	28.1	171.4
Average	20.4	13.7	15.7	17.6	8.9	.6	2.0	13.0	17.8	20.8	25.1	155.5
Corn												
1975	6.0	6.6	6.0	3.3	-	-	-	1.6	3.4	10.8	12.2	50.0
1976	7.7	9.4	6.9	.7	-	-	.1	4.8	7.7	13.6	12.7	63.6
1977	9.9	10.3	4.8	4.0	8.3	-	-	.2	3.5	5.4	3.6	50.0
Average	7.87	8.77	5.9	2.7	2.8	-	.03	2.2	4.9	9.9	9.5	54.5
Tobacco												
1975	20.6	26.3	21.0	14.4	13.8	4.4	.6	3.4	6.8	21.2	28.7	161.2
1976	27.1	15.9	29.1	32.4	23.7	1.2	-	1.5	8.3	26.9	41.9	208.0
1977	28.5	79.3	44.9	23.4	3.1	-	.8	3.0	11.0	41.4	44.0	280.0
Average	25.4	40.5	31.7	23.4	13.5	1.57	.47	2.63	8.7	29.8	38.2	215.9
Mungbeans												
1975	6.5	10.2	13.1	.3	-	-	-	-	.3	2.9	15.5	48.8
1976	2.4	4.0	17.2	-	-	-	-	-	.1	1.1	6.4	31.2
1977	7.5	17.2	13.5	5.7	2.8	-	.7	1.0	2.0	2.7	7.3	60.4
Average	5.5	10.5	14.6	2.0	.9	-	.2	.3	.8	2.33	9.7	46.8
Rice												
1975	13.6	8.9	11.4	4.6	-	-	-	.7	6.6	13.4	19.2	78.4
1976	10.5	10.6	22.2	6.1	-	-	-	.7	6.1	24.8	25.2	106.2
1977	3.9	27.3	21.1	7.0	1.7	-	-	2.6	10.0	27.9	34.6	136.1
Average	9.3	15.6	18.3	5.9	.6	-	-	1.3	7.6	22.0	26.3	106.9

TABLE 8

PERCENTAGE OF LABOR HIRED AND RATE PER MAN-DAY
SSD SURVEYS, ILOCOS REGION

Year and Farm Classification	Cotton		Corn		Tobacco		Mungbeans		Rice	
	%	₱	%	₱	%	₱	%	₱	%	₱
1975										
Low	27	6.91	7	8.43	6	5.23	12	9.20	47	5.39
Medium	18	4.90	2	3.52	15	5.75	33	9.00	59	5.31
High	15	4.97	10	3.44	9	4.17	42	9.48	68	5.54
Average	23	5.59	6	5.62	10	5.05	32	9.23	59	5.41
1976										
Low	19	8.09	7	9.58	12	7.73	56	*	55	6.36
Medium	14	4.45	3	6.59	8	5.40	60	*	55	4.85
High	22	6.93	8	6.59	15	4.98	64	*	55	8.18
Average	18	6.56	6	7.70	11	6.09	61	*	55	6.03
1977										
Low	9	7.40	49	7.12	23	4.85	36	7.18	49	5.57
Medium	19	6.38	53	6.67	38	5.40	50	7.89	53	6.67
High	15	5.26	43	6.77	49	5.16	50	9.19	43	6.77
Average	15	6.19	49	6.88	37	5.18	46	8.10	49	6.88
3 Year Average										
Low	18	7.47	21	8.38	14	5.94	35	8.19	50	5.77
Medium	20	5.24	19	5.59	20	5.52	48	8.45	56	5.61
High	17	5.72	20	5.60	24	4.77	51	9.34	55	6.83
Average	18	6.14	20	6.52	19	5.41	44	8.66	54	6.07

* Rates recorded include tractor rent

called priming wherein leaves are removed from the stalk by hand as they ripen[3]. This is the most widely used method of harvesting tobacco in the Philippines.

b. Rate per man-day

Table 8 also shows the rate per man-day for hired labor. On the average, mungbean farmers paid the highest rate of ₱ 8.66 per man-day while tobacco farmers paid the lowest of ₱ 5.41. The amount paid by cotton, corn and rice farmers did not differ very much, rates ranging from ₱ 6.07 to ₱ 6.52. The difference can be explained by the kind of work necessary for each crop and the time when labor is needed. The critical periods for labor in a mungbean farm coincide with those in rice, tobacco and cotton farms. Since mungbean is not as important as these crops, the farmer has to pay a higher rate to get the labor he needs in his farm.

5. Fertilizer Usage

Fertilizer applications differed for each crop (Table 9). On the average, the highest amount of fertilizer utilized was on rice amounting to 4.48 bags per hectare. The least amount, .5 bag per hectare was used on mungbean farms. The amounts applied on tobacco, cotton and corn were 3.2, 2.5 and .78 bags per hectare respectively.

In rice, cotton and tobacco, more fertilizer was applied on high-yield farms. In mungbean, medium-sized farms received the least amount of fertilizer.

6. Insecticide Usage

Insecticides used are of two forms, granular and liquid. As Table 10 shows, cotton farms used insecticide the most, utilizing 12.39 quarts of

---

[3]Philippine Council for Agriculture and Research, Philippine Recommends for Tobacco(Los Banos, Laguna, Philippines, PCARR, 1976), p.41

TABLE 9

AVERAGE FERTILIZER USED PER HECTARE
SSD SURVEYS, ILOCOS REGION
(UNIT IN 50 KILOGRAM-BAGS)

Year and Farm Classification	Cotton	Corn	Tobacco	Mungbeans	Rice
1975					
Low	1.60	1.98	2.70	.18	2.29
Medium	2.15	2.44	2.36	.07	3.91
High	3.09	2.15	2.00	.20	4.51
Average	2.21	2.19	2.37	.15	3.57
1976					
Low	2.08	2.32	2.57	.03	3.33
Medium	2.58	1.14	3.48	.08	4.55
High	2.92	2.38	5.53	.05	6.51
Average	2.53	1.93	3.47	.03	4.42
1977					
Low	2.47	.35	3.69	.31	4.30
Medium	2.62	1.14	3.48	.08	4.55
High	3.23	.59	3.19	.41	7.09
Average	2.73	.75	3.45	.26	5.05
3-Year Average					
Low	2.05	1.55	2.99	.17	3.31
Medium	2.45	2.10	3.07	.05	4.09
High	3.08	1.71	3.57	.22	6.04
Average	2.53	1.79	3.24	.15	4.48

TABLE 10

AVERAGE INSECTICIDE USED PER HECTARE
SSD SURVEYS, ILOCOS REGION
(LIQUIDS IN QUARTS AND GRANULARS IN KILOGRAMS)

Year and Farm Classification	Cotton		Corn		Tobacco		Mungbeans		Rice	
	qts.	kgs.	qts.	kgs.	qts.	kgs.	qts.	kgs.	qts.	kgs.
1975										
Low	6.76	2.75	1.84	.12	1.77	.23	2.41	.49	1.32	.46
Medium	15.41	3.59	1.01	9.06	3.06	.79	3.85	.82	1.66	1.40
High	23.67	6.02	.87	1.11	3.50	.51	4.41	.77	2.38	4.19
Average	14.44	3.95	1.24	3.43	2.59	.47	3.56	.69	1.79	2.02
1976										
Low	6.36	2.41	1.06	1.02	1.10	1.56	1.27	.44	1.48	1.27
Medium	8.47	2.09	.96	.01	1.89	.32	1.38	.46	1.02	1.93
High	14.60	2.95	1.36	.05	2.36	1.27	1.46	.67	1.56	2.27
Average	9.88	2.49	1.12	.39	1.62	1.11	1.36	.52	1.55	1.90
1977										
Low	7.37	1.72	.29	.02	2.18	.29	1.61	1.59	3.80	2.10
Medium	12.55	2.50	.21	-	3.03	.50	1.32	.70	8.06	2.72
High	16.36	2.76	.24	-	4.24	.79	1.52	.36	16.79	3.17
Average	11.58	2.27	.24	.01	3.60	.50	1.49	.90	8.39	2.66
3-Year Average										
Low	6.83	2.29	1.06	.36	1.68	.69	1.76	.84	2.20	1.28
Medium	12.14	2.88	.73	4.54	2.66	.54	2.18	.66	3.58	2.02
High	18.21	3.91	.82	.58	3.53	.86	2.46	.60	6.91	3.21
Average	12.39	3.03	.87	1.84	2.62	.70	2.13	.70	4.23	2.17

liquid and 3.03 kilograms of granular insecticides per hectare. The least amount of liquid insecticide was used on corn farms while the lowest applications of granulars were made on tobacco and mungbean.

Table 10 also shows that on the average, high-yield farms used more insecticides than low-yield farms which is also true in the fertilizer usage. This implies a better supervision of high-yield farms.

7. Disposition of Crops

Farmers raise crops either for home-consumption or for cash. Crops for home-consumption are those produced primarily to satisfy home needs such as food for humans and animals, and for seeds. Farmers set aside a substantial amount of their produce for their family needs and then sell the remainder. Cash crops, on the other hand, are those produced mainly for monetary reasons or as a major source of income. The goal of the farmer is to sell all his produce. In the Ilocos Region, tobacco and cotton are considered as cash crops while rice, corn and mungbean belong to the other category.

Table 11 shows the percentage of the total produce for each crop each year for the different farm classes. Since tobacco and cotton are raised for monetary reasons, large percentages, 93 and 96% respectively, of the total production are sold. A small amount is kept by the farmer for his consumption or for sale later. As it was pointed out earlier, rice is a staple in the area so that only 16% of the total production is disposed of. Mungbean is also utilized for human consumption while corn is used for livestock and poultry feed so that only small amounts of these crops are sold.

8. Prices

On the average, tobacco offers the highest price among the 5 crops, ₱ 4.98 per kilo (Table 11) while corn is the cheapest, ₱ 1.08 per kilo. Cotton, mungbean and rice were priced ₱ 3.72, ₱ 3.57 and ₱ 1.12 per kilo

TABLE 11

PERCENTAGE OF PRODUCE SOLD WITH PRICE PER KILO
SSD SURVEYS, ILOCOS REGION

Year and Farm Classification	Cotton %	Cotton ₱	Corn %	Corn ₱	Tobacco %	Tobacco ₱	Mungbeans %	Mungbeans ₱	Rice %	Rice ₱
1975										
Low	100	3.50	30	.93	97	5.89	33	3.51	8	1.12
Medium	100	3.50	31	1.08	94	6.33	36	3.55	6	1.13
High	100	3.50	33	1.18	96	5.09	29	3.55	14	1.17
Average	100	3.50	32	1.13	96	5.77	11	3.54	10	1.14
1976										
Low	85	3.82	30	1.25	93	4.36	21	2.99	7	1.12
Medium	91	3.83	42	1.04	86	4.76	33	2.83	13	1.06
High	95	3.81	52	.97	90	4.15	37	2.90	16	1.07
Average	92	3.82	47	1.01	92	4.42	33	2.89	13	1.08
1977										
Low	92	3.85	45	1.07	95	4.65	58	4.25	25	1.23
Medium	99	3.85	56	1.10	95	4.66	48	4.17	31	1.20
High	99	3.85	73	1.08	95	4.95	49	4.37	27	1.15
Average	98	3.85	64	1.09	95	4.80	50	4.29	28	1.18
3-Year Average										
Low	92	3.72	32	1.08	94	4.97	37	3.58	13	1.11
Medium	97	3.73	43	1.07	94	5.25	39	3.52	17	1.13
High	98	3.72	53	1.08	92	4.73	38	3.61	19	1.13
Average	96	3.72	43	1.08	93	4.98	38	3.57	16	1.12

respectively.

9. Costs and Returns

To enable the reader to understand this section better, definitions of some of the terms are included.

a. Cash Income - Income derived from selling all or part of the farmer's produce.

b. Non-Cash Income - Income derived from that part of production not sold but which was used for other purposes such as payment for rent, other payments for landlord, payment to harvesters, for home-use and for seeds.

c. Cash Expenses - Expenses that were paid in cash.

d. Non-Cash Expenses - Expenses that were paid in kind.

e. Return to Operator's Resources - Gross income less cash expenses and non-cash cost other than labor (operator, family and exchange), interest on investment and depreciation.

Financial returns per crop, per year and per farm class are shown in Tables 12a to 12c . As previously stated, there are wide differences in proportions of crop sold (Table 11) which is relatively low for rice, mungbean and corn and high for Virginia tobacco and cotton. This explains why in Tables 12a, 12b and 12c, percentage cash income of Virginia tobacco and cotton was high while in rice, mungbean and corn, the non-cash incomes were bigger than cash incomes. Tobacco had the biggest gross income and corn had the smallest in all cases.

In terms of expenses, except for cotton, non-cash expenses for the crops were bigger than cash expenses. If expenses were to be considered as

TABLE 12A

FINANCIAL RETURNS IN PESOS, 1975
SSD SURVEY, ILOCOS REGION

Item and Crop	Low	Medium	High	Average
CASH INCOME PER HECTARE:				
Virginia tobacco	3470.94	6286.71	7888.31	5442.30
Palay	103.37	154.30	578.76	270.43
Mongo	150.47	479.96	824.81	461.27
Corn	62.22	215.04	468.93	323.56
Cotton	1582.53	3439.00	6182.33	3498.99
NON-CASH INCOME PER HECTARE:				
Virginia tobacco	74.03	354.60	313.74	217.19
Palay	1253.76	2526.70	3558.61	2409.17
Mongo	250.88	509.07	1160.42	619.67
Corn	244.03	485.94	934.89	690.24
Cotton	-	-	-	-
GROSS INCOME PER HECTARE:				
Virginia tobacco	3544.97	6641.31	8202.05	5659.49
Palay	1357.13	2681.00	4137.37	2679.60
Mongo	401.35	989.03	1985.23	1080.94
Corn	306.25	700.98	1403.82	1013.80
Cotton	1582.53	3439.00	6182.33	3498.99
CASH EXPENSES PER HECTARE:				
Virginia tobacco	1262.27	1813.50	1907.05	1579.60
Palay	588.57	749.18	972.38	766.62
Mongo	318.55	482.61	520.85	429.88
Corn	314.89	313.66	269.64	290.05
Cotton	1323.63	2048.51	2376.91	1856.06
NON-CASH EXPENSES PER HECTARE:				
Virginia tobacco	1775.08	3106.02	3209.41	2475.61
Palay	1314.47	1775.24	2518.20	1851.39
Mongo	603.30	1168.04	1321.36	1010.98
Corn	1155.83	888.23	1211.97	1116.13
Cotton	1014.51	1362.20	2000.28	1416.17
TOTAL EXPENSES PER HECTARE:				
Virginia tobacco	3037.35	4919.52	4936.46	4055.21
Palay	1903.04	2524.42	3490.58	2618.01
Mongo	921.85	1650.65	1842.21	1440.86
Corn	1470.72	1201.89	1481.61	1406.18
Cotton	2338.14	3410.71	4377.19	3272.23

TABLE 12A-Continued

Item and Crop	Low	Medium	High	Average
NET PROFIT PER HECTARE:				
Virginia tobacco	507.62	1721.79	3265.59	1604.28
Palay	-545.91	156.58	646.79	61.59
Mongo	-520.50	-661.62	143.02	-359.92
Corn	-1164.47	-500.91	-77.79	-392.38
Cotton	-755.61	28.29	1805.14	226.76
CASH INCOME LESS CASH EXPENSES PER HECTARE:				
Virginia tobacco	2208.67	4473.21	5981.26	3862.70
Palay	-485.20	-594.88	-393.62	-496.19
Mongo	-168.08	-2.65	303.96	31.39
Corn	-252.67	-98.62	199.29	33.51
Cotton	258.90	1390.48	3805.41	1642.93
RETURN TO OPERATOR'S RESOURCES PER HECTARE:				
Virginia tobacco	2161.77	4408.21	5881.31	3797.62
Palay	266.19	682.16	1710.65	855.60
Mongo	46.71	253.59	649.25	260.72
Corn	-74.92	243.51	738.03	458.62
Cotton	258.90	1390.48	3805.41	1642.93

TABLE 12B

FINANCIAL RETURNS IN PESOS, 1976
SSD SURVEY, ILOCOS REGION

Item and Crop	Low	Medium	High	Average
CASH INCOME PER HECTARE:				
Palay	111.25	312.30	619.17	322.57
Corn	102.04	280.90	793.64	384.51
Mongo	109.69	290.60	571.89	316.43
Virginia tobacco	1502.37	3240.59	4714.81	2744.88
Cotton	954.21	2454.50	4606.81	2673.28
NON-CASH INCOME PER HECTARE:				
Palay	1452.55	2070.59	3295.31	2177.89
Corn	236.49	388.72	719.54	432.74
Mongo	401.45	597.91	983.46	649.69
Virginia tobacco	93.47	193.08	417.35	196.53
Cotton	-	-	-	-
GROSS INCOME PER HECTARE:				
Palay	1563.80	2382.89	3914.48	2500.46
Corn	338.53	669.62	1513.18	817.25
Mongo	511.14	888.51	1555.35	966.12
Virginia tobacco	1613.84	3433.67	5159.16	2941.41
Cotton	954.21	2454.50	4606.81	2673.28
CASH EXPENSES PER HECTARE:				
Palay	693.43	906.24	1256.48	915.12
Corn	286.08	332.92	492.75	368.20
Mongo	122.03	152.71	160.80	143.80
Virginia tobacco	737.30	994.96	1555.16	992.31
Cotton	1016.09	1326.76	2059.33	1458.26
NON-CASH EXPENSES PER HECTARE:				
Palay	1597.15	1753.25	2615.01	1933.92
Corn	1008.96	1160.74	1531.41	1226.77
Mongo	739.22	956.63	1225.31	962.65
Virginia tobacco	1285.97	2041.84	2724.84	1843.42
Cotton	964.36	1238.55	1401.70	1191.59
TOTAL EXPENSES PER HECTARE:				
Palay	2290.58	2659.49	3871.49	2849.04
Corn	1295.04	1493.66	2024.16	1594.97
Mongo	861.25	1109.34	1386.11	1106.45
Virginia tobacco	2023.27	3036.80	4280.00	2835.73
Cotton	1980.45	2565.31	3461.03	2649.85

TABLE 12B-Continued

Item and Crop	Low	Medium	High	Average
NET PROFIT PER HECTARE:				
Palay	-726.78	-276.60	42.99	-348.58
Corn	-956.51	-824.04	-510.98	-777.72
Mongo	-350.11	-220.83	169.24	-140.33
Virginia tobacco	-409.43	396.87	879.16	-105.69
Cotton	-1026.25	-110.81	1145.78	-23.42
CASH INCOME LESS CASH EXPENSES PER HECTARE:				
Palay	-582.18	-593.94	-637.31	-592.55
Corn	-184.04	-52.02	300.89	16.31
Mongo	-12.34	137.89	411.09	172.63
Virginia tobacco	783.07	2245.63	3186.65	1752.57
Cotton	-61.88	1127.74	2547.48	1215.02
RETURN TO OPERATOR'S RESOURCES PER HECTARE:				
Palay	158.84	479.11	1050.07	524.07
Corn	-11.52	182.49	792.66	305.19
Mongo	83.41	270.91	586.16	304.36
Virginia tobacco	744.52	2239.87	3157.38	1726.20
Cotton	-61.88	1127.74	2547.48	1215.02

TABLE 12C

FINANCIAL RETURNS IN PESOS, 1977
SSD SURVEY, ILOCOS REGION

Item and Crop	Low	Medium	High	Average
CASH INCOME PER HECTARE:				
Mongo (Mungbean)	499.22	636.81	1362.66	816.08
Cotton	944.38	2705.54	5449.57	2749.24
Palay (Rice)	423.06	853.16	1318.39	797.44
Virginia tobacco	2567.47	3898.18	7298.72	4418.33
Corn	141.99	513.60	1143.17	585.11
NON-CASH INCOME PER HECTARE:				
Mongo	377.19	715.91	1426.87	820.65
Cotton	81.99	26.15	69.57	59.50
Palay	1140.95	1773.58	3524.31	1943.88
Virginia tobacco	176.59	192.37	430.11	258.03
Corn	190.73	401.29	475.07	359.98
GROSS INCOME PER HECTARE:				
Mongo	876.41	1352.72	2789.53	1636.73
Cotton	1026.37	2731.69	5519.14	2808.74
Palay	1564.01	2626.74	4842.70	2741.32
Virginia tobacco	2744.06	4090.55	7728.83	4676.36
Corn	332.72	914.89	1618.24	945.09
CASH EXPENSES PER HECTARE:				
Mongo	356.28	363.85	456.94	388.39
Cotton	1057.06	1796.58	2519.02	1802.35
Palay	975.25	1164.36	1415.77	1155.47
Virginia tobacco	2031.42	3313.94	4736.91	3267.46
Corn	320.17	387.75	466.65	385.04
NON-CASH EXPENSES PER HECTARE:				
Mongo	1247.86	887.64	1719.19	1269.36
Cotton	1501.19	1542.53	2435.71	1759.52
Palay	1563.48	1553.80	2407.02	1774.66
Virginia tobacco	2300.40	2438.30	2709.03	2479.92
Corn	630.26	709.02	746.63	693.24
TOTAL EXPENSES PER HECTARE:				
Mongo	1604.14	1251.49	2716.13	1657.75
Cotton	2558.25	3339.11	4954.73	3561.87
Palay	2538.73	2718.16	3822.79	2903.13
Virginia tobacco	4331.82	5752.24	7445.94	5747.38
Corn	950.43	1096.77	1213.28	1078.28

TABLE 12C-Continued

Item and Crop	Low	Medium	High	Average
NET PROFIT PER HECTARE:				
Mongo	-727.73	101.23	613.40	-21.02
Cotton	-1531.88	-607.42	564.41	-753.13
Palay	-974.72	-91.42	1019.91	-188.81
Virginia tobacco	-1661.69	-1661.69	282.89	-1071.02
Corn	-617.71	-181.88	404.96	-133.19
CASH INCOME LESS CASH EXPENSES PER HECTARE:				
Mongo	142.94	272.96	905.72	427.69
Cotton	-112.68	908.96	2930.55	946.89
Palay	-552.19	-311.20	-97.38	-358.03
Virginia tobacco	536.05	584.24	2561.81	1150.87
Corn	-178.18	125.85	676.52	200.05
RETURN TO OPERATOR'S RESOURCES PER HECTARE:				
Mongo	324.49	641.13	1304.64	739.20
Cotton	-30.70	935.11	3000.11	1006.30
Palay	159.45	771.19	2396.84	916.34
Virginia tobacco	563.43	589.91	2653.95	1190.36
Corn	-34.30	415.81	979.31	450.29

capital invested, tobacco is very likely to be regarded as a highly capital intensive crop while corn as the least capital intensive (except in 1976 when mungbean had the smallest expense).

E. Summary

This study was done primarily to compare the performance of cotton with four dry season crops, namely, rice, corn, mungbean and tobacco in Ilocos Region. As a result,the study has come up with the following:

a. Size of Farms - On the average, rice farms were biggest while tobacco farms were smallest. Cotton farms were next to tobacco.

b. Use of Labor - It was found that tobacco, on the average, was the most labor intensive crop with mungbean as the least. Cotton was second to tobacco.

c. Percentage of Hired Labor - rice farms, on the average, required the highest percentage of hired labor, while cotton had the least.

d. Rate per man-day of hired labor - On the average, hired laborers in mungbean farms received the highest rate and those in tobacco farms the lowest. Cotton farmers paid the second highest rate.

e. Use of Fertilizer - Rice farmers used fertilizer most on the average. Mungbean farmers utilized the least amount of fertilizer. Cotton farmers were the third biggest consumer.

f. Disposition of Produce - On the average, the biggest percentage of produce sold was in cotton and the smallest in rice.

g. Total cost incurred - Considering cost as capital invested, tobacco, on the average, is the most capital intensive crop and corn is the least.

CHAPTER III

COMPARISON OF ENTERPRISE PERFORMANCE USING NET RETURN APPROACH

A. Measures of Relative Profitability

The cited study included three measures of profitability namely; net profit, cash income less cash expenses and return to operator's resources.

Net profit is a good measure of relative profitability but it considers non-cash returns such as home use and seed use and non-cash expenses including operator and family labor and interest and depreciation on invested capital, thus making it difficult to understand. Since the operator's judgement was used in determining the value of his labor and that of his family members, and the value of the invested capital, it has a further disadvantage as costs on a farm could differ from those on other farms when perhaps no true difference really existed.

Cash income less cash expenses, on the other hand, favors those enterprises for which a high proportion of the crop was sold (Virginia tobacco and cotton) and disfavors those for which a lower proportion of the crop was sold (rice, mungbean and corn). Many people understand this measure very easily but it is not considered useful in this analysis because of enterprise differences.

Return to operator's resources represents the return to the operator for his (and his family) labor, management, and capital invested. It represents the amount left after deducting cash expenses and non-cash cost other than labor (operator, family and exchange), interest on investment and depreciation. This measure is perhaps the best to use since it eliminates the major problems that occur with other measures, hence it was used in this study.

B. Results Using Return to Operator's Resources

Table 12d shows the comparison of enterprise performance using return to operator's resources per hectare. This table indicates that, on the average, in all three periods, the return to operator's resources of cotton is higher than rice, corn and mungbean but lower than that of tobacco. This may imply that if a farmer will base his farming decision on the outcome of this study, he might as well choose either tobacco and cotton since they give higher return to operator's resources. On the other hand, from the Philippine Cotton Corporation's point of view, they have to concentrate their effort on convincing rice, corn and mungbean farmers to plant cotton.

Looking back to Tables 12a, 12b and 12c, one may observe that if farm classification were to be considered, the outcome will be different. In Table 12c, for example, the return to operator's resources of high-yield cotton farms is higher than all other farms. However, in the same table, the low-yield cotton farms have the second lowest return to operator's resources.

This kind of comparison will be very useful to the Philippine Cotton Corporation (PCC). From this, PCC will be able to pinpoint problem areas as far as cotton is concerned and areas that can be converted to cotton farms, i.e., farms planted to crops whose return to operator's resources is lower than cotton.

C. Remarks on the Cited Study

The cited study has no doubt attained its objective. Based on the previous analysis, data presented are indeed useful in comparing crop situations and performance of the crops being considered. However, the study

TABLE 12d

RETURN TO OPERATOR'S RESOURCES
(AVERAGE FOR ALL FARMS)

Crops	1975	1976	1977
Tobacco	₱ 3,797.62	₱ 1,726.20	₱ 1,190.36
Cotton	1,642.93	1,215.02	1,006.30
Rice	855.60	524.07	916.35
Corn	458.62	305.19	450.29
Mungbean	260.72	304.36	789.00

has its weak points, one of which is the inclusion of some unnecessary data. Furthermore, the study did not have information on average monthly labor used per farm when data on average labor used per type of operation per farm per month were included. The presence of such data will be very useful in analyzing amount of labor being used in each farm class in relation to the availability of labor which might have some effect in decision making. There is also a possibility of some overlapping in the amount of resources used since the study considered only dry season operations. It might be that farmers are giving information which include rainy season operation. Figures in Table 7, for example, show the amount of monthly labor used in each crop. One might observed that labor usage has been distributed within a period of 11 months in the case of cotton. Cotton crop matures in 3 to 4 months. It is possible that some of these labor were used in another crop. The author believes that it would be better if both cropping seasons were considered and crops that should be included are those double cropped with the five original crops.

The study did not also specify the yield of non-cotton crops that were planted in rainfed and irrigated farms. This is important in order to compare the adaptability of each crop to rainfed or irrigated farms or its water requirement in relation to the availability of water.

The use of net return per hectare in the said study indicates which crop grown in an area gives the highest income to the farmers. However, it does not give information on the feasibility of planting such crops considering other factors like their importance to the farmers in the area, the ability of the farmers to grow them and the availability of other resources in relation to the requirements of each crop. A better method can be employed to take at least one of these factors into account and that is through linear programming.

CHAPTER IV

EXTENSION OF ANALYSIS USING LINEAR PROGRAMMING

A. Linear Programming as an Analytical Tool

Linear programming is one of several mathematical tools used to analyze the problem of resource allocation. It is a method often used in choosing alternatives that will minimize or maximize some goals subject to certain restraint or side conditions. It is based on the assumptions that input-output, input-input and output-output relationships are linear. To have a better understanding of this method, one must have a clear grasp of the different assumptions and their implications.

Restriction on production and limited resources are typical conditions existing in agriculture. These include availability of resources such as family labor during certain months of the year, capital for field operations, water, working animals and other implements, farm inputs like fertilizers and insecticides and participation in a government program which limits the use of a given resource. Restriction can also be subject to the value judgment of the farmers. A farmer may limit the amount of crop he will produce because of inadequate storage facilities or uncertainty in market conditions. These restrictions can represent upper limits such as the need for a farmer to produce at least 20 cavans of rice in order to meet his home needs. Restriction can also take the form of equalities requiring a farmer to use an exact amount of a given input to produce a certain level of a given crop.

Given these restrictions, a farmer can develop a plan where he can use his resources wisely. He can grow different crops in his area where each crop competes for the use of his resources or he can consider altertive ways of planting only one crop yet attaining his objectives. In most cases, farmers base their decisions on past experiences. They generally compare yields or returns from each crop in adjusting their yearly activities. Consequently, plans resulting from this approach can provide a good basis for farm decisions but may not be considered as the best. One advantage of linear programming over this aproach is that a number of choices can be thoroughly tested and analyzed within a short period of time.

1. Parts of a Linear Programming Problem

A linear programming problem has three parts, each of which is expressed in quantitative terms.

a. Objective function - it states the main goal of the problem. It must be clearly defined and expressed in quantitative terms. The objective can be in the form of maximization or minimization.

b. Alternative methods or processes - These are ways and means of attaining the above objective. There should be more than one choice for the problem of choice to exist. If there is only one way of attaining a given objective, then the linear programming approach is not needed.

c. Resources or other restrictions - The existence of a linear programming problem is dependent on whether there are resource limitations or side conditions. Examples of these restrictions were given in the preceding section.

2. Format of a Linear Programming Problem

In general, a linear programming model can be expressed in matrix form as:

MAXIMIZE (OR MINIMIZE)

$$Z = C' X$$

Subject to:

$$A X \lesseqqgtr B \qquad X \geq 0$$

Where A is an m x n matrix of technical coefficients.

B is an m x 1 vector of resources and other restraints.

C is an n x 1 vector of prices or weights for the objective function.

C' is the prime of vector C - it is an m x 1 vector of prices and weights for the objective function.

X is an n x 1 vector of activities.

$C' X = Z$ is the objective function.

The problem can be written as:

Maximize (or minimize)

$$Z = C_1X_1 + C_2X_2 + \ldots\ldots + C_nX_n$$

Subject to:

$$\begin{array}{ccccc} a_{11}x_1 + & a_{12}x_2 + & \ldots\ldots + & a_{1n}x_n & \leq b_1 \\ a_{21}x_1 + & a_{22}x_2 + & \ldots\ldots + & a_{2n}x_n & \leq b_2 \\ \cdot & \cdot & \cdot\cdot\cdot\cdot\cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot\cdot\cdot\cdot\cdot & \cdot & \cdot \\ a_{m1}x_1 + & a_{m2}x_2 + & \ldots\ldots + & a_{mn}x_n & \leq b_m \end{array}$$

$$x_1 \geq 0, \quad x_2 \geq 0, \ldots, \quad x_n \geq 0$$

all functions are linear in n variables $X_1, X_2, \ldots, X_n$ where the c_i's, b_i's and a_{ij}'s are known constants.

3. Basic Assumptions for the Linear Programming Model

Any individual using linear programming as a tool must be aware of the basic assumptions attached to it. Some of these assumptions may not apply to certain problems. In these cases, an application of linear programming may not give very accurate results.

a. <u>assumptions of linearity</u> - This assumption is based on the notion that linear relationship exists between X and Z in the above formula or all c_i's are constants, hence, the objective function is linear. In the case of input-output relationships, it is assumed that the law of diminishing marginal returns does not hold. This implies that in a given crop farm where there are two resources, with a fixed amount of one resource, increases in the amount of the second resource will result in constant increases in output.

b. <u>addivity of resources and activities</u> - The sum of resources used by different activities must be equal to the amount of resources used by each activity for all resources. This ignores the existence of interactions among the activities of the resources. If the growing of a crop increases the production of another crop, then there is interaction and these two crops must be combined and treated as one activity.

c. <u>divisibility of activites and resources</u> - This assumption allows the use of resources in fractional forms such as 4.25 hours of labor or 1.75 hectares of land and the production of 3.25 head of cow and 100.99 cavans of rice. There may not be such thing as 3.25 head of cow but this figure can be rounded-off to 3 head without breaking the restrictions.

d. <u>single valued expectations</u> - Linear programming techniques make use of the purely competitive approach to prices. Hence, its application to agriculture is appropriate since most agricultural products are assumed to be on a purely competitive market. It is assumed that there are no variations in prices or in the use of resources. It implies that input-output coefficients, amount of available resources, prices or resources and activities and others are known with certainty. The model uses mean values such as average prices, average yield, average cost, average labor requirements and others in its analysis.

B. Application of Linear Programming

The previously cited study concluded that, on the average, cotton can compete effectively with three other crops such as rice, corn and mungbean but will have difficulty in competing with tobacco. This may also mean that rice, corn and mungbean farmers in the Ilocos Region may start thinking about planting cotton or they may also consider growing tobacco since these two crops can offer higher returns to their resources. This chapter will try to determine whether linear programming would give the same results.

1. Defining Objectives

In the study cited, the main purpose was to compare the performance of cotton with four dry season crops based on net returns. The objective of this analysis is similar in nature but the inclusion of some assumptions necessitates a more precise definition of the objective. There are three important things that need to be pointed out before defining the objective. First, this paper will consider the problem from the point of view of an average farmer in the Ilocos Region. Second, Filipino farmers generally plant at least two crops a year, hence, aside from the five crops that were included in the cited study, this paper will consider the possibility of double cropping which will require the inclusion of other information not provided by the study such as data on crops being planted during the rainy season and farm operations of probable double crops such as rice-rice, rice-corn, rice-tobacco, rice-cotton, rice-mungbean, corn-cotton, corn-tobacco and corn-mungbean. Lastly, analysis of the problem will be centered on the effect of the availability of monthly family labor on farm decision making by having it one of the constraints. One reason for doing this is that there are indications that availability of family labor has some effects on the decision of the farmers to grow certain crops.

The main objective of this analysis is to determine the combination of dry season crops, rainy season crops and double crops which will maximize the income of an average farmer in Ilocos Region given a certain level of family labor and land availability. This objective is similar to that of the study earlier mentioned because performances of each crop or crop combinations are also being compared. The only difference is that this analysis is considering the amount of family labor and land that are available to an average farmer.

2. Facts and Assumptions

There is similarity between the information required for developing a farm plan by linear programming and the data needed in computing net return. The only difference is that the former needs a more detailed input-output data and a rigid specification of constraints. The information which will be used in this analysis came from the cited study plus assumptions based on other research and hypothetical data.

Fifteen (15) activities (crops) will be considered in this analysis which will consist of five (5) original activities (crops included in the cited study) and ten (10) new ones which incorporate rainy season crops and potential double crops. The addition of ten new activites is necessary in order to have a more realistic situation and to give an average farmer wider choices. As mentioned earlier, Filipino farmers usually plant at least two crops per year, hence, the double cropping system will be considered in this analysis. In doing this, assumptions and hypothetical data will be used to feed in missing information which the study did not provide. By double cropping, farmers plant a crop in the rainy season which is immediately followed by another crop during the dry season. Varieties of crops grown for double cropping purposes are those early maturing since a short period of time is available in planting both of them in a crop year. This analysis will also take into account the critical period for labor when farmers start shifting from harvesting a crop to planting another in the event of double cropping. It is necessary to point out that all activities included are combinations of several functions from planting to marketing. The activity unit is hectare.

The 15 activities will be as follows:

1. Dry Rice
2. Dry Corn
3. Dry Cotton
4. Dry Tobacco
5. Dry Mungbean
6. Wet Rice
7. Wet Corn
8. Rice-Rice
9. Rice-Corn
10. Rice-Tobacco
11. Rice-Cotton
12. Rice-Mungbean
13. Corn-Cotton
14. Corn-Tobacco
15. Corn-Mungbean

The planting calendar for double cropping activities is shown in Figure 3. The length of maturity of the variety used for each crop is also shown in the same figure. The terms dry and wet are used to specify the season when the crops are grown.

3. Crop Budgets

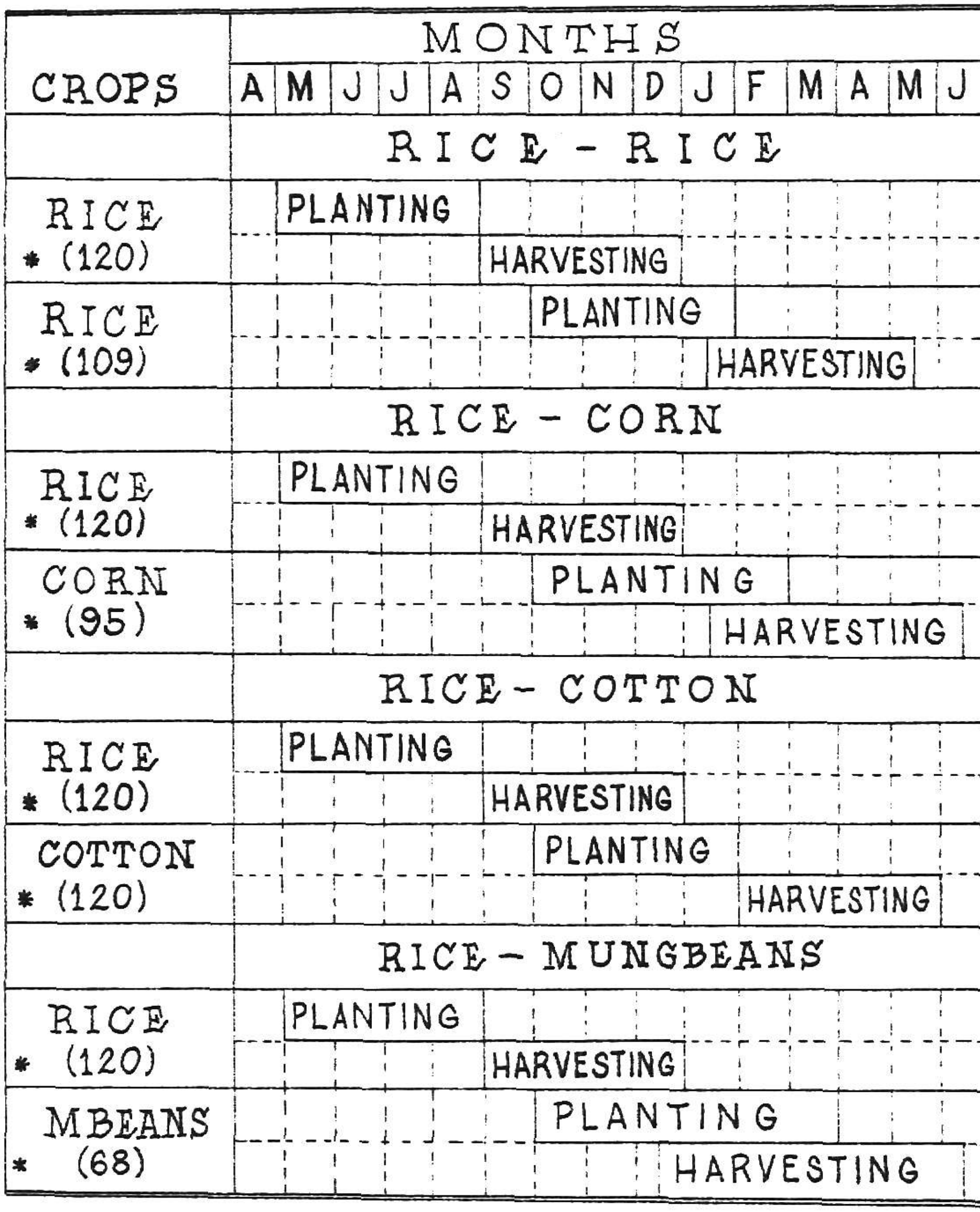
Gross income less variable cost (GI-VC) is required in a linear programming model. It can be derived from the estimated budget for each crop. Tables 13 and 14 show the crop budgets for the original and additional activities respectively.

Figures in Table 13 were computed from the study. Average yield corresponds to the mean yield of each crop for 3 years and three farm classes as indicated in Table 3 of Chapter 2. Average prices, on the other hand, came from Table 11 and were computed as a mean price for each crop for 3 years and 3 farm classes.

Table 14 includes estimates based on outside materials. In this table, there are such terms as short wet rice, short dry rice, short wet corn, etc.. The word "short" is used to indicate the length of maturity of the variety of each crop, e.g., early maturing variety. A "short wet" activity will have to go with a "short dry" activity in order to have a double cropping activity, i.e., short wet rice plus short dry tobacco = rice-tobacco. Yield data in this table are estimates based on the following assumptions:

a. rainy season crops are expected to have lower yields than dry season crops due to the possible occurence of storms, infestations by insects and other calamities,

b. early maturing varieties are also expected to have lower yields due to their greater susceptibility to certain infestation and other characteristics.



NOTE: Sequence = Rainy followed by Dry.
Only 1 month separates the two crops - for land prep. etc...
* Maturity days

Figure 3. Planting Calendar of Double Crops and Length of Maturity of Variety Used

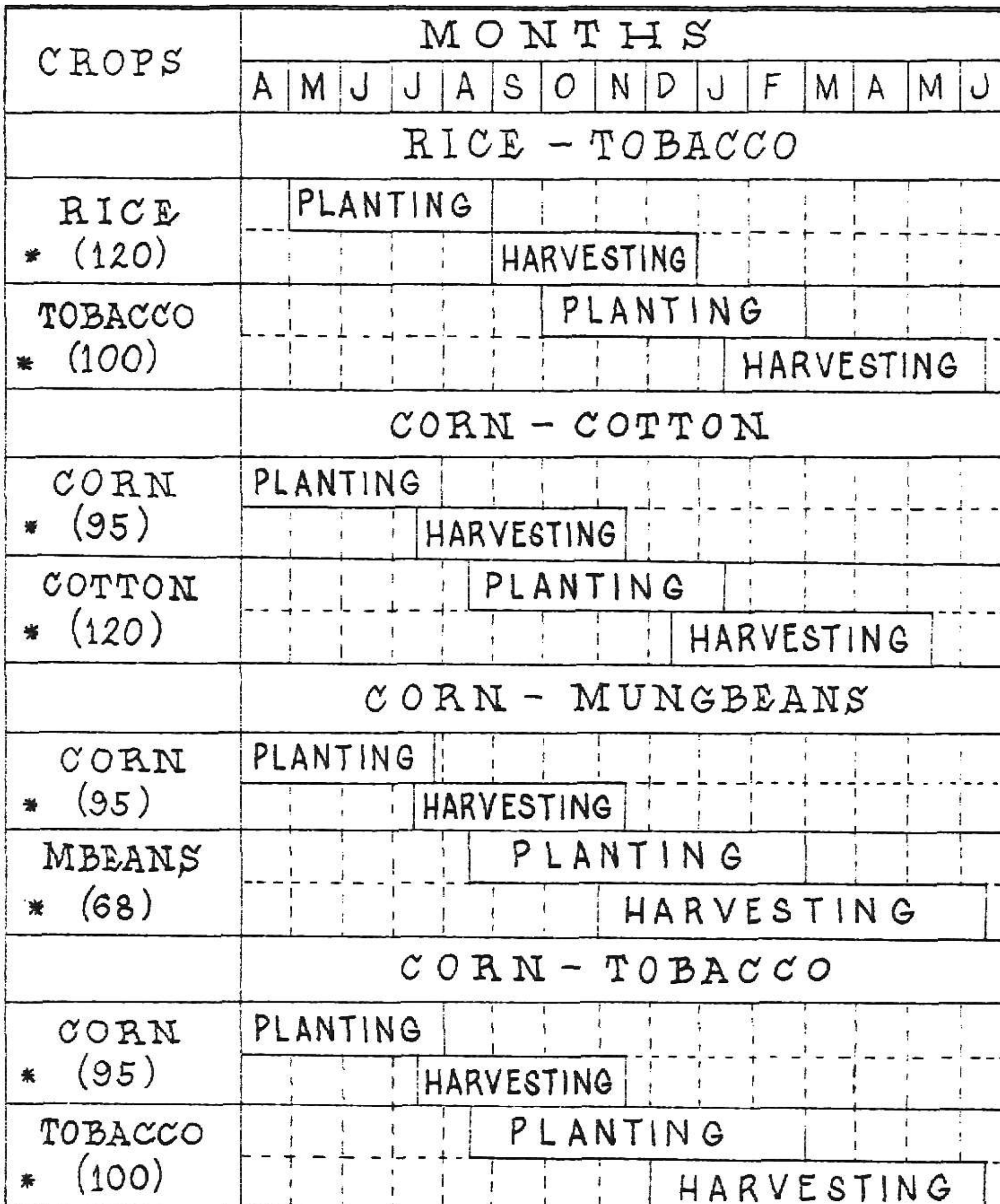


Figure 3 - Continued

TABLE 13

CROP BUDGETS IN PESOS PER HECTARE

Particulars	Cotton	Corn	Tobacco	Mungbeans	Rice
Average Yield (kgs.)	820.7	855.0	884.4	354.4	2368.3
Average Price/kg.(₱)	3.72	1.09	4.99	3.59	1.13
Gross Income (₱)	3053.00	931.95	4413.16	1272.30	2676.21
Variable Costs					
Fertilizer	302.63	194.85	324.55	11.42	335.26
Insecticide/ Chemicals	590.00	32.47	123.14	100.32	127.22
Seeds	89.98	26.20	2.50	145.70	103.74
Landlord Share	301.98	144.97	389.80	228.29	473.66
Miscellaneous Cost	142.38	117.93	999.11	233.84	536.82
Total Variable Costs	1426.88	516.42	1839.10	719.57	1576.70
Gross Income less Variable Costs	1626.12	415.53	2574.06	552.73	1099.51

TABLE 14

ESTIMATED CROP BUDGETS IN PESOS PER HECTARE

Particulars	Wet Rice	Wet Corn	Short Wet Rice	Short Wet Corn	Short Dry Rice	Short Dry Corn	Short Dry Tobacco	Short Dry Cotton	Short Dry Mbeans
Yield (kgs.)	2295.00	830.00	2290.00	825.00	2300.00	832.00	880.00	815.00	350.00
Price/kg.	1.13	1.09	1.13	1.09	1.13	1.09	4.99	3.72	3.59
Gross Income	2593.35	904.70	2587.70	899.25	2599.00	906.88	4391.20	3031.80	1256.50
Variable Costs									
Fertilizer	324.69	189.17	323.98	188.03	325.39	189.63	322.74	300.45	11.31
Insecticide/ Chemicals	123.18	31.48	122.92	31.29	123.45	31.56	122.51	585.74	99.01
Seeds	100.62	25.42	100.40	25.27	100.84	25.48	2.63	89.13	145.87
Landlord Share	459.02	140.77	458.02	139.92	460.02	141.11	387.73	299.85	225.45
Miscellaneous Costs	520.23	114.44	519.09	113.76	521.36	114.72	994.12	141.28	230.94
Total Variable Costs	1527.74	501.28	1524.41	498.27	1531.06	502.50	1829.73	1416.45	710.58
Gross Income less Variable Costs	1065.61	403.42	1063.29	400.98	1067.94	404.38	2561.47	1615.47	545.92

Gross Income less Variable Cost for:

Rice-Rice	=	1063.29 + 1067.94 = 2131.23
Rice-Corn	=	1063.29 + 404.38 = 1467.67
Rice-Cotton	=	1063.29 + 1615.35 = 2678.64
Rice-Tobacco	=	1063.29 + 2561.47 = 3624.76
Rice-Mungbean	=	1063.29 + 545.92 = 1609.21
Corn-Tobacco	=	400.98 + 2561.47 = 2962.45
Corn-Cotton	=	400.98 + 1615.35 = 2016.33
Corn-Mungbean	=	400.98 + 545.92 = 946.90

Prices used are the same as those in Table 13.

In both tables, only variable cost is deducted from the gross income (GI-VC). In view of this, the difference does not represent the "real" net income since fixed cost is not deducted. This is so because of the economic principle which states that only variable cost can affect marginal cost and hence also affect profit maximization and cost minimization decisions since these two are based on marginal cost and marginal returns.

Data for the variable costs were computed from the Financial Return data of the original study. There are five components of these costs namely, fertilizers, chemicals, seeds, landlord share and miscellaneous costs. The inclusion of landlord share is due to the fact that most farmers in the area are share-tenants, that is, they pay their landlord a certain percentage of their produce. Hence, the higher the yield, the higher is the amount paid to the landlord. Miscellaneous costs, on the other hand, consist of several expense items which vary for each crop. Some of the expense items included are firewood for drying, fuel, containers, and food for the laborers.

Since variable costs vary directly with changes in volume or output, figures in Table 14 were computed using relationships between variable cost and gross income of each of the original crops as shown in number 2, Table 14a and the estimated income for each of the 10 additional crops. It is assumed that the ratio of variable cost to gross income of the additional crops is the same as those of the original ones. This may be a dubious assumption since it is possible that short maturing and rainy season crops have a bigger ratio than regular dry season crops, i.e., they have bigger variable cost in relation to their gross income. However, due to the

TABLE 14a

1. COST AS A FRACTION OF GROSS INCOME

Crops	Fertilizers	Insecticides/ Chemicals	Seeds	Landlord Share	Miscellaneous Costs
Cotton	.0991	.1932	.0294	.0989	.0466
Corn	.2091	.0248	.0281	.1556	.1265
Tobacco	.0735	.0279	.0006	.0883	.2264
Mungbeans	.0090	.0788	.1145	.1794	.1838
Rice	.1252	.0475	.0388	.1770	.2006

2. ESTIMATED EXPENSES BASED ON THE ABOVE TABLE

Crops	Fertilizers	Insecticides/ Chemicals	Seeds	Landlord Share	Miscellaneous Costs
Wet Rice	324.69	123.18	100.62	459.02	520.23
Wet Corn	189.17	31.48	25.42	140.77	114.44
Short Wet Rice	323.98	122.92	100.40	458.02	519.09
Short Wet Corn	188.03	31.29	25.27	139.92	113.76
Short Dry Rice	325.39	123.45	100.84	460.02	521.36
Short Dry Corn	189.63	31.56	25.48	141.11	114.72
Short Dry Tobacco	322.74	122.51	2.63	387.73	994.12
Short Dry Cotton	300.45	585.74	89.13	299.85	141.28
Short Dry Mungbeans	11.31	99.01	143.87	225.45	230.44

Example of how crop expense was computed:

Fertilizer Expense for wet rice = Gross Income for Wet rice (Table 11) multiplied by Cost as a Fraction of Gross Income (See above, fertilizer column, rice row) or

324.69 = 2593.35 x .1252

unavailability of information on costs and returns of the 10 additional crops, these assumptions can take their place.

Gross Income less Variable Costs (GI-VC) for double cropping activities can be determined by adding GI-VC's of "short wet" activity and "short dry" activity, hence, for rice- tobacco, the GI-VC will be GI-VC of short wet rice plus GI-VC of short dry tobacco.

4. Labor Requirements

The problem will deal only with labor and land as constraints, hence, there is a need to specify the amount of labor needed each month for each activity. Monthly labor requirements for original and additional activities are shown in Tables 15 and 16 respectively. Table 16a shows how some figures in Table 16 were derived.

The total amount of labor needed for additional short dry season crops are assumed to be the same as the regular dry season crops (original ones). In Table 16a, the writer used his own judgement in estimating the percentage of labor needed each month based on the assumed maturity days. It will be observed that estimated percentage of labor in some months are relatively high. These months represent planting and harvesting periods when most labor is needed.

5. Other Assumptions

In addition to the assumptions given earlier, other important ones which have to be specified are:

a. Capital resource and farm inputs such as fertilizers and chemicals are assumed not to be limiting.

b. Water for irrigation is available where and when needed.

c. Soil conditions are suitable for all kinds of crops included in the study.

TABLE 15

MONTHLY LABOR REQUIREMENT IN MAN-DAYS PER HECTARE

Months	Cotton	Corn	Tobacco	Mungbeans	Rice
August	1.97	.03	.47	.23	-
September	12.97	2.20	2.63	.33	1.33
October	17.77	4.87	8.70	.80	3.57
November	20.83	9.93	29.83	2.23	22.03
December	25.17	9.50	38.20	9.73	26.33
January	20.40	7.87	25.40	5.47	9.33
February	13.70	8.77	40.50	10.47	15.60
March	15.67	5.90	31.67	14.60	18.23
April	17.60	2.67	23.40	2.00	5.90
May	8.90	2.77	13.53	.93	.57
June	.63	-	1.57	-	-

TABLE 16

ESTIMATED MONTHLY LABOR REQUIREMENT IN MAN-DAYS PER HECTARE

Months	Wet Rice*	Wet Corn**	Rice-Rice	Rice-Corn	Rice-Cotton	Rice-Tobacco	Rice-Mungbean	Corn-Cotton	Corn-Tobacco	Corn-Mungbean
May	1.74	.04	21.72	21.72	21.72	21.72	21.72	3.52	3.52	3.52
June	10.42	1.76	40.53	40.53	40.53	40.53	40.53	13.20	13.20	13.20
July	29.82	3.92	10.13	10.13	10.13	10.13	10.13	4.40	4.40	4.40
August	35.61	8.01	26.06	26.06	26.06	26.06	26.06	5.28	5.28	5.28
September	12.59	7.66	46.32	46.32	46.32	46.32	4.632	17.60	17.60	17.60
October	21.14	6.34	16.03	4.36	15.55	17.27	5.61	15.55	17.27	5.61
November	24.76	7.08	29.93	16.35	46.65	62.61	15.91	46.65	62.61	15.91
December	7.96	4.75	7.48	5.45	18.66	28.07	6.55	18.66	28.07	6.55
January	.724	2.20	19.24	6.54	26.44	32.39	18.72	26.44	32.39	18.72
February	-	2.24	34.20	21.80	48.21	75.57	-	48.21	75.57	-

Source: * Masagana 99 Estimated Labor Requirement for Wet Season Rice

** Masaganang Maisan Estimated Labor Requirement for Wet Corn

TABLE 16a

ESTIMATED AMOUNT OF LABOR IN MAN-DAYS REQUIRED
IN FIVE SELECTED CROPS PER MONTH

Crops	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Rice (Rainy) 120*											
Estimate %	15	28	7	18	32						
Amount of Labor	21.72	40.53	10.13	26.06	46.32						144.76
Rice (Dry) 120*											
Estimate %						15	28	7	18	32	
Amount of Labor						16.03	29.93	7.48	19.24	34.20	106.89
Corn (Rainy) 95*											
Estimate %	8	30	10	12	40						
Amount of Labor	3.52	13.20	4.40	5.28	17.60						44.0
Corn (Dry) 95*											
Estimate %						8	30	10	12	40	
Amount of Labor						4.36	16.35	5.45	6.54	48.21	54.51
Cotton 120*											
Estimate %						10	30	12	17	31	
Amount of Labor						15.55	46.65	18.66	26.44	48.21	155.51
Mungbean 68*											
Estimate %						12	34	14	40		
Amount of Labor						5.61	15.91	6.55	18.72		46.79
Tobacco 100*											
Estimate %						8	29	13	15	35	
Amount of Labor						17.27	62.61	28.07	32.39	75.57	215.90

* Days to Maturity

C. Constructing the Model

1. Constraints

This study concentrates on the analysis of the effect of labor availability on farm decision making due to lack of data about other resources. As several researchers in the Philippines have indicated, availability of family labor during certain months of the year has some influence on a farmer's decision to plant certain crops and to adopt new agricultural practice or inputs[4]. In the study made by Van Der Veen[5], it was found that the failure on the part of the Filipino farmers to provide additional labor has resulted in their not maximizing the profit obtained from new technology. Elsewhere, early research in the U.S. indicated that a close relationship exists within the context of the family farm between the availability of family labor and the type of farming operation. In another study, it was stated that the composition of farm family influenced both current farm organization and the adjustments farm families made in response to economic forces[6]. Hence, the writer believes that the use of monthly family labor as the constraint is appropriate in this paper in order to determine its effect on farm organization.

Labor and land are the two resources which are assumed to be available

---

[4]W.A. Schutjer and M.G. Van Der Veen, Economic Constraints on Agricultural Technology Adoption in Developing Nations (Washington D.C., United States Agency for International Development, 1977), p. 16.

[5]M.G. Van Der Veen, Analysis of Interfarm Variation in Rice Yields: An Economic Study of High Yielding Variety Rice Production in Cavite Province, Philippines, Unpublished Ph.D dissertation, (The Pennsylvania State University, 1975).

[6]E.J. Long, Labor Foundations of Wisconsin Family Farms, Unpublished Ph. D. dissertation, (University of Wisconsin, 1944).

in limited amounts in the problem. Based on the study, the average size of farm in Ilocos Region is 1.5 hectares. Therefore, it is assumed that each farmer has this size of farm. This figure will serve as the land constraint.

The problem considered monthly labor and not total labor requirements. Since the information on the amount of labor available is not provided by the study, figures for this constraint was based on the ILO report[7] which provided the following information:

The average working hours per week in agriculture in 1972 were:

for both sexes	-	42.4 hours per week
for females	-	33.9 hours per week
for males	-	44.8 hours per week

Based on this information, the total number of working hours for each month can be computed as shown in Table 17.

The following data were used to determine the amount of available farm family labor per month:

Average size of farm family (Ilocos Region) - 7 persons[8]

Ratio of male to female - 3:1[9]
- a. % of population whose age is 10 and above - 70
- b. % of "a" employed in agriculture - 50

From the above information, one may hypothesize that each farm family

---

[7]International Labor Organization, Sharing in Development - A Programme of Employment, Equity and Growth in the Philippines (Manila: National Economics and Development Authority, 1974), p. 501.

[8]Lydia Oliva, Demand Analysis of Animal Foods in the Philippines, Unpublished M.S. Thesis (UPCA, Los Banos, Philippines, 1971).

[9]National Economic and Development Authority, 1977 Philippine Statistical Yearbook (Manila: NEDA, 1977).

TABLE 17

ESTIMATED WORKING HOURS PER MONTH

Months	A No. of Weeks in each Month	B (A x 44.8)	C (A x 33.9)
May	4.43	198.46	150.18
June	4.29	192.19	145.40
July	4.43	198.46	150.18
August	4.43	198.46	150.18
September	4.29	192.19	145.40
October	4.43	198.46	150.18
November	4.29	192.19	145.40
December	4.43	198.46	150.18
January	4.43	198.46	150.18
February	4.00	179.20	135.60
March	4.43	198.46	150.18
April	4.29	192.19	145.40

in Ilocos Region is composed of 7 members where 5 are males and 2 are females and 5 are from 10 years old and above. Of the 5, three are employed in agriculture. Most likely, the farmer, his wife, and his son work in the farm. It is also possible that the son is in school thus, he can be regarded as partially employed so that the farmer can only avail of his services during weekends and vacations.

Since the problem requires the use of man-day as the labor unit, it is necessary that the number of working hours be converted to man-days. For analysis purposes, it is assumed that 8 hours is equivalent to one (1) working day. However, to account for the possibility of farmers and their family working longer during certain months of the year, additional assumptions will be made. One is that farmers work 10 hours a day which is equivalent to 1.2 working days based on the first assumption, and the other is that farmers work longer during rainy season and shorter during dry season. Some farmers take advantage of the abundance of water during the rainy season while others take necessary precautions against flooding and other damages which may result from heavy rains and storms. Tables 18, 19, and 20 show the estimated amount of family labor available per month. The figures on the son's column are arbitrary. Months with fewer working days correspond to months during the school year. The total figures in each table plus the average size of farm comprise the constraint in the problem. These three assumptions will mean three levels of constraints.

2. Technical Coefficients

Technical coefficients are numbers which represent the amount of a resource needed to produce a unit of a given activity. They specify the extent to which an increase of one unit of each activity in the model will affect the level of a given restraint. They can be positive or negative.

TABLE 18

MONTHLY FAMILY LABOR AVAILABLE
(1 MAN-DAY = 8 HOURS)

Month	Farmer	Wife	Son	Total
May	24.81	18.77	24.81	68.39
June	24.02	18.18	24.02	66.22
July	24.81	18.77	12.01	55.59
August	24.81	18.77	8.0	51.58
September	24.02	18.18	8.0	50.20
October	24.81	18.77	8.0	51.58
November	24.02	18.18	8.0	50.20
December	24.81	18.77	12.01	55.59
January	24.81	18.77	12.01	55.59
February	22.40	16.98	8.0	47.38
March	24.81	18.77	8.0	51.58
April	24.02	18.18	12.01	54.21

TABLE 19

MONTHLY FAMILY LABOR AVAILABLE
(10 WORKING HOURS PER DAY = 1.2 MAN-DAYS)

Month	Farmer	Wife	Son	Total
May	29.77	22.52	29.77	82.06
June	28.82	21.82	28.82	79.46
July	29.77	22.52	14.41	66.70
August	29.77	22.52	9.60	61.89
September	28.82	21.82	9.60	60.24
October	29.77	22.52	9.60	61.89
November	28.82	21.82	9.60	60.24
December	29.77	22.52	14.41	66.70
January	29.77	22.52	14.41	66.70
February	26.88	20.38	9.60	56.80
March	29.77	22.52	9.60	61.89
April	28.82	21.82	14.41	65.05

TABLE 20

MONTHLY FAMILY LABOR AVAILABLE
(RAINY SEASON(MAY-OCT) - 10 WORKING HOURS PER DAY,
DRY SEASON (NOV-APR) - 8 WORKING HOURS PER DAY)

Month	Farmer	Wife	Son	Total
May	29.77	22.52	29.77	82.06
June	28.82	21.82	28.82	79.46
July	29.77	22.52	14.41	66.70
August	29.77	22.52	9.60	61.89
September	28.82	21.82	9.60	60.24
October	29.77	22.52	9.60	61.89
November	24.02	18.18	8.0	50.20
December	24.81	18.77	12.01	55.59
January	24.81	18.77	12.01	55.59
February	22.40	16.98	8.0	47.38
March	24.81	18.77	8.0	51.58
April	24.02	16.98	12.01	54.21

Positive coefficients signify a demand for the resources and other restraints while negative ones imply that an activity will add to the supply of a resource represented by a row.

Figures in Table 15 and 16 will play the part of the technical coefficients in this problem. Each number in these tables represents the amount of labor in each month required to produce a unit of a given activity corresponding to that amount.

In the case of land, since the activity unit is hectare, the land coefficient for each activity is 1 hectare. This means that a hectare of land is needed to produce a unit of activity corresponding to that coefficient.

3. The Objective Function

This paper deals with the problem of determining the combinations of 15 activities and considered which will maximize the income of an average farmer in Ilocos Region. In formula form. this problem can be written as:

$$\text{Maximize } Z = c_1X_1 + c_2X_2 + \ldots\ldots c_nX_n$$

This is the objective function. The letter Z represents the total income. X_i's correspond to each activity that will be considered and c_i's stand for the price of a unit of ith activity which may be in the form of prices or net income of each activity.

To have a clear picture of the objective function for this problem, it will be better to plug in some figures in the above formula. Hence,

Let: X_1 = Dry Rice

X_2 = Wet Rice

X_3 = Rice-Rice

. .

. .

X_{15} = Mungbeans

Therefore, from Tables 13 and 14, the values of c_i's can be derived as follows:

$$
\begin{aligned}
c_1 &= ₱\ 1099.51 \\
c_2 &= 1063.29 \\
c_3 &= 2131.23 \\
&\vdots \\
c_{15} &= 552.73
\end{aligned}
$$

c_i's in this case, stand for the GI-VC of each activity, thus:

$$
\text{Maximize } Z = 1099.51\ X_1 + 1063.29\ X_2 + 2131.23\ X_3 + \ldots\ldots + 552.73\ X_{15}
$$

c_i's in the above formula indicate how the total income (Z) will be affected by an addition of any activity. If X_1, for example, is equal to 1 hectare, then the addition of a hectare of dry rice will give ₱ 1099.51 more to the total income. If the farmer has only 1 hectare available, then only dry rice is being considered and the total income will be ₱ 1099.51.

4. The Problem Matrix

The objective function, the technical coefficients and the restraints can be put together to form a problem matrix as shown in Table 21. The values in the Z row are GI-VC of each activity. Each GI-VC stands for the c_i's in the objective function. These figures came from Tables 13 and 14. The values in the first column represent the amount of available resources or the restraints in this problem. Each Roman numeral corresponds to a resource level given below the problem matrix. These amounts of resources limit the size of each enterprise which is necessary to prevent the possibility of unlimited size. Figures in this column were derived from Tables 18-20. The values on the left hand side of the resource level and below

TABLE 21

PROBLEM MATRIX

	Resource Level	Dry Rice	Wet Rice	Rice-Rice	Rice-Corn	Rice-Cotton
Z		1099.51	1065.61	2131.23	1467.67	2678.84
Land*		1.0	1.0	1.0	1.0	1.0
May Labor**	I,II,III	.57	1.74	21.72	21.72	21.72
June "	I,II,III	-	10.42	40.53	40.53	40.53
July "	I.II,III	-	29.82	10.13	10.13	10.13
Aug. "	I,II,III	-	35.61	26.06	26.06	26.06
Sept. "	I,II,III	1.33	12.59	46.32	46.32	46.32
Oct. "	I,II,III	3.57	21.14	16.03	4.36	15.55
Nov. "	I,II,III	22.03	24.76	29.93	16.35	46.65
Dec. "	I,II,III	26.33	7.96	7.48	5.45	18.66
Jan. "	I,II,III	9.33	.724	19.24	6.54	26.44
Feb. "	I,II,III	15.60	-	34.20	21.80	48.27
Mar. "	I,II,III	18.23	-	-	-	-
Apr. "	I,II,III	5.90	-	-	-	-

* in hectares ** in man-days

RESOURCE LEVELS

	I	II	III
Land (ha.)	1.50	1.50	1.50
May Labor (man-days)	68.39	82.06	82.06
June Labor	66.22	79.46	79.46
July Labor	55.59	66.70	66.70
August Labor	51.58	61.89	61.89
September Labor	50.20	60.24	60.24
October Labor	51.58	61.89	61.89
November Labor	50.20	60.24	50.20
December Labor	55.59	66.70	55.59
January Labor	55.59	66.70	55.59
February Labor	47.38	56.86	47.38
March Labor	51.58	61.89	51.58
April Labor	54.21	65.05	54.21

TABLE 21-Continued

	Resource Level	Rice Tobacco	Rice Mungbeans	Dry Corn	Wet Corn	Corn Cotton
Z		3624.74	1609.21	415.53	403.42	2016.33
Land	I,II,III	1.0	1.0	1.0	1.0	1.0
May Labor	I,II,III	21.72	21.72	2.77	.04	3.52
June "	I,II,III	40.53	40.53	-	1.76	13.20
July "	I,II,III	10.13	10.13	-	3.92	4.40
Aug. "	I,II,III	26.06	26.06	.03	8.01	5.28
Sept. "	I,II,III	46.32	46.32	2.20	7.66	17.60
Oct. "	I,II,III	17.27	5.61	4.87	6.34	15.55
Nov. "	I,II,III	62.61	15.91	9.93	7.08	46.65
Dec. "	I,II,III	28.07	6.55	9.50	4.75	18.66
Jan. "	I,II,III	32.39	18.12	7.87	2.20	26.44
Feb. "	I,II,III	75.57	-	8.77	2.24	48.21
Mar. "	I,II,III	-	-	5.90	-	-
Apr. "	I,II,III	-	-	2.67	-	-

TABLE 21-Continued

	Resource Level	Corn-Tobacco	Corn-Mungbeans	Cotton	Tobacco	Mungbeans
Z		2962.45	946.90	1626.12	2574.06	552.73
Land	I,II,III	1.0	1.0	1.0	1.0	1.0
May Labor	I,II,III	3.52	3.52	8.90	13.53	.93
June "	I,II,III	13.20	13.20	.63	1.57	-
July "	I,II,III	4.40	4.40	-	-	-
Aug. "	I,II,III	5.28	5.28	1.97	.47	.23
Sept. "	I,II,III	17.60	17.60	12.97	2.63	.33
Oct. "	I,II,III	17.27	5.61	17.77	8.70	.80
Nov. "	I,II,III	62.61	15.91	20.83	29.93	2.23
Dec. "	I,II,III	28.07	6.55	25.07	38.20	9.73
Jan. "	I,II,III	32.39	18.72	20.40	25.40	5.47
Feb. "	I,II,III	75.57	-	13.70	40.50	10.47
Mar. "	I,II,III	-	-	15.67	31.67	14.60
Apr. "	I,II,III	-	-	17.60	23.40	2.00

the Z row represent the technical coefficients which are input-output coefficients assumed for each activity. Sources of these figures are Tables 15 and 16.

D. Interpretation of Results

There are three assumptions to be considered in the problem. Each assumption corresponds to a set of constraints which will be used in each problem matrix. Therefore, there will be three results which will be interpreted individually and compared thereafter. The land constraint is the same under all assumptions.

1. 1st Assumption - (Eight (8) hours = 1 working day)
(Relevant Data - Solutions 1A and 2A)

The most profitable organization calls for a profit of ₱ 3626.60. It includes only three activities namely, raising rice-mungbean, rice-tobacco, and tobacco. This organization used all of the available land which was allotted to each activity in the following manner:

Rice-Mungbean	-	.67 hectare
Rice- Tobacco	-	.39 hectare
Tobacco	-	.44 hectare
Total		1.50 hectares

This means 1.06 hectares of land would be devoted to rice during the rainy season and .67 to mungbean and .83 hectare to tobacco during the dry season.

The amount of resources used are shown in the Activity column of Solution 1A while the unused portion is indicated in Slack Activity column of the same section. It is obvious that all February and September labor and land were used. These are considered limiting resources each of which has shadow price as shown in the Dual Activity column. Shadow prices can be interpreted as the reduction in income resulting from a withdrawal of a unit of a limiting resource. Therefore, if a unit of February labor will

SOLUTION IA

LP APPLICATION IN PHILIPPINE FARMING

SECTION I ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	Z	BS	3626.60368	3626.60368 -	NONE	NONE	1.00000
2	MAYLAB	BS	28.96583	39.42417	NONE	68.39000	.
3	JUNLAB	BS	43.60231	22.61769	NONE	66.22000	.
4	JULLAB	BS	10.72472	44.86528	NONE	55.59000	.
5	AUGLAB	BS	27.79737	23.78263	NONE	51.58000	.
6	SEPLAB	UL	50.20000	.	NONE	50.20000	2.63991 -
7	OCTLAB	BS	14.33145	37.24855	NONE	51.58000	.
8	NOVLAB	BS	48.24266	1.95734	NONE	50.20000	.
9	DECLAB	BS	32.19474	23.19526	NONE	55.59000	.
10	JANLAB	BS	36.36553	19.22447	NONE	55.59000	.
11	FEBLAB	UL	47.38000	.	NONE	47.38000	26.67130 -
12	MARLAB	BS	13.97568	37.60432	NONE	51.58000	.
13	APRLAB	BS	10.32621	43.88379	NONE	54.21000	.
14	LAND	UL	1.50000	.	NONE	1.50000	1286.92940 -

SOLUTION 2A

LP APPLICATION IN PHILIPPINE FARMING

SECTION 2 COLUMNS

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
15	DRYRICE	LL	.	1099.51000	.	NONE	807.00280-
16	WETRICE	LL	.	1065.61000	.	NONE	454.55591-
17	RICRICE	LL	.	2131.23000	.	NONE	390.13840-
18	RICCORN	LL	.	1467.67000	.	NONE	722.97430-
19	RICECOT	LL	.	2678.64000	.	NONE	216.39328-
20	RICEMBE	BS	.66824	1609.21000	.	NONE	.
21	RICETOB	BS	.39047	3624.76000	.	NONE	.
22	DRYCORN	LL	.	415.53000	.	NONE	1311.11455-
23	WETCORN	LL	.	403.42000	.	NONE	1163.47487-
24	CORNCOT	LL	.	2016.33000	.	NONE	802.88513-
25	CORNTOB	LL	.	2962.45000	.	NONE	586.49185-
26	CORNMBE	LL	.	946.90000	.	NONE	586.49185-
27	COTTON	LL	.	1626.12000	.	NONE	260.44586-
28	TOBACCO	BS	.44129	2574.06000	.	NONE	.
29	MBEANS	LL	.	552.73000	.	NONE	1214.31913-

be removed from this organization, there will be a reduction of ₱ 26.67 in the total income. Similar interpretations would apply to September labor and land which have shadow prices of ₱ 2.64 and ₱ 1468.93 respectively.

Figures in the Reduced Cost column of Solution 2A correspond to the opportunity of each activity not included in the optimum organization. Like the shadow prices, opportunity cost is also a reduction in total income but there will be such reduction only if the farmer will force a unit of any excluded activity into the organization, hence, the total income will be reduced by ₱ 1,311.11 if the farmer grows a hectare of dry corn.

2. 2nd Assumption - (Ten (10) hours = 1.2 working days)
(Relevant Data - Solutions 1B and 2B)

The total value of this optimum organization is ₱ 3,905.95. The same set of activities as in the 1st assumption was considered. Again, all available land was used but this time, apportioning was as follows:

Rice-Mungbean	-	.65 hectare
Rice-Tobacco	-	.64 hectare
Tobacco	-	.21 hectare
Total	-	1.50 hectares

Rice will be grown in 1.29 hectares during the rainy season while during the dry season, there will be .65 hectare of mungbean and .85 hectare of tobacco.

The limiting resources and their respective shadow prices are the same as in the previous assumption. There is also no change in the opportunity cost of excluded activities.

3. 3rd Assumption - (10 working hours per day in Rainy Season and 8 hours per day in Dry Season)
(Relevant Data - Solutions 1C and 2C)

A similar set of activities was considered in this optimum organization but its total value is lower than the 2nd assumption and higher than the first which is ₱ 3,646.93. It also made use of all available land

SOLUTION 1B

LP APPLICATION IN PHILIPPINE FARMING

SECTION 1 ROWS

NUMBER	...ROW...	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	Z	BS	3905.95226	3905.95226-	NONE	NONE	1.00000
2	MAYLAB	BS	30.84790	51.21210	NONE	82.06000	.
3	JUNLAB	BS	52.55535	26.90465	NONE	79.46000	.
4	JULLAB	BS	13.05261	53.64739	NONE	66.70000	.
5	AUGLAB	BS	33.67797	28.21203	NONE	61.89000	.
6	SEPLAB	UL	60.24000	.	NONE	60.24000	2.63991-
7	OCTLAB	BS	16.52008	45.36992	NONE	61.89000	.
8	NOVLAB	BS	56.65359	3.58641	NONE	60.24000	.
9	DECLAB	BS	30.27148	36.42852	NONE	66.70000	.
10	JANLAB	BS	38.22886	28.47114	NONE	66.70000	.
11	FEBLAB	UL	56.86000	.	NONE	56.86000	26.67130-
12	MARLAB	BS	6.69789	55.19211	NONE	61.89000	.
13	APRLAB	BS	4.94887	60.10113	NONE	65.05000	.
14	LAND	UL	1.50000	.	NONE	1.50000	1486.92947-

SOLUTION 2B

LP APPLICATION IN PHILIPPINE FARMING

SECTION 2 COLUMNS

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
15	DRYRICE	LL	.	1099.51000	.	NONE	807.00280-
16	WETRICE	LL	.	1065.61000	.	NONE	454.55591-
17	RICRICE	LL	.	2131.23000	.	NONE	390.13840-
18	RICCORN	LL	.	1467.67000	.	NONE	722.97430-
19	RICECOT	LL	.	2678.64000	.	NONE	216.39328-
20	RICEMBE	BS	.64944	1609.21000	.	NONE	.
21	RICETOB	BS	.63907	3624.76000	.	NONE	.
22	DRYCORN	LL	.	415.53000	.	NONE	1311.11455-
23	WETCORN	LL	.	403.42000	.	NONE	1163.47487-
24	CORNCOT	LL	.	2016.33000	.	NONE	802.88513-
25	CORNTOB	LL	.	2962.45000	.	NONE	586.49185-
26	CORNMBE	LL	.	946.90000	.	NONE	586.49185-
27	COTTON	LL	.	1626.12000	.	NONE	260.44586-
28	TOBACCO	BS	.21149	2574.06000	.	NONE	.
29	MBEANS	LL	.	552.73000	.	NONE	1214.31913-

SOLUTION 1C

LP APPLICATION IN PHILIPPINE FARMING

SECTION 1 ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	Z	BS	3646.92773	3646.92773-	NONE	NONE	1.00000
2	MAYLAB	BS	30.40902	51.65098	NONE	82.06000	.
3	JUNLAB	BS	50.46759	28.99241	NONE	79.46000	.
4	JULLAB	BS	12.50977	54.19023	NONE	66.70000	.
5	AUGLAB	BS	32.30667	29.58333	NONE	61.89000	.
6	SEPLAB	BS	57.89877	2.34123	NONE	60.24000	.
7	OCTLAB	BS	14.88810	47.00190	NONE	61.89000	.
8	NOVLAB	UL	50.20000	.	NONE	50.20000	10.38349-
9	DECLAB	BS	28.64988	26.94012	NONE	55.59000	.
10	JANLAB	BS	36.47939	19.11061	NONE	55.59000	.
11	FEBLAB	UL	47.38000	.	NONE	47.38000	20.25461-
12	MARLAB	BS	8.39500	43.18500	NONE	51.58000	.
13	APRLAB	BS	6.20281	48.00719	NONE	54.21000	.
14	LAND	UL	1.50000	.	NONE	1.50000	1444.00873-

SOLUTION 2C

LP APPLICATION IN PHILIPPINE FARMING

SECTION 2 COLUMNS

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT	.REDUCED COST.
15	DRYRICE	LL	.	1099.51000	.	NONE	889.21892-
16	WETRICE	LL	.	1065.61000	.	NONE	635.49385-
17	RICRICE	LL	.	2131.23000	.	NONE	316.26428-
18	RICCORN	LL	.	1467.76000	.	NONE	587.65932-
19	RICECOT	LL	.	2678.64000	.	NONE	226.23332-
20	RICEMBE	BS	.75002	1609.21000	.	NONE	.
21	RICETOB	BS	.48491	3624.76000	.	NONE	.
22	DRYCORN	LL	.	415.53000	.	NONE	1288.45274-
23	WETCORN	LL	.	403.42000	.	NONE	1159.47415-
24	CORNCOT	LL	.	2016.33000	.	NONE	888.54332-
25	CORNTOB	LL	.	2962.45000	.	NONE	662.31000-
26	CORNMBE	LL	.	946.90000	.	NONE	662.31000-
27	COTTON	LL	.	1626.12000	.	NONE	311.66497-
28	TOBACCO	BS	.26508	2574.06000	.	NONE	.
29	MBEANS	LL	.	552.73000	.	NONE	1126.49971-

but the division was different.

Rice-Mungbean	-	.75 hectare
Rice-Tobacco	-	.48 hectare
Tobacco	-	.27 hectare
Total	-	1.50 hectares

The portion of land planted to rice during the rainy season will now be 1.23 hectares while .75 and .75 hectare will be grown to mungbean and tobacco during the dry season.

There is a significant change in the set of limiting resources. The optimum organization disregards September labor and considers November labor as one of its limiting resources. There are also changes in shadow prices. The shadow prices of February labor and land were reduced to ₱ 1,444.01 and ₱ 20.25 respectively while November labor has ₱ 10.38 as its shadow price. Opportunity costs are also changed but the highest and the lowest remain the same.

CHAPTER V

COMPARATIVE ANALYSIS OF THE RESULTS OF BOTH APPROACHES

Results of the cited study and the analysis made in Chapter III are not comparable because of two obvious reasons. First, the former considers only dry season crops while the latter includes rainy season and potential double crops. Second, the former's result was based on return to operator's resources which does not include some fixed cost while the latter used GI-VC where all fixed cost are included. To be able to compare the two approaches, it is necessary to have the same problem where they can be applied and the same set of criteria on which conclusions will be based. The writer considers the linear programming problem as more appropriate where both approaches can be applied since it has more alternatives and the situation is somewhat more realistic. Hence, an application of net return approach to the linear programming problem will be made.

In this paper, the writer considered the following as part of a bigger set which he called "Net Returns",

i) Return to Operator's Resources
ii) GI-VC
iii) Net Profit
iv) Cash Income less Cash Expenses

All these are concerned with that part of income in excess of whatever cost, be it fixed, variable or a combination of both. Since GI-VC was used in the linear programming problem being considered, it will be used as the basis for applying net return approach.

Results for both approaches are shown in Tables 22, 23, 24, and 25. Table 22 figures are mere ranking of activities based on GI-VC. Obviously,

TABLE 22

RESULT USING NET RETURN APPROACH

Rank	Activity	GI-VC/hectare (₱)
1	Rice-Tobacco	3624.76
2	Corn-Tobacco	2962.45
3	Rice-Cotton	2678.64
4	Tobacco	2574.06
5	Rice-Rice	2131.23
6	Corn-Cotton	2016.33
7	Cotton	1626.12
8	Rice-Mungbean	1609.21
9	Rice-Corn	1407.51
10	Dry Rice	1099.51
11	Wet Rice	1065.61
12	Corn-Mungbean	946.90
13	Mungbean	552.73
14	Dry Corn	415.53
15	Wet Corn	403.42

TABLE 23

RESULTS USING LINEAR PROGRAMMING
(IST ASSUMPTION)

TOTAL VALUE OF OPTIMUM ORGANIZATION = ₱ 3626.60 Land = 1.5 ha.

Rank	Activity	Activity Level (ha.)	Opportunity Cost	GI-VC (₱)
1	Rice-Mungbean	.67	-	1609.21
2	Tobacco	.44	-	2574.06
3	Rice-Tobacco	.39	-	3624.76
4	Rice-Cotton	-	216.39	2678.64
5	Cotton	-	260.44	1626.12
6	Rice-Rice	-	390.14	2131.23
7	Wet Rice	-	454.56	1065.61
8	Corn-Tobacco	-	586.49	2962.45
9	Corn-Mungbean	-	586.49	946.90
10	Rice-Corn	-	722.97	1467.67
11	Corn-Cotton	-	802.89	2016.33
12	Dry Rice	-	802.89	1099.51
13	Wet Corn	-	1163.47	403.42
14	Mungbean	-	1214.32	552.73
15	Dry Corn	-	1311.11	415.53

TABLE 24

RESULT USING LINEAR PROGRAMMING
(2ND ASSUMPTION)

TOTAL VALUE OF OPTIMUM ORGANIZATION = ₱ 3905.95 Land = 1.5 ha.

Rank	Activity	Activity Level (ha.)	Opportunity Cost	GI-VC (₱)
1	Rice-Mungbean	.65	-	1609.21
2	Rice-Tobacco	.64	-	3624.76
3	Tobacco	.21	-	2574.06
4	Rice-Cotton	-	216.39	2678.64
5	Cotton	-	260.44	1626.12
6	Rice-Rice	-	390.14	2131.23
7	Wet Rice	-	454.56	1065.61
8	Corn-Tobacco	-	586.49	2962.45
9	Corn-Mungbean	-	586.49	946.90
10	Rice-Corn	-	722.97	1467.67
11	Corn-Cotton	-	802.00	2016.33
12	Dry Rice	-	807.00	1099.51
13	Wet Corn	-	1163.47	403.42
14	Mungbean	-	1214.32	552.73
15	Dry Corn	-	1131.11	415.53

TABLE 25

RESULT USING LINEAR PROGRAMMING
(3RD ASSUMPTION)

TOTAL VALUE OF OPTIMUM ORGANIZATION = ₱ 3646.92 Land = 1.5 ha.

RANK	Activity	Activity Level (ha.)	Opportunity Cost	GI-VC (₱)
1	Rice-Mungbean	.75	-	1609.21
2	Rice-Tobacco	.48	-	3624.76
3	Tobacco	.27	-	2574.06
4	Rice-Cotton	-	226.23	2678.06
5	Cotton	-	311.66	1626.12
6	Rice-Rice	-	316.26	2131.23
7	Rice-Corn	-	587.66	1467.67
8	Wet Rice	-	635.49	1065.61
9	Corn-Tobacco	-	662.31	2962.45
10	Corn-Mungbean	-	662.31	946.90
11	Corn-Cotton	-	888.54	2016.33
12	Dry Rice	-	889.22	1099.51
13	Mungbean	-	1126.50	552.73
14	Wet Corn	-	1159.47	403.42
15	Dry Corn	-	1288.45	415.53

activities with higher GI-VC are better than those with lower GI-VC. The rice-tobacco enterprise can be regarded as the most profitable of all enterprises with wet corn as the least. Cotton and other activities with cotton are also highly profitable. Cotton, therefore, can compete effectively with rice, corn, and mungbean but not with tobacco, thus cotton is in a competitive position as far as this approach is concerned. This implies that cotton supporters can convince farmers growing crops whose GI-VC are lower than cotton related activities to plant these crops.

Although net return is a good basis in making farm decisions, other factors must be considered. One must also take into account those which may affect farm decision-making which include the following:

a. The necessity of growing such crop - As previously stated, rice is a staple food in Ilocos Region, therefore, farmers should grow rice to meet their needs. The same is true with other crops for human consumption.

b. The knowledge of growing each crop - Most farmers prefer to grow crops whose cultural requirements are not new to them. Growing tobacco, for example, may be the most profitable enterprise, but a farmer who is not well acquainted with this crop may not enjoy the maximum profit it offers.

c. Availability of resources necessary for each activity - Consider the three assumptions (Tables 18, 19, and 20) on the amount of land and family labor available to an average farmer in Ilocos Region. Consider also the amount of resource needed to produce a unit of each activity included in this problem (Tables 15 and 16). Such tables show that not all of the labor requirements of some activities can be satisfied by the amount of family labor available.

Farmers having the same level of resources as that in the 1st assumption will find that they cannot produce a unit of any of the following activities:

i) Rice-Tobacco
ii) Rice-Cotton
iii) Corn-Tobacco
iv) Corn-Cotton

To produce a hectare of rice-tobacco and corn-tobacco will require 62.61 and 75.57 man-days of labor in November and February respectively. Rice-cotton and corn-cotton enterprises also need 48.27 man-days of labor in February. The amount of available family labor for November is only 50.20 man-days while for February, 47.38 man-days. In both cases, there is a shortage of family labor during the months of November and February for rice-tobacco and corn-tobacco and during February for rice-cotton and corn-cotton. Assuming that there is no available labor to be hired, then it would be impossible to produce a hectare of these enterprises in order to get the maximum profit they offer.

In the 2nd assumption, the shortage of labor in November and February has affected two enterprises, rice-tobacco and corn-tobacco. The increase in the number of man-days is not sufficient to meet the labor requirements of these activities. The amount of family labor available is set at 60.24 for November and 56.36 man-days for February.

The activities affected in the 3rd assumption are the same as those in the 1st assumption (rice-tobacco, corn-tobacco, rice-cotton, and corn-cotton). There is no increase in the amount of family labor available in November and February.

This does not mean, however, that farmers cannot grow any of the four enterprises. They can, by limiting the hectarage to the amount of labor resources that they have. For example, they can produce .63 hectare (47.38/75.57 = .63) of rice-tobacco, thereby using all available February labor, that is, if they have the 1st or the 3rd assumption as their level of resources or based on the 2nd assumption, they can grow .75 hectare of rice-tobacco (56.86/75.57 = .75). In this case however, they are not using their resources wisely and they are not maximizing their profit. In producing .63 hectare of rice-tobacco, for example. all of the February labor will be used up while leaving some of the resources idle (like .83 hectare of land). The total income is only ₱ 2,283.60 (₱ 3,624.76 x .63).

The farmer has to find efficient ways of allocating his resources to enterprise or enterprises which will give him maximum profit. The use of net return is good only if all the necessary resources are available whereas linear programming techniques efficiently allocate the scarce resources to enterprise or enterprises which will give maximum return to the farmer.

Tables 23, 24, and 25 show the results from linear programming application in Chapter III. Each table has corresponding assumed resources level. Ranking was based on the importance or insignificance of each activity to the plan. Importance is measured by the amount of land allotted to each activity, (the bigger the allotment, the more important the activity is) while the insignificance is gauged by the opportunity cost attached to each activity (the bigger the opportunity cost, the more significant is the activity).

In all three tables, only three activities are considered important and the rest insignificant. The GI-VC column indicates that the plan did not consider the size of GI-VC. Rice-mungbean, for example, is only 8th in the GI-VC ranking in Table 22 but is considered the most important activity in all three plans. Cotton related crops are not included in the optimum organization which implies that competition is not only in terms of net return but also in terms of the amount of available resources in relation to what is necessary to produce a unit of each activity.

In using linear programming as a tool, there are certain things to remember. First, the activity with the highest net return but uses the least amount of resources is expected to dominate in the optimum plan. On the contrary, the activity with the lowest net return and uses more resources than any other activity will be excluded from the optimum organization. It is also possible for the activity with a low GI-VC but uses the least amount of resources to be included in the optimum plan. This explains why rice-mungbean is included in the plan. Although its GI-VC is lower than most activity, mungbean as previously noted, is the least labor intensive crop in this problem. Second, a resource which limits the production of most of the activity more than the others is considered as the most critical resource. February labor is the critical resource in this problem because it is the most limiting. For example, rice-tobacco, the activity with the highest GI-VC but requires a lot of February labor, is not the most important activity in the optimum organization.

Comparing the two approaches, both are concerned with the concept of profit maximization. The net return approach offers a good ground for comparison only if there are no other data available, e.g., only net returns are given. It does not consider the relationship between the amount of available resources and the need for these resources by each activity, but it offers a good starting point for analyzing the performance of enterprises. On the other hand, linear programming techniques offer perhaps the most efficient way of allocating scarce resources at the same time maximizing income. It eliminates most of the problems which occurred in the net return approach.

A. Linear Programming Application to Food Programs

Linear programming techniques can also be used in determining the adaptability of new farm technology. In the Philippines, there are several government food production programs which require the use of new technology. A good example is the Masagana 99 rice production program. Studies revealed that inspite of the numerous benefits (like high yield, support prices on produce, subsidized prices on inputs, non-collateralized and low interest on production loans, free extension services, etc .....) which can be derived from the program, some farmers are still reluctant to join. One reason is that those farmers prefer their old "reliable", least capital intensive technology than the Masagana 99 technology. There are rice producing areas which are not included in the program but are being targetted by the implementing government agency for inclusion in the program. One way of finding this is by testing if the Masagana 99 technology can compete with the commonly used technology in that area. This can be done through linear programming. The targetted area can be surveyed to get information on the commonly used cultural practices and the available resources. The support price of the program and the average price can be used as the price for the model. From this, a model can be built where activities to be considered are the Masagana 99 rice and the traditional rice. These are the competing activities. Average available resources which will serve as constraints may include labor, capital and land.

The resulting data will show if the program is feasible or not. If it is not feasible, the reason is also shown in the resulting data. The probable reasons are limited capital and lack of available labor in certain months. There are some indications that Masagana 99 technology requires more labor. This is because it entails the use of high yielding varieties (HYV) which need more fertilizer and chemicals, proper spacing, proper land preparation and others. The problem of labor unavailability was cited as an important barrier to adoption of new farm technology in the U.S.A.I.D. paper[10]. Capital deficiency is being attended to by the government through the inclusion of supervised credit scheme in the program. With this scheme, program participant can avail of a low interest, non-collateralized production loan.

Masaganang Maisan, an intensified white corn and feedgrain production program, is another area where linear programming can be of help. It includes crops such as white corn, yellow corn, sorghum, and soybeans. The linear programming technique can be used to determine which of the four (4) crops can be grown in a given programmed area. In this case, only information on average yield, input availability, and average resources available are needed. In the said program, there is a recommended technology tailored for each crop. These technologies will serve as the competing activities.

Masagana 99 and Masaganang Maisan are two of several food programs of the Philippine government. What has been suggested in this paper can also be applied to other programs.

---

[10] W.A. Schutjer and M.G. Van Der Veen, Economic Constraints on Agricultural Technology Adoption in Developing Nations (Washington, D.C., USAID Occasional Paper No. 5, 1977), p. 16.

Other program problems which require selection among numerous alternatives include fertilizer and chemical allocation, cost minimization, determination of the proper rate of interest, supply and demand determination, and product distribution. The writer plans to employ linear programming to some of the above problems in the future.

B. Limits in the Use of Linear Programming

The above discussion illustrates the usefullness of linear programming not only as an analytical tool but also as a guide in planning. Like any other tool, linear programming has its limitations. There are areas where this method cannot offer any assistance or solution. Beneke and Wintereboer[11] have enumerated some limitations in the use of this method.

1. Linear programming cannot be used in price expectation formulation. Once a given price is chosen as the price of the model, that price will be used in determining the most efficient way of allocating resource. Thus, it is very important that such price has an accurate basis. Using a lower price than the expected would make the activity appear less profitable.
2. There is difficulty in specifying the constraints. Plans are being prepared in advance. It is hard to predict how much labor will be available in the months ahead. The supply of hired labor is somewhat unpredictable. This makes it hard for operator using credit to prepare his plan.
3. One important assumption in a linear programming problem is that each additional unit of output will need the same amount of input.

---

[11] Raymond R. Beneke and R.W. Wintereboer, Linear Programming Application to Agriculture (Ames, Iowa: The Iowa State University Press, 1973), p. 7-9.

This implies that the law of diminishing marginal productivity does not hold. It has been a common knowledge that adding more fertilizer to a hectare of crop will increase its production only to a certain point where it levels off and starts to diminish. However, this problem can be avoided by treating crops with a certain level of input as a separate activity.

4. Risk is not considered in a linear programming procedure. Information or price expectation and input-output relationship are regarded as reliable once entered into the model, hence, all enterprises are dealt with as if there is no risk attached to them. However, the degree of risk can serve as basis in considering activities.

Two of the above limitations deal with the data problem (1 and 2). These, the writer believes, together with other data problems, will serve as a restraint in the use of linear programming in the Philippines. This method requires some degree of accuracy on the necessary data, the collection of which is not easy. Some farmers are reluctant in giving the right information. In getting data on yield, for example, a farmer may understate his yield if he thinks he will be taxed or overstate it if he is competing for the "Farmer of the Year" contest.

Generally, farmers do not keep track of their daily farm activities, hence, they give just an estimate of everything. Sometimes these estimates are way above the actual figure so using them will give unreliable results. For example, a farmer may give an overestimate of the amount of labor used in a given crop. If the researcher used this amount as the labor required for that crop where the amount of labor available is less than what is needed, then it will make labor the most limiting resource when it is not.

The succeeding chapter will present some guidelines on data collection with the proposal for linear programming application to other related research. In order to build a more realistic model, one has to solve the above data problems first.

CHAPTER VI

PROPOSALS AND CONCLUSIONS

A. Proposal for Linear Programming Applications to Studies Conducted and to be Conducted

The writer proposes that linear programming be applied to research dealing with problems such as those discussed in this paper. This proposal is specifically addressed to the Special Studies Division of the Ministry of Agriculture which does all the research for the said ministry with which the writer is connected. To those who will implement this proposal, this paper will provide some guidelines on how linear programming can be applied in addition to what has been discussed in this paper.

1. Guidelines for Linear Programming Application

There are numerous studies in the Philippines which are concerned with problems requiring choices among many alternatives. A good example is the study presented in this paper. Information provided by these studies are considered secondary data which can be analyzed further. However, careful analysis must be done before applying the linear programming approach. The following suggestions can be of help.

a. Know what the study is all about - Obtain an overview of the conditions existing in the study area. Try to get all necessary information and determine the feasibility of applying linear programming as an alternative way of analyzing the results.

b. If linear programming application is feasible, rephrase the objective so that it conforms with a linear programming problem (maximization or minimization). Such objective must be stated in quantitative terms. In some cases, a study may have several objectives. If possible, try to limit the number of objectives by choosing those which are transformable to a linear programming problem. All objectives must be precisely defined.

c. Analyze the data presented - Isolate the variables relevant to the achievement of goals. Determine which of these factors are controllable and which are not. The strategies or alternative ways are therefore separated from other irrelevant variables. In such case, one has to be extra careful so as not to distort the whole picture while discarding some data. Variables isolated will soon become part of the model. It is possible that some necessary data are not in the study. If this is the case, be sure that there is a ready source for the missing information before going any further. Assumptions can be used as alternative information.

d. Formulate a functional relationship between the variables and the objectives. From b and c, a model can be constructed. This model must present the empirical situations existing in the study although some modifications may be made in order to improve the situation. One must be certain about what kind of relationship must exist between the variables, i.e., technical coefficients and constraints, goals, and the price of each activity.

e. Obtain results by manipulating the data. Models can be used to represent the real world. One cannot manipulate the real world to determine the results of alternative courses of action but he can manipulate his mathematical concept of the real world situation which is the model. The purpose of manipulating the model is to determine what will happen, if for example, a given level of resource is increased or decreased, or the price of a given activity is increased. Given the model, numerical solutions to the problem are calculated. Big or complicated problems may require the use of computers.

f. Interpret the result and determine its implication to the real world. Not all results are applicable to real situations. One must first know the consequences of such result. The exclusion of an important enterprise in the optimal plan may have some bad effects on existing organization, i.e., exclusion of a staple food crop such as rice or wheat. If this is the case, he has to continue manipulating his model until he finds the most appropriate solution.

2. Guidelines in Data Collection

The insufficiency of information provided by the study cited in this paper illustrates the need for efficient data collection. One must have some basis for data collection such as theory and assumption. If one, for example, seeks to collect data on the cost of an operation with the intention of reducing costs, he should be operating on at least an assumption if not a theory. Otherwise, the rationality of his approach is questionable. Assumption and theory are guides in the collection of data needed in the analysis. In a linear programming problem, for example, specifically maximizing profit problem, data collected should be relevant to the given problem and the theory to be used can be MR = MC - - where the profit is being maximized. The following guidelines can be used in the collection of data needed in a linear programming problem.

a. Define the objective. The first and perhaps the most important task for the researcher is to develop a concise statement of the objective or the problem. Most frequently, data collection activities are geared towards providing answers for management on problems they encounter and anticipate.

b. Once the objective is established, the researcher must formulate assumptions or use a theory which is relevant to the given objective. In the problem of profit maximization, for example, the data necessary are those pertaining to operating cost and return of the concerned enterprise or enterprises in order to apply the thoery, MR = MC. Theory and assumptions give direction to the kind of data to be collected, hence, minimizing the collection of unnecessary data.

c. A researcher can also plan ahead. He can work backward by planning the data to be collected in terms of the model to be constructed. This will enable him to analyze whether or not he is on the right track.

d. The use of assumption and theory - assumption should be used if theory is inadequate. If assumptions have to be used, it is logical to make them explicit to allow for their critical examination. As long as the assumptions are implicit, one is in danger of using those which are not only unrealistic but also illogical.

If one can find a pertinent theory as a guide in collection and interpretation of data, this would be an ideal situation. In most cases, however, assumptions are used to supplement theory.

e. Length of planning period. Once the planning period is established, the researcher should use it as a guide in the collection of data. For example, if he is concerned with the problem of profit maximization, he must have in mind the length of time involved in the operation of the enterprises in question.

f. If possible, use one standard for each enterprise. For example, if a researcher is interested in analyzing the operation of several crops, he must be consistent with the unit of activity he will use. If he chooses hectare, for example, he must collect data on a per hectare basis, i.e., amount of labor per hectare, fertilizer application per hectare, etc... This will help him analyze his data easier.

g. The use of format. The researcher may be better off if he prepares a format wherein he can enter collected data. This will make editing and computations easier because the data are in their proper places.

These are few guides in data collection. The researcher must use his judgement in knowing what is proper as long as he does not deviate from his goals.

B. Conclusion

This paper has shown and enumerated the advantages of using linear programming techniques over the use of net returns in comparing the performance of two or more enterprises. As indicated earlier, net return offers a good starting point for analyzing performance only if no other data are available, that is, if only net return is given. Linear programming is considered a better approach since it takes into account the availability of resources in relation to the need of each enterprise. Its applicability to food programs and other research has motivated the writer to propose its application to the Philippine environment. The writer believes that there is more to gain in its application especially in terms of better solutions to some agricultural problems being faced by the government.

Should the Ministry of Agriculture decide to adopt this method, it must first formulate a plan where it can solve the data problem. For example, it can revive its previous scheme of distributing log books to randomly selected farmers where they can record their day-to-day activities. (However, this may not be possible for farm families where nobody can read and write.) In doing this, farmers should be properly notified on the purpose of the scheme and they must be assured of confidentiality or anonymity of any information they provide. This can be done best if the farmers will be given some incentives. This day-to-day activities can include all information needed to build a model depending on the purpose. If the objective is to find the most profitable crops in an area, the log book must contain information on the production, labor usage, fertilizer and chemical use, members of the family who are working in the farm and others. This scheme can provide a ready source of more reliable information for the ministry, hence, solving the data problem.

The two major constraints in the adoption of this method are the lack of skills and facilities. Lack of skills can be solved through seminars or sending qualified employees to institutions where its application is being taught. The second problem will exist if there are big and complicated problems which will require the use of computers. However, most government agencies in the Philippines are now gaining access to computers, hence, this will not pose a big problem to its implementation. It is the intention of the writer to initiate its application as soon as he gets back to the Philippines.

SELECTED BIBLIOGRAPHY

Agrawal, R.C. and Heady, Earl O. Operations Research Methods for Agricultural Decisions. Ames, Iowa; The Iowa State University Press, 1972.

Beneke, Raymond R. and Winterboer R.W. Linear Programming Application to Agriculture. Ames, Iowa; The Iowa State University Press, 1973.

Levin, L.I. and Lamone, R.P. Linear Programming for Management Decisions. Homewood, Illinois; R.D. Irwin Inc., 1969.

Hughes, Ann J. and Grawoig, Dennis E. Linear Programming: An Emphasis on Decision Making. Reading, Massachussetts; Addison Wesley Publishing Company, 1973.

International Labor Organization. Sharing in Development - A Programme of Employment, Equity and Growth in the Philippines. Manila, Phil.; National Economic and Development Authority, 1974.

Long, E.J. Labor Foundations of Wisconsin Family Farms. Unpublished Ph.D. dissertation, University of Wisconsin, 1944.

National Economic and Development Authority. 1977 Philippine Statistical Yearbook. Manila, Philippines; NEDA, 1977.

Oliva, L. Demand Analysis of Animal Foods in the Philippines. Unpublished M.S. Thesis, University of the Philippines College of Agriculture, 1971.

Philippine Council for Agriculture and Resources Research. Philippines Recommends for Tobacco. Los Banos, Laguna, Phil.; PCARR, 1976.

Schutjer, W.A. and Van Der Veen, M.G. Economic Constraints on Agricultural Technology Adoption in Developing Nations. Washington, D.C.; United States Agency for International Development, 1977.

Van Der Veen, M.G. Analysis of Interfarm Variation in Rice Yields: An Economic Study of High Yielding Rice Production in Cavite Province. Unpublished Ph. D. dissertation, The Pennsylvania State University, 1975.

LINEAR PROGRAMMING: ITS APPLICATION IN THE PHILIPPINES

by

HERMINIGILDO MONTEMAYOR MONTALVO

B.S.C., Philippine College of Commerce, 1973

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Agricultural Economics

Department of Economics

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1979

The application of linear programming in the field of agriculture is gaining popularity. Its ability to solve numerous resource allocation problems makes it the most widely used mathematical tool nowadays. Its application to researches as an alternative method of relating performance of two or more enterprises is the main concern of this paper. Linear programming was compared with net return approach which was used in the analysis of the results of the survey "Comparative Input, Output and Financial Data for Virginia Tobacco, Palay, Mongo, Corn, and Cotton in the Ilocos Region" to determine the profitability of growing cotton over the raising of other crops such as tobacco, corn, rice, and mungbean.

The comparison indicated that application of linear programming to such survey gave better results. Net return offers a good ground for comparison only if there are no other data available, that is, only data on net return are given. Linear programming, on the other hand, considers the relationship between the availability of resources and the enterprise requirements for each resource.

This paper also considered the application of linear programming to food programs and other areas of research in the Philippines. Some limitations to its use were also discussed.

The author proposed its application to other related research and surveys conducted and to be conducted. To those who intend to use linear programming in the analysis of research data, some guidelines were presented in this paper.