PREDICTION OF INCOME ON PEASANT FARMS IN ANDEAN ECUADOR

by

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ABSTRACT:

It is the purpose of this study to determine empirically the contribution of a set of variables to the observed variation in income per hectare on 100 peasant farms in Ecuador. Specific consideration will be given to the relationship between farm size and farm productivity.

Twenty-four characteristics were chosen to describe the structure of peasant agriculture. An examination of the distribution of each characteristic over the 100 farms illustrated the heterogeneous nature of the farm sample. Regression analysis applied to the sample at the aggregate level yielded poor results. Large amounts of variability in the dependent variable remained unexplained, and the standard error of the estimate was relatively large in comparison to the observed mean value of the dependent variable. The model was improved when the sample was disaggregated by region, although the standard error remained high which greatly weakened the potential of the model as a predictor equation.

To increase the power of the regression model, and to more effectively analyse the significance of the set of variables to variation in farm income, it was decided to type the farms using factor analysis.

Principal axes factor analysis was performed on the matrix of correlation coefficients for the twenty-four standardized characteristics. The factors were then rotated using varimax rotation to obtain a more simplified loading matrix. Eight primary factors were produced which together accounted for 62.25 percent of the variance in the original matrix. Ward's hierarchical grouping algorithm was then applied to the matrix of factor scores for the principal eight factors, and a classification containing fourteen types of farming activity was produced.

The relationship between income and farm size was then reconsidered by farming type. There was a slight improvement in the power of the model applied to farm type although the amount of explained variability remained small. Simple regression of income per hectare on farm size, then, failed to explain a large proportion of the variance in the dependent variable even when the sample was considered by farming type.

In order to reduce the measure of 'non-explained' variability in the dependent variable, and to increase the potential of the regression model as a predictor equation, income per hectare was regressed on the rotated factors. Multiple step-wise regression was performed on (a) the complete sample, (b) the sample disaggregated by region, and (c) two major farming types. The multiple step-wise regression model greatly increased the amount of explained variability in the dependent variable and indicated the significance of the contribution of each independent variable to variation in income per hectare on the farms.

The study is presented in five parts:

Chapter 1 introduces the problem to be analysed.

Chapter II presents the data base, and a simple linear regression analysis examines the relationship between income and farm size on the 100 farms. The results of the regression performed on the aggregate level are poor. The analysis is then repeated on the sample disaggregated by region. The power of the model is greatly increased when the sample is divided into regional subsets, but large amounts of variability are left unexplained and the standard error of the estimate remains high.

Chapter III groups the 100 farms according to a typology based on an analysis of the structural and economic organization of the farming unit. A correlation analysis is performed on the twenty-four characteristics and simple correlations between the data are considered. Factor analysis is then performed on the matrix of correlations, and the major dimensions of variation in the data are enumerated. Finally, a grouping algorithm is applied to the matrix of factor scores on the principal factors, and a classification of the farms is produced.

Chapter IV reconsiders the relationship between income and farm size by farming type. Multiple step-wise regression then examines the contribution of a set of variables to variation in income per hectare.

Chapter V summarizes the merits and weakness in the methodological approach of the study and enumerates the major findings of the analysis.

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CHAPTER I

INTRODUCTION

> "Land reform is one of the cornerstones of agricultural policy in most underdeveloped countries...The core relationship in this entire problem is that between size of operating unit and productivity."

The two most common policy measures adopted in land reform programmes in underdeveloped countries are: (a) a redistribution of large landholdings into smaller farm units, and (b) the combination of a number of smaller units into larger co-operative farms. These alternate policies are rationalized on the basis of arguments advocating or opposing small-scale farming. The adoption of either measure requires an understanding of the functional relationship between farm size and farm productivity.

Long (1961) cautions that the generally accepted premise in American literature of increased efficiency with increased farm size cannot be inferred in studies of agricultural production for most underdeveloped countries. Increased efficiency in terms of higher returns to managerial contributions is not meaningful in the context of peasant farming where almost all production factors are limiting except labour. In his study of gross output per acre by size of farm in India, Long illustrated the inverse relationship to hold true. Where size of farm increased, there was an associated drop in farm productivity.

The phenomenon of higher production on smaller plots represents an adjustment to relatively small amounts of land per family worker. Kanel (1967), in an attempt to provide a theoretical explanation for this inverse relationship to productivity, employed a production function in which output depended on four types of input: (1) labour, (2) land, (3) labour-saving capital, and (4) land-saving (yield-increasing) capital. Comparing the least cost combination of labour and capital for peasant farms in India in comparison with North American farms, he concluded that the adoption of yield-increasing as opposed to labour-saving technology, was the more appropriate to early stages of economic development.

> On small farms the basic economic decision is how to obtain the most income from the available family labour and other family owned resources. Since acres per worker and not size of farm is the variable directly responsive to changing factor prices, the size of farm need not necessarily increase in the course of economic development.

Discussing the needed redirection in economic analysis for agricultural development policy, Dorner (1971) criticises the inappropriate solution of farm enlargement and mechanization where there is surplus agricultural labour and a shortage of working-capital. He contends that one of the initial responsibilities of non-industrialized countries is to increase efficiency of production while maintaining maximum employment.

Grunig (1969) in examining development alternatives to the minifundio problem in Colombia, enumerates specifically this priority of employing yield-increasing technology as an instrument in the transition of the minifundio structure to entrepreneurial status. He considers an evaluation of the productivity of alternate farm enterprises to be an important step in land reform programmes.

It is with a view to this discussion that the present study examines the structure of peasant farming in Ecuador. One hundred farms representing several different forms of agricultural activity in the mountains are analysed. Initially, the question of land division or consolidation in reform policy is considered by studying the functional relationship between farm size and observed variation in farm income. The strength and direction of the relation is evaluated by a simple linear regression model. It is anticipated that the phenomenon of higher productivity on smaller plots will be characteristic of the sample of Ecuadorian farms.

The study then addresses the second question of alternate development policy through increased productivity. The significance of the contribution of crop and livestock production to overall farm productivity is analysed in a multiple regression model. This is completed first, for the complete sample and for four regions, and then for two farming types which were identified earlier by way of multivariate analysis. In addition, the effect of three farm attributes on the level of income is considered.

CHAPTER II

SIMPLE RELATIONSHIP BETWEEN INCOME AND FARM SIZE FOR COMPLETE SAMPLE

A. The Data Base:

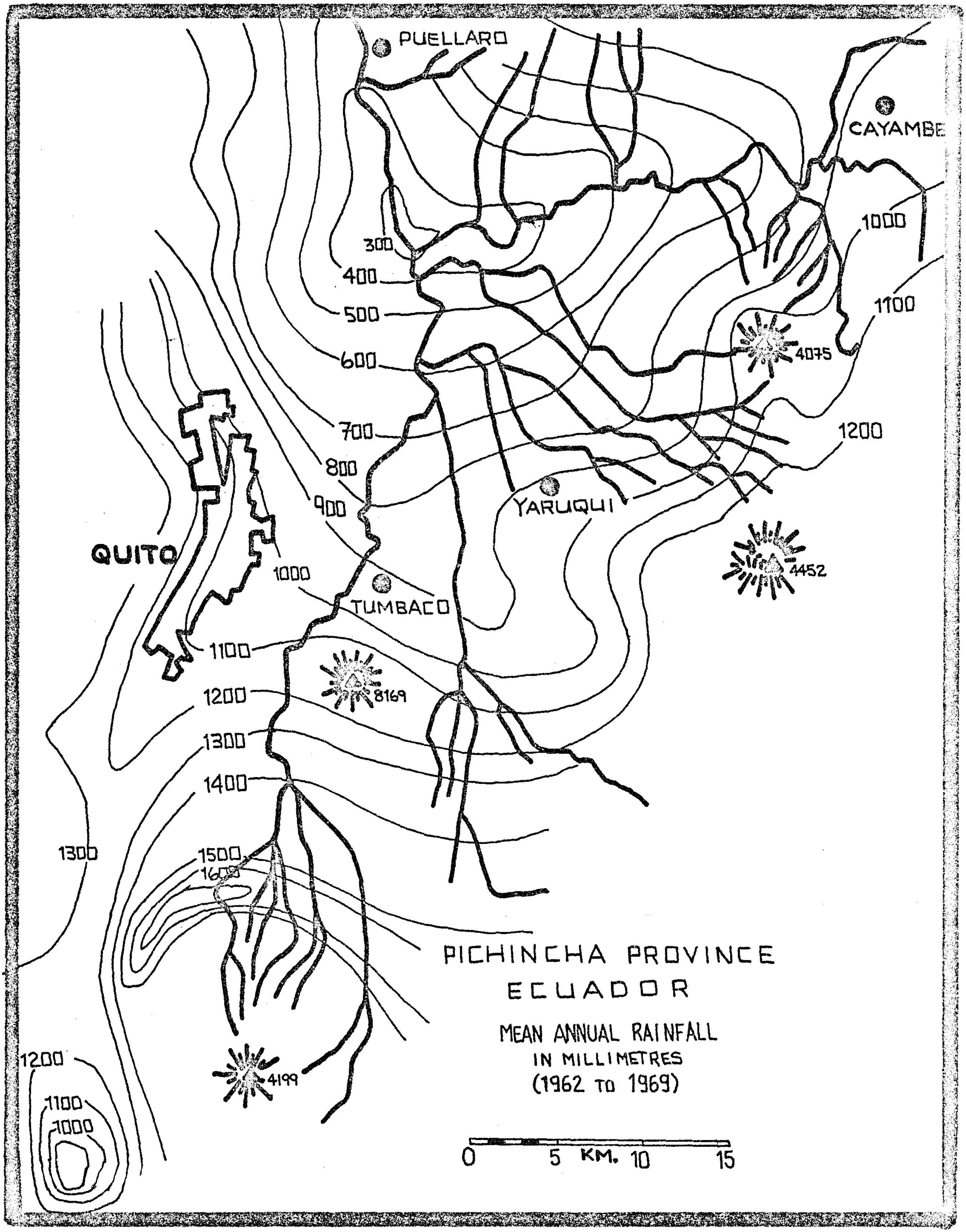
The 100 sample farms occur in four separate regions surrounding the capital city, Quito, in the Sierra portion of the Province of Pichincha, Ecuador. The regions, and the farms within the regions, were selected by an agronomist so as to represent all major forms of peasant agriculture occuring in the area. A questionnaire was individually completed with each farm family during a four month period in the summer of 1971. Table 1 lists the four regions in the study and the corresponding sample size.

TABLE 1

FARM SAMPLE

REGION AND IDENTIFYING NUMBER	SAMPLE SIZE FOR THE REGION
1. Yaruqui	31
2. Tumbaco	12
3. Cayambe	31
4. Puellaro	26

In subsequent analysis, each farm is identified by a pair of reference numbers such that the first number represents the locality and the second number identifies the farm. For example: (3:11) refers to the eleventh farm within the third region which is Cayambe.



Batchelor (1971)

The accompanying map of the Quito portion of Pichincha Province, Ecuador, illustrates the location of the four regions considered in this study. Ratford (1971) listed the distance in kilometers from each region to Quito, and, in addition, estimated the accessibility of the regions by calculating the road cost for a five ton truck travelling to the capital city. The measures were as follows:

REGION	DISTANCE TO QUITO	ROAD COST TO QUITO
1. Yaruqui	32.5 km.	$3.989 U.S.
2. Tumbaco	14.0 km.	$0.947 U.S.
3. Cayambe	75.4 km.	$9.690 U.S.
4. Puellaro	45.6 km.	$6.860 U.S.

Yaruqui and Tumbaco have drier climates than the Cayambe region, although they are not as subtropical as Puellaro. The Yaruqui region, generally, has a dry Sierran soil of coarse texture and suffers from soil erosion. Tumbaco is more moist. The soils are deeper and have a moderately high fertility. Cayambe has the most humid climate of the four regions. The moist Sierran soil is deep and has moderately high fertility, although the region suffers from poor drainage. In contrast, Puellaro is subtropical. Soils in the region are dry and very coarse with the accompanying problem of high soil erosion.

Farm samples selected within each region are not widely dispersed, and were chosen to represent all major types of farming observed in the area.

Twenty-four characteristics were chosen to describe the structure of peasant agriculture. Eight variables describe selected farm attributes. The remaining sixteen variables record income from each type of crop and livestock production in addition to 'other' income earned apart from the farm.

Farm Attributes

Table 2 illustrates the variation and spread of farm attributes over the 100 farms. Six farms are each operated by a single person; three farms support thirteen persons. More commonly, however, the farm-family has seven members. The variables describing the use of (1) chemicals, (2) tractors, (3) irrigation, (4) hired hands, and (5) off-farm employment, are not qualified by a measure of magnitude. Responses were recorded as yes/no alternatives. Considered generally, however, the 100 farms have a moderate level of technology and their incomes are supplemented in the majority of cases by off-farm employment.

Production cost records the capital invested in rental of a tractor, rental of irrigation, payment of hired hands, purchase of chemicals, purchase of feeding, and veterinary expenses. The median production cost per hectare for the 100 farms is S/1,128.00 or $43.02. This is approximately one sixteenth of the median gross income per hectare. Machinery cost indexes any new purchase of farm equipment. Three-quarters of the farms did not indicate any expenditure of this nature for the preceeding year.

TABLE 2

DISTRIBUTION OF FARM ATTRIBUTES

A: Family Size

minimum score	1.0	extreme farms: high
maximum score	13.0	
range in score	12.0	(4:10)(4:11)(2:6)
upper quartile	8.0	
median score	7.0	extreme farms: low
lower quartile	4.0	
		(1:6)(1:17)(1:18)
mean score	6.6	
standard deviation	2.9	(3:17)(4:13)(4:23)

B: Technology and Employment

	YES	NO
use of chemicals	31	69
use of tractor	64	36
use of irrigation	35	65
use of hired hands	56	44
off-farm employment	69	31

C: Production Cost

minimum score	0.00	extreme farms: high
maximum score	14088.00	
range in score	14088.00	(3:11)(4:17)(4:2)
upper quartile	2040.00	
median score	1079.50	extreme farms: low
lower quartile	375.00	
		(2:5)(2:13)(3:22)
mean score	1525.33	
standard deviation	1876.00	(4:8)(4:11)(4:14)(4:15)

D: Machinery Cost

minimum score	0.00	
maximum score	1128.00	
range in score	1128.00	extreme farms: high
upper quartile	0.00	(3:11)(1:24)(1:11)
median score	0.00	
lower quartile	0.00	extreme farms: low
mean score	56.25	77 farms record
standard deviation	157.36	no expenditure

Farm Incomes

There are three major forms of income: (1) gross income from crop production, (2) gross income from livestock production, and (3) 'other' income earned apart from the farming operation. Each income is expressed as a percentage of the total gross income.

Eleven types of crop production were observed on the peasant farms: vegetables, mixed beans, alfalfa, fruit, corn, beans, peas, lima beans, potatoes, wheat, and barley. The gross income obtained from each crop was calculated by adding the value of crop sales to the value of crop consumption.

Four types of livestock production were recorded on the farms: pig-raising, chicken-raising, cattle-raising, and sheep-raising. The gross income for each type of livestock production was calculated by adding the value of livestock and produce sales to the value of livestock and produce consumption.

'Other' income represents income earned independently of the farming operation in off-farm employment or in the rental of farm equipment.

Table 3 illustrates the distribution of crop and livestock incomes on the 100 farms. Farms with the highest scores on each type of income are enumerated for an initial indication of farm specialization in the sample.

TABLE 3
DISTRIBUTION OF INCOMES
FROM CROP AND LIVESTOCK PRODUCTION:

VARIABLE	NUMBER OF FARMS	UPPER QUARTILE	MEDIAN SCORE	LOWER QUARTILE	RANGE	MEAN SCORE	STANDARD DEVIATION	EXTREME FARMS (HIGH)
% inc. from vegetable	12	0.00	0.00	0.00	26.10	1.01	3.98	(1:24)(3:15)(4:14)
% inc. from mixed beans	2	0.00	0.00	0.00	21.11	.17	1.26	(2:13)(2:15)
% inc. from alfalfa	14	0.00	0.00	0.00	10.03	.48	1.54	(2:13)(2:12)(2:08)
% inc. from fruit	16	0.00	0.00	0.00	90.91	6.65	20.20	(3:17)(3:24)(3:16)
% inc. from corn	59	9.67	1.97	0.00	77.42	8.55	14.70	(1:8)(1:13)(1:3)
% inc. from beans	47	5.38	0.00	0.00	30.93	3.99	6.81	(1:15)(4:26)(3:15)
% inc. from peas	21	0.00	0.00	0.00	20.60	1.51	3.99	(2:1)(1:13)(1:11)
% inc. from lima beans	28	.57	0.00	0.00	8.64	.72	1.60	(4:26)(1:16)(1:26)
% inc. from potatoes	54	7.28	.96	0.00	53.32	6.57	11.61	(3:2)(3:27)(3:29)
% inc. from wheat	31	4.25	0.00	0.00	93.01	5.99	14.99	(3:5)(3:3;)(1:17)
% inc. from barley	39	1.48	0.00	0.00	33.02	2.13	5.06	(4:4)(4:3)(4:22)
% inc. from pigs	61	24.54	10.69	0.00	89.14	14.68	17.92	(1:27)(1:28)(6:15)
% inc. from chickens	64	17.95	15.08	0.00	93.24	10.78	15.16	(3:11)(1:4)(1:29)
% inc. from cows	49	22.28	0.00	0.00	83.14	11.79	17.02	(3:3)(6:11)(1:23)
% inc. from sheep	10	0.00	0.00	0.00	6.44	.26	.93	(4:6)(4:4)(4:17)

SOURCES OF HIGHEST INCOME ON THE 100 FARMS

SOURCE	MEDIAN SCORE	UPPER QUARTILE	RANGE IN SCORE	NUMBER OF SCORES
chickens	15.08 %	17.95 %	93.24 %	64
pigs	10.69 %	24.54 %	89.14 %	61
corn	1.79 %	9.67 %	77.42 %	59
potatoes	.96 %	7.28 %	53.32 %	54
cows	.00%	22.28 %	83.14 %	49

The most common source of income on the 100 farms is chicken-raising. Although the range in scores on percentage income from chickens is extreme (93.24%), the upper quartile is just slightly above the median score (2.87%) indicating that chicken-raising generally provides around one sixth of the total income.

Pig-raising is the second most common farm production. The median income from pigs is lower than that for chickens, but the upper quartile score is the highest recorded for all productions. One quarter of the farms derive at least twenty-five percent of their income from pig-raising.

The economic importance of corn production is relatively weaker (median income: 1.97% of total income). The highest score occurs on a farm where just over three-quarters of the total income depends on income earned from corn production. On this farm, the operator supplements his farm income with off-farm employment.

The secondary nature of potato production is reflected by the relatively lower value of the upper quartile score. No farm derives more than fifty-four percent of its total income from potato production.

Cattle-raising, as a source of income, records the second highest upper quartile value. This indicates that farms engaged in cattle-raising rely on the activity to provide a substantial proportion of total income.

SOURCES OF LOWEST INCOME ON THE 100 FARMS

SOURCE	MEDIAN SCORE	UPPER QUARTILE	RANGE IN SCORE	NUMBER OF SCORES
vegetables	0.00 %	0.00 %	26.10 %	12
mixed beans	0.00 %	0.00 %	21.11 %	2
alfalfa	0.00 %	0.00 %	10.03 %	14
sheep	0.00 %	0.00 %	6.44 %	10

The economic importance of vegetables, mixed beans, alfalfa, and sheep is weak. These activities are practiced infrequently but are included in the analysis since, together with the major types of farm productions, they represent all observed forms of land use on the peasant farms.

The farm recording the highest income from vegetables earns over one quarter of its total income from this source. The two farms having mixed beans derive, respectively, twenty-one and six percent of their incomes from the activity. The mean income from alfalfa is less than one percent of total farm income. Sheep provide a very minor source of income contributing only six percent of total income in the highest case.

B. Simple Linear Regression:

The purpose of this model is to analyse the functional relationship between farm size and income per hectare. The technique employed is a simple linear regression model of the form

$$Y = a + b X$$

where Y denotes income per hectare, and X stands for farm size.

It is hypothesized that income per hectare will tend to decrease as size of farm increases. The peasant's own labour is often the most important input on the farm. Hired labour is infrequently employed. The quantity of labour per farm, therefore, is more or less fixed at the family-unit level so that as farms become larger, the quantity of labour per hectare decreases. A drop in productivity is expected with an increase in the amount of land per family worker.

Results of Regression Model
Total Sample and Sample divided by Region:

Table 4 demonstrates that the hypothesis is meaningfully stated. The sign on the regression coefficient for each equation is negative, although in Yaruqui and Tumbaco there is no significant regression of the dependent variable on the independent variable.

TABLE 4

SUMMARY TABLE: SIMPLE LINEAR REGRESSION

Y Income per hectare

X Farm size

SAMPLE	CONSTANT (a)	REGRESSION COEFFICIENT (b)	STANDARD ERROR OF (b) and 't'	r	STANDARD ERROR OF ESTIMATE	r^2
Total	51233.6	-6470.9	2036.9 t=3.1768*	.3056	65495.6	.0934
Yaruqui	48885.8	-3424.5	3311.8 t=1.1850	.2149	87021.3	.0462
Tumbaco	94965.8	-21216.7	11996.4 t=1.7686	.4881	80198.6	.2383
Cayambe	50305.2	-8507.7	4473.8 t=1.9017+	.3330	52998.6	.1109
Puellaro	62786.1	-15813.5	3654.2 t=4.3275*	.6620	32890.9	.4383

* Significant on the 99 percent level.

+ Significant on the 95 percent level.

The regression coefficient for the total sample is significant on the 99 percent level, but only 9 percent of the variability in the dependent variable is explained by the regression. In general, the measure of non-explained variability is reduced when the 100 farms are disaggregated by region. Explanation within Yaruqui, however, is very low.

The standard error of the estimate measures the accuracy with which the regression model can predict values of the dependent variable. The potential of the regression as a predictor equation is greatly increased where the standard error is relatively small in comparison with the observed mean value of the dependent variable. The Table below illustrates, for each of the simple regression equations, the associated error of the estimate.

TABLE 5

STANDARD ERROR OF THE ESTIMATE: SIMPLE REGRESSION

SAMPLE	MEAN VALUE OF THE DEPENDENT VARIABLE $\bar{y}$	STANDARD ERROR OF THE ESTIMATE	ERROR AS A PERCENTAGE OF $\bar{y}$
Total	32,006.5	65,495.6	205 %
Yaruqui	34,517.2	87,021.3	252 %
Tumbaco	53,893.8	80.198.6	149 %
Cayambe	19,183.5	52,998.6	276 %
Puellaro	34,200.2	32,890.9	96 %

Only in the case of Puellaro, does the standard error of the estimate drop below the observed mean value of the dependent variable. The high percentage error associated with the regression equations indicates the weak potential of the model as a predictor equation.

Summary: Chapter II

An examination of the distribution and spread of the twenty-four primary variables over the 100 farms illustrated the heterogeneous nature of the farm sample. In general, however, the farm enterprises providing the strongest economic support (in percentage figures) to total income are: chicken-raising, pig-raising, corn growing, potato growing, and cattle-raising. The farm enterprises providing the weakest economic support (in percentage figures) to total income on the farms are: vegetable production, mixed-bean production, alfalfa production, and sheep-raising. In addition, the 100 farms generally have a moderate level of technology, and in the majority of cases their incomes are supplemented by off-farm employment.

Simple linear regression analysis performed at the aggregate level yielded poor results. Large amounts of variability in the dependent variable remained unexplained, and the standard error of the estimate was relatively large in comparison to the observed mean value of the dependent variable. The power of the model was greatly increased when the sample of 100 farms was disaggregated by region, but the standard error of the estimate remained high which greatly reduced the potential of the model as a predictor equation.

Prior to further analysis, it was decided to attempt to improve the results of the regression model by more effectively subdividing the sample of 100 farms. Chapter III constructs a typology of the farms based on an examination of the structural and economic organization of the farming unit.

CHAPTER III

A TYPOLOGY OF THE FARMS

A. Correlation Analysis:

The original data matrix records, in each row, the pattern for each farm across the set of twenty-four variables and, in each column, the pattern of observations for each variable. The data, however, are in different metrics: the farm attributes are listed in yes/no forms; incomes from production are recorded in percentage form; costs are tabulated in Ecuadorian sucres; and family size is listed directly. For correlation analysis, each variable is standardized so as to have a mean of zero and a variance of one.

The coefficient of correlation is a measure of the level of covariance of two variables. A coefficient of 1 indicated a perfect correlation between two sets of values. A coefficient of '0' means that the two sets of values are unrelated in their manner of variation. The sign associated with the coefficient indicates the direction of the relationship.

Rikkinen (1971) notes in his examination of farms in central Finland that the presence of many high coefficients in the matrix theoretically lessens the usefulness of correlation analysis as a means of grouping. Correlation coefficients, as descriptive statistics, serve to test the uniqueness of variance in the variables. Where two variables are measuring the same thing, this will be reflected in high coefficients.

TABLE 6

CORRELATION ANALYSIS USING 24 PRIMARY VARIABLES:

1																							
2	.34																						
3	.54	.76																					
4	-.14	-.01	-.02																				
5	-.12	.00	-.00	.18																			
6	.37	.61	.75	-.05	-.03																		
7	-.12	-.14	-.12	.11	.38	-.11																	
8	.09	-.06	-.05	.00	.04	-.05	.17																
9	-.13	-.06	-.05	.04	-.13	-.10	-.01	-.05															
10	-.00	-.01	.01	-.13	-.13	-.02	-.11	.15	.15														
11	.01	.09	.03	.17	.36	.02	.11	-.02	-.08	-.08													
12	-.12	-.05	-.04	-.11	-.12	-.07	.02	-.05	.20	.25	-.08												
13	.18	-.06	-.04	-.05	-.06	-.04	-.05	-.03	-.03	-.05	-.04	-.04											
14	-.07	-.08	-.07	.01	-.06	-.07	.11	-.04	.35	.16	.01	-.02	-.04										
15	-.03	.17	.18	.19	.16	.09	-.02	-.01	.03	-.10	.38	-.09	-.04	.02									
16	-.12	-.09	-.08	-.09	.08	-.08	-.09	-.04	-.07	.03	-.04	.24	-.04	-.05	-.07								
17	-.07	.15	.06	.38	.12	.06	-.09	-.01	-.07	-.09	.35	-.07	-.04	-.02	.24	-.05							
18	-.10	.24	-.02	.05	-.04	-.01	-.08	-.04	-.04	-.09	.11	-.08	-.04	-.02	.21	-.04	.27						
19	-.12	.08	-.09	-.10	-.11	-.08	-.09	-.05	-.05	-.09	-.08	-.07	-.03	-.06	-.08	-.06	-.06	.38					
20	.06	.03	.08	.00	-.20	.09	.02	.20	-.10	.02	-.02	-.00	.00	.17	-.02	-.12	.01	.05	.10				
21	-.12	-.02	-.09	-.13	-.11	-.14	-.15	-.07	-.12	-.06	-.12	.07	-.06	-.09	-.10	.25	-.07	.48	.39	.04			
22	.04	-.12	-.10	.16	.19	-.10	.20	-.01	.11	-.09	.22	-.07	-.04	.10	-.06	.02	-.07	-.05	-.07	-.04	-.08		
23	-.06	.11	-.02	.07	.06	.03	-.07	-.00	-.04	-.04	.62	-.02	-.04	-.05	.38	.04	.39	.19	-.03	-.00	.01	-.06	
24	.06	-.14	-.13	.06	.03	-.13	.25	-.03	.06	-.11	.14	-.10	.07	.29	-.09	-.08	-.07	-.04	-.08	.18	-.13	.24	-

1. family size
2. use of tractor
3. use of chemicals
4. use of irrigation
5. use of hired hands
6. off-farm employment
7. production cost/hectare
8. machinery costs/hectare
9. % inc. from vegetables
10. % inc. from mixed beans
11. % inc. from alfalfa
12. % inc. from fruit
13. % inc. from corn
14. % inc. from beans
15. % inc. from peas
16. % inc. from lima beans
17. % inc. from potatoes
18. % inc. from wheat
19. % inc. from barley
20. % inc. from pigs
21. % inc. from chickens
22. % inc. from cows
23. % inc. from sheep
24. % inc. from employment

Table 6 lists the correlation coefficients among the pairs of variables for this study. The matrix contains very few high coefficients, only five values being equal to or greater than the absolute value of 0.4. Table 7 lists for each variable the highest associated variable.

In observing the substantial correlation between percent income from sheep, and percent income from alfalfa, it must be cautioned that both of these characteristics are only intermittently found over the 100 farms, and never occur in association with each other.

The high coefficients between use of chemicals and use of tractors reflects their inter-relationship as measures of technology in the farming operation. The coefficient is not excessively high, however, so that both variables may remain in the matric for subsequent analysis.

The peculiar association of family size with use of chemicals may be more meaningfully interpreted in the context of a wider interrelationship. The second highest correlation recorded for family size is off-farm employment. Off-farm employment, in turn, is highly associated with both family size and use of chemicals. Thus, for example, where a large family may necessitate off-farm employment to supplement farm income, this additional source of income may in turn afford the capital for the purchase of chemicals.

TABLE 7:
CORRELATIONS OF EACH VARIABLE WITH
HIGHEST ASSOCIATED VARIABLE:

PRIMARY VARIABLE	HIGHEST ASSOCIATED VARIABLE
1. family size	3. use of chemicals.......... 0.54
2. use of tractor	3. use of chemicals.......... 0.54
3. use of chemicals	2. use of tractor............ 0.54
4. use of irrigation	17. % inc. from potatoes...... 0.38
5. use of hired hands	7. production cost/hectare... 0.38
6. off-farm employment	3. use of chemicals.......... 0.75
7. production cost/hectare	5. use of hired hands........ 0.38
8. machinery costs/hectare	20. % inc. from pigs.......... 0.20
9. % inc. from vegetables	14. % inc. from beans......... 0.35
10. % inc. from mixed beans	12. % inc. from fruit......... 0.25
11. % inc. from alfalfa	23. % inc. from sheep......... 0.62
12. % inc. from fruit	10. % inc. from mixed beans... 0.25
13. % inc. from corn	1. family size.............. 0.18
14. % inc. from beans	9. % inc. from vegetables.... 0.35
15. % inc. from peas	23. % inc. from sheep......... 0.38
16. % inc. from lima beans	21. % inc. from chickens...... 0.25
17. % inc. from potatoes	23. % inc. from sheep......... 0.39
18. % inc. from wheat	19. % inc. from barley........ 0.38
19. % inc. from barley	21. % inc. from chickens...... 0.39
20. % inc. from pigs	5. use of hired hands........ 0.20
21. % inc. from chickens	18. % inc. from wheat......... 0.48
22. % inc. from cows	24. % inc. from employment.... 0.24
23. % inc. from sheep	11. % inc. from alfalfa....... 0.62
24. % inc. from employment	14. % inc. from beans......... 0.29

B. Principal Axes Factor Analysis:

Factor analysis applied to a matrix of correlation coefficients with ones on the principal diagonal yields a set of mutually orthogonal factors that together reproduce the total covariance of the original matrix. Placing ones on the diagonal assumes that the total variance of each variable is accounted for by its covariance with the underlying factors.

The eigenvalue associated with each factor is the variance term for that factor, and it measures the initial variance accounted for by that factor. Eigenvalues are often used to determine the number of factors to be rotated in factor analysis with orthogonal or oblique rotation. King (1969) notes:

> A convenient rule of thumb seems to be to evaluate all components with eigenvalues equal to or greater than one...

Principal axes factor analysis performed on the twenty-four primary variables for this study yields eight factors with eigenvalues greater than 1 that together account for 62.25 percent of the total variance in the original matrix.

Rotation of the factors is performed where the emphasis is upon identifying basic clusters of variables sharing common covariance on the characteristics. Since each rotated factor represents a distinct cluster of relationship among the variables, only a small number of variables particular to a pattern load highly on the factor. Varimax rotation is used to obtain more simplified column loadings in the loading matrix.

TABLE 8
PRINCIPAL AXES FACTOR ANALYSIS
ROTATED LOADINGS

VARIABLE	FACTORS							
	I	II	III	IV	V	VI	VII	VIII
1	-.60	-.09	.17	.04	.09	-.02	.12	-.46
2	-.84	.15	-.16	.05	.01	.07	-.04	.11
3	-.95	.05	.07	.01	.02	.05	-.01	.03
4	.11	.30	.12	.48	-.06	-.12	-.09	.37
5	.01	.22	.15	.01	.31	-.61	-.11	.31
6	-.84	.02	.07	.04	.05	.06	.00	.04
7	.11	-.11	.12	.07	.03	-.67	.24	.25
8	.06	-.01	.14	-.01	.19	-.03	.74	.16
9	.07	-.04	.12	-.07	-.73	.07	-.20	.19
10	-.01	-.05	.21	-.43	-.29	.28	.32	.16
11	-.04	.78	.04	-.06	.03	-.38	.02	-.11
12	.06	-.04	.08	-.64	-.19	.13	-.00	.18
13	.08	-.00	.12	.10	.09	.10	-.07	-.64
14	.04	.01	.01	.02	-.75	-.17	.13	-.04
15	-.13	.64	.02	.13	-.04	.08	-.08	.09
16	.01	.01	-.09	-.67	.19	-.11	-.20	.01
17	-.01	.65	-.02	.26	.04	.13	-.00	.18
18	-.05	.30	-.76	.09	-.04	.04	.00	.10
19	.04	-.13	-.73	.11	.03	.09	.04	.05
20	-.09	.00	-.20	.12	-.19	.02	.68	-.18
21	.09	-.08	-.77	-.28	.14	.06	-.05	.00
22	.04	-.02	.04	.01	-.18	-.64	-.14	-.06
23	.01	.83	-.06	-.16	.05	.04	.06	-.10
24	.10	-.05	-.01	.16	-.37	-.53	.14	-.39

The loading of each variable on a factor is a correlation coefficient and measures the degree and direction of the relationship between the variable and the factor. An examination of those variables with the highest loadings on each factor allows for an interpretation to be made of the real-world pattern that each factor is indexing. The matrix of factor loadings will have as many rows as there are original variables (in this case 24), and as many columns as there are factors (hypothetically 24 also but only the first 8 are analysed further).

Table 8 illustrates the loading matrix for the twenty-four standardized variables.

Interpretation of the Principal Eight Factors

Factor I is identified with a specific combination of farm attributes. Factors, II, III, VI, and VII are associated (either inversely or directly) with both crop and livestock productions. Factors IV, V, and VIII are identified inversely with particular crop productions. No factor is related solely to a pattern of livestock production.

In order to identify more clearly the pattern being indexed by each factor, the variables displaying the highest loadings on each factor are separately listed and a real-world interpretation is given to each factor.

Factor I

use of chemicals	-0.94
use of tractor	-0.84
off-farm employment	-0.84
family size	-0.60

Factor I is identified with a full-time farming activity supporting a smaller family unit. The factor is inversely associated with the use of chemicals and the use of a tractor indicating the more rudimentary nature of the farming operation.

Approximately three-quarters of the farms have positive factor scores on Factor I. At the lower end of the scale, farms from Yaruqui, Tumbaco and Puellaro are highly negatively related to the pattern. Generally, however, there is no clear grouping of the farms on Factor I according to region.

Factor II

% income from sheep	+0.83
% income from alfalfa	+0.78
% income from potatoes	+0.65
% income from peas	+0.64

Factor II is identified with two of the rarer sources of income on the 100 farms (income from sheep and income from alfalfa), in addition to pea and potato production. The peculiar association of these characteristics emerged in correlation analysis and is an extension of the weakness built into the study through the inclusion of these variables displaying irregular distribution over the 100 farms. Factor II indexes these oddities as a distinguishing feature in a pattern of variance in the data.

Approximately three-quarters of the farms have negative scores on Factor II. Farms ranking high on the factor are located in all four regions.

Factor III

% income from chickens	-0.77
% income from wheat	-0.76
% income from barley	-0.73

Factor III is inversely identified with three types of farm production. The factor indexes a pattern of farming which is not dependent on income earned from these three sources.

Factor scores on Factor III do not display any clear regionalization. Approximately three-quarters of the 100 farms are positively associated with the factor. Farms ranking low on the factor come from all four regions.

Factor IV

% income from lima beans	-0.66
% income from fruit	-0.64
use of irrigation	+0.48
% income from mixed beans	-0.43

Factor IV is less strongly identified since only two variables have relatively high loadings. The factor is inversely related to the production of lima beans, fruit, and mixed beans. Each of these three crop productions provides weak economic support to total income (Table 2). The mean percentage income from lima beans is 0.72%, from fruit is 6.65% and from mixed beans is 0.17% of total income. Factor IV, then, is negatively identified with these less productive activities.

In addition, Factor IV is positively identified with the use of irrigation.

There is a slight grouping of the farms on Factor IV according to region. Nine of the twelve farms in Tumbaco rank highly on the factor. The highest ranking farms, however, are located in the other three regions and farms ranking low on the pattern are found in all four regions.

Factor V

% income from beans	-0.75
% income from vegetables	-0.73
use of hired hands	+0.31

Factor V, like Factor IV, is less strongly identified. Income from beans and income from vegetables, are both negatively related to the factor. Only twelve farms record an income from vegetables, while nearly half the sample grow beans. Both these productions provide only weak economic support to total farm income (Table 3). Factor V, then, is inversely identified with these two less productive crops.

The factor is positively identified with the use of hired hands, although the loading is weak.

Similar to Factor IV, the farms in Tumbaco appear to group together on Factor V. Ten of the twelve farms in the region are positively related to the pattern. The highest and lowest ranking farms, however, occur in the other three regions.

Factor VI

production cost	-0.67
% income from cows	-0.64
use of hired hands	-0.61
% 'other' income	-0.52
% income from alfalfa	-0.38

Factor VI is identified with a self-supporting farming activity operated by the family unit. The pattern is inversely related to income earned from cattle-raising and alfalfa production. The factor is also identified with a much lower investment in the farming operation reflected by the high negative loading of production cost on the factor.

There is no clear grouping of the farms on Factor VI according to region.

Factor VII

machinery cost	+0.74
% income from pigs	+0.67
% income from mixed beans	+0.32

Factor VII is less strongly identified since only two variables have relatively high loadings on the pattern. The variable with the highest loading, machinery cost, is recorded on less than one quarter of the 100 farms. Income from mixed beans is recorded even more infrequently. These two oddities are combined with income from pig-raising to index a pattern of variation in the data.

Regions are more individualistic in the manner in which they relate to this pattern. A large number of farms in Yaruqui rank at the lower end of the scale on Factor VII. The highest ranking farms are located in Puellaro where twenty-two of the twenty-six farms are positively related to the pattern.

Factor VIII

% income from corn	-0.64
family size	-0.46
% 'other' income	-0.39
use of irrigation	+0.37
use of hired hands	+0.31

The eighth factor is the least strongly identified of the principal eight factors. Only one variable, income from corn, is relatively strongly related to the pattern. A further four variables display weak loadings on the factor.

Factor VIII is identified with a self-supporting farming operation, investing capital in the use of irrigation and the use of hired hands, and supporting a small family unit. The factor is inversely related to income earned by growing corn.

Generally, there is no clear grouping of the farms on Factor VIII according to region.

C. Hierarchical Grouping Algorithm:

The grouping algorithm considers how the 100 farms are located relative to one another in the total farming-dimension space. Each farm is described by eight factor scores and treated as a point in space. Quantitative measures of the distances between pairs of points are determined, and a matrix of distances between all pairs of farms in space is constructed.

The two farms closest together in space are first grouped. A new reduced matrix of distances is then calculated by replacing the row and column elements of the two points grouped, with a single row and column of distances measured from the centroid of the two-member group to all other farms.

At each stage in the analysis, all possible unions are identified, and the 'best' union is selected. A point is assigned to a group if it is closer to that group centroid than to the centroid of any other group or residual individual in the matrix.

The greatest amount of information is available when the set of 100 farms is ungrouped. With each simplification, groupings become less homogeneous. In the final cycle, all farms are combined into a single group.

It is a problem to determine at what level to stop the grouping algorithm in order to give the best groupings. Ahmad (1965) notes:

> The ratio of increment to total distance characteristically decreases in the grouping process to a minimum value, and then increases again. The step at which the minimum value occurs is usually a convenient point at which to pick groups for further study.

The ratio for each of the one hundred cycles of the analysis was calculated. The step at which the minimum value occured produced fourteen groups of farms.

Three farms were isolated as single-member groups:

<u>Group 11</u>: farm (3:31)

<u>Group 12</u>: farm (4:3)

<u>Group 14</u>: farm (4:15)

One group was assigned only two members:

<u>Group 13</u>: farm (4:12)(4:24)

<u>Table 9</u> lists, by their location, the member farms within each of the first ten Groups produced by the analysis. The size of membership in the group is listed at the head of each column.

TABLE 9

CLASSIFICATION OF 100 PEASANT FARMS BY HIERARCHICAL GROUPING ANALYSIS

Region	Group 1 9 farms	Group 2 4 farms	Group 3 5 farms	Group 4 39 farms	Group 5 5 farms	Group 6 7 farms	Group 7 8 farms	Group 8 4 farms	Group 9 11 farms	Group 10 3 farms
YARUQUI	(1:1) (1:3) (1:13) (1:14)	(1:2) (1:10)	(1:4) (1:28)	(1:5) (1:6) (1:7) (1:8) (1:16) (1:19) (1:20) (1:22) (1:25) (1:29)	(1:9) (1:21)	(1:11) (1:23)	(1:12) (1:18) (1:24)	(1:15) (1:27)	(1:17) (1:26) (1:30) (1:31)	
TUMBACO			(2:10)	(2:4) (2:8) (2:9) (2:13) (2:15)	(2:2)	(2:1)	(2:5)		(2:3) (2:12)	(2:6)
CAYAMBE	(3:6) (3:8)	(3:13) (3:25)		(3:1) (3:3) (3:9) (3:10) (3:11) (3:12) (3:15) (3:16) (3:20) (3:21) (3:22) (3:23) (3:24) (3:26) (3:27)	(3:2) (3:14)	(3:4) (3:28)	(3:5) (3:17) (3:29)		(3:7) (3:19)	(3:18) (3:30)
PUELLARO	(4:1) (4:11) (4:23)		(4:14) (4:26)	(4:6) (4:7) (4:8) (4:16) (4:17) (4:18) (4:19) (4:20) (4:22)		(4:9) (4:21)	(4:10)	(4:13) (4:25)	(4:2) (4:4) (4:5)	

Region as a Determinant

Within each region, there is a large mixture of farming types. A minimum of 7 classes of farms occur in each region. Yaruqui contains farms classified in nine different Groups. Cayambe and Puellaro each contain eight classes of farms; and Tumbaco has members from seven separate Groups. While it may be observed that the Tumbaco region contains the smallest absolute number of farming types, it may be alternately argued that proportionately Tumbaco is the most agriculturally heterogeneous region, since seven of the twelve farms sampled belong to different Groups.

Nevertheless, the heterogeneous nature of farming in each region is evident. The farms sampled in each of the four regions are not widely dispersed and in no case represent major breaks in climatic or physical conditions. Diversity in farming enterprises, then, cannot be explained solely in terms of changing physical-environmental factors.

Similarly, there is no clear grouping of the farms into farming types according to region. Four of the first ten Groups have members in all four regions. Three Groups have members in three regions; and three Groups have members in two regions. No class is specific to one locale.

Association with Principal Factors

Similarity among farms within Groups can be described by observing the particular association of each Group of farms with the eight primary Factors. The matrix of factor scores for the 100 farms on the primary Factors is listed, by Group, in the appendix. Table 10 summarizes the identifying characteristic of each Group. Where all farms in a Group rank extremely high on a Factor, an X is indicated.

TABLE 10

ASSOCIATION OF GROUPS WITH PRINCIPAL FACTORS

GROUPS	FACTORS I	II	III	IV	V	VI	VII	VIII
Group 1				X^+				
Group 2					X^-			X^+
Group 3	X^-							
Group 4		X^-				X^+		
Group 5				X^-				
Group 6			X^-					
Group 7					X^+			
Group 8		X^+				X^-		
Group 9		X^-						X^-
Group 10		X^+						
Group 11					X^-			
Group 12								X^-
Group 13							X^+	
Group 14								X^+

+upper end of the scale
-lower end of the scale

It must be noted that the use of factor scores as the input data for the grouping does give rise to certain difficulties of interpretation. Recall that any factor is a linear combination of all of the original variables and that the factor scores are weighted accordingly. Hence, it is quite possible for some farms to have high scores on a given factor and yet to have quite different profiles over the original variables. The difficulty is compounded when the interpretation of the factor in question is based on only a few of the higher loadings (and the associated variables) and the factor scores are used in a grouping algorithm. One consequence is that a group may contain farms having high scores on a factor identified say as a "corn-livestock" factor (these being presumably the higher loadings) and yet some of these farms may not even grow corn or keep livestock. The fact that they have the high scores on this factor and are in the group may simply reflect the weightings produced by a combination of lower loadings and yet high original data values on some of the other variables combined in the factor.

Summary: Chapter III

Correlation Analysis demonstrated that very few high correlations existed among pairs of variables in the data. The matrix of correlation coefficients then provided a good base for subsequent grouping analysis. A weakness incorporated into the data, was the inclusion of four more rarely found sources of income. These variables were included in the study in order to represent all observed forms of agricultural activity.

Principal Axes Factor Analysis performed on the matrix of correlation coefficients, yielded eight factors with eigenvalues greater than 1 and that together accounted for 62.25 percent of the total variance in the original matrix. The principal eight factors were given meaning by examining the matrix of rotated factor loadings. Three factors were identified inversely with particular crop production. Four factors indexed a pattern of crop and livestock farming, and one factor was described by specific farm attributes. The matrix of factor loadings did not indicate any clear grouping of the farms on the factors according to region.

Ward's Hierarchical Grouping Analysis produced a classification of farming types containing fourteen Groups. The four regions each encompassed a large mixture of Groups representing various types of farming enterprises. In addition, no one Group was specific to a particular region. Similarity among the farms within each Group, then, was described by examining the matrix of factor scores for the principal eight Factors, and Groups of farms were characterized by their strong association with particular Factors.

CHAPTER IV

RELATIONSHIP BETWEEN INCOME AND FARM SIZE RECONSIDERED

A. Simple Linear Regression by Farming Type:

Classification of the farms by factor analysis and the grouping algorithm, produced fourteen classes of farming activity among the 100 farms. The functional relationship between farm size and income per hectare for each type of activity is next examined.

The regression coefficient for each of the samples is negative. This supports the postulated inverse relationship between the dependent variable and the independent variable. As farm size increases, there is an associated drop in the productivity of the farm. The three Groups, where the relationship is statistically significant, contain over one half the sample farms. For seven of the ten Groups, however, there is no significant regression of the dependent variable on the independent variable.

Grouping the farms on the basis of economic activity has generally resulted in an increase in the explanation of the variability of the dependent variable. The model applied to Group 4 (coefficient significant on the 99 percent level) explains nineteen percent of the variability in the dependent variable. For Groups 1 and 9 (coefficients significant on the 95 percent level), the explained variability is increased to thirty-five and thirty-nine percent respectively.

TABLE 11

SUMMARY TABLE FOR THE SIMPLE REGRESSION MODEL BY FARMING TYPE:

Dependent variable: Income per hectare

Independent variable: Farm size

SAMPLE:	CONSTANT (a)	REGRESSION COEFFICIENT: (b)	STANDARD ERROR OF (b) and t	r	STANDARD ERROR OF THE ESTIMATE	r^2
Group 1: 9 farms	32084.8	-3791.3	1949.1 t=1.945+	.5923	21227.5	.3509
Group 2: 4 farms	22352.5	-559.1	628.2 t= .8900	.5236	12407.2	.2837
Group 3: 5 farms	37880.1	-7865.2	9337.5 t= .8423	.4373	20457.4	.1913
Group 4: 39 farms	65181.9	-13494.0	4604.7 t=2.9304*	.4340	55421.0	.1884
Group 5: 5 farms	38229.0	-6670.1	4921.9 t=1.3552	.6162	21055.4	.3797
Group 6: 7 farms	14478.7	-2206.1	1547.2 t=1.4259	.5377	8668.0	.2891
Group 7: 8 farms	94039.8	-14705.9	11282.4 t=1.3034	.4698	92526.6	.2207
Group 8: 4 farms	110608.2	-73005.0	3300.6 t=1.5151	.3862	251390.4	.1491
Group 9: 11 farms	40021.2	-6041.0	2517.1 t=2.4000+	.6247	22497.0	.3902
Group 10: 3 farms	18593.3	-1888.0	6669.6 t= .2831	.2724	10278.5	.0742

*Significant on the 99 percent level
+Significant on the 95 percent level

The standard error of the estimate, listed for each type of farming activity in the Table below, is large in each equation. This indicates that the variance about the regression line is considerable.

TABLE 12

STANDARD ERROR OF THE ESTIMATE: SIMPLE REGRESSION

SAMPLE	MEAN VALUE OF THE DEPENDENT VARIABLE $\bar{y}$	STANDARD ERROR OF THE ESTIMATE	ERROR AS A PERCENTAGE OF $\bar{y}$
Group 1	16,624.6	21,227.5	128 %
Group 2	19,845.0	12,407.2	70 %
Group 3	19,790.2	20,457.4	103 %
Group 4	29,242.9	55,421.0	190 %
Group 5	16,884.8	21,055.4	125 %
Group 6	8,459.1	8.668.0	102 %
Group 7	47,936.9	92,526.6	193 %
Group 8	156,767.0	251,390.4	160 %
Group 9	21,003.0	22,497.0	107 %
Group 10	14,345.3	10,278.5	72 %

Although the regression equation is significant for Group 1, 4, and 9, the large error associated with the model in each case indicates the poor potential of the regression as a predictor equation. Nevertheless, the model applied to farm types is slightly stronger than the previous model applied to farms disaggregated by region.

Summary: Simple Linear Regression Model

The findings of this study on peasant farms in Ecuador concur with the generally observed inverse relationship between farm size and farm income on small farms in most underdeveloped countries. For all samples considered, the sign on the regression coefficient is negative. In a high number of cases, however, the coefficient is not statistically significant. For these samples, there is no significant regression of the dependent variable on the independent variable.

The standard error of the estimate associated with each regression equation is relatively large in comparison with the observed mean value of the dependent variable. The model, therefore, cannot be used as a reliable predictor of the dependent variable. Nevertheless, it should be noted that the model applied to farms divided by type is a slight improvement over the model applied to farms disaggregated by region.

The poor results yielded by the simple regression model indicate that variations in income per hectare are a function of a more complex interaction among variables. Variability in farm income cannot be explained in terms of a simple functional relationship to farm size even when farms are subdivided according to farming type.

B. Multiple Step-Wise Regression Model:

It is the purpose of this section to determine empirically the contribution of a set of independent variables to the observed variation of income per hectare. The model employed is a multiple regression model of the form

$$Y = a + b_1X_1 + b_2X_2 + ,,,,,,,+b_nX_n$$

where Y denotes income per hectare and $X_1X_2,,,,,X_n$ stand for the selected explanatory variables. The multiple step-wise regression model is designed to include one independent variable at a time. The variable with the highest simple correlation with the dependent variable is the first variable to enter the equation. With each step, the variable which explains the greatest amount of residual variance is entered, and a new regression equation is computed.

Selection of the Independent Variables

A problem in multiple regression analysis is that of multicollinearity among the explanatory variables. The inclusion of the complete set of 24 original variables in a multiple regression analysis would involve such problems since it is clear that there are correlations among some of these variables and hence they are not truly independent. Where this problem arises, Daling and Tamura (1970) observe:

> Resulting equations often contain coefficients with theoretically incorrect signs restricting the use of the equation as a functional relationship explaining the system under study.

In the constructing of a prediction equation, Daling and Tamura made use of factor analysis in the selection of explanatory variables. Variables with the highest loadings on each factor were selected, and where two variables had near equally high loadings on the factor, the variable with the highest simple correlation with the dependent variable was chosen. Daling and Tamura (1970) state:

> By regressing the dependent variable Y on each varimax component we could more easily identify the explanatory variables which, having minimum interdependence among themselves, appear to make a significant contribution of the variation of Y.

It was decided to employ the same selection technique in the choice of independent variables in income in the present study.

The independent variables included in the regression equation were selected from the matrix of factor loadings for the principal eight factors (Table 8). In the case of factor II where four variables loaded significantly high onto the factor, income from potatoes was selected since it had the highest simple correlation coefficient with the dependent variable. Similarly for factor VII, where two variables loaded highly only the pattern, income from pigs was chosen as the explanatory variable to be used in the regression equation.

The following set of independent variables were selected.

X_1 .... farm size
X_2 .... use of chemicals
X_3 .... production cost
X_4 .... % income from corn
X_5 .... % income from beans
X_6 .... % income from lima beans
X_7 .... % income from potatoes
X_8 .... % income from pigs
X_9 .... % income from chickens

Farm size was included along with the subset of eight explanatory variables since it was not one of the twenty-four primary characteristics and therefore was not a part of any factor.

Results of the Multiple Step-Wise Regression

TABLE 13 SUMMARY TABLE FOR THE REGRESSION: TOTAL SAMPLE

Included variables								Var. not included	
Step	Variable	R	Std. err.	R^2	Increase	Regr. coeff.	Std. err.	Variable	Partial corr. coeff
1	X_3	.3537	64339.6	.1251	.3537	b_3 = 12.8*	3.4	X_1	-.30969
								X_2	.05687
								X_4	-.26925
								X_5	-.26157
								X_6	-.13461
								X_7	-.22608
								X_8	.37187
								X_9	.17246
2	X_8	.4961	60032.6	.2461	.1424	b_3 = 13.0	16.4	X_1	-.25572
						b_8 = 1321.9*	15.6	X_2	.14301
								X_4	-.24774
								X_5	-.27259
								X_6	-.12360
								X_7	-.18362
								X_9	.21501
3	X_5	.5496	58059.1	.3020	.0535	b_3 = 14.5	21.1	X_1	-.21252
						b_5 = -2404.5*	7.7	X_2	.09298
						b_8 = 1301.1*	16.1	X_4	-.19239
								X_6	-.05134
								X_7	-.09194
								X_9	.17990
4	X_1	.5776	57030.6	.3336	.0280	b_1 = -3930.7+	1854.3	X_2	.04637
						b_3 = 13.9*	3.1	X_4	-.12465
						b_5 = -2029.2+	869.0	X_6	-.03617
						b_8 = 1157.5*	325.5	X_7	-.11830
								X_9	.15217
5	X_9	.5908	56665.5	.3490	.0132	b_1 = -3498.3+	1865.0	X_2	.06046
						b_3 = 12.3*	3.3	X_4	-.11360
						b_5 = -1860.5+	870.8	X_6	-.03617
						b_8 = 1209.8*	325.3	X_7	-.10595
						b_9 = 606.2	406.1		
6	X_4	.5979	56600.6	.3575	.0071	b_1 = -2704.9	1997.0	X_2	.03349
						b_3 = 12.9*	3.3	X_6	-.04993
						b_4 = -482.7	437.8	X_7	-.13262
						b_5 = -1687.4+	883.9		
						b_9 = 568.5	407.1		
7	X_7	.6073	56404.7	.3688	.0094	b_1 = -2811.6	1991.9	X_1	.05743
						b_3 = 13.1*	3.3		-.07319
						b_4 = -598.8	445.6		
						b_5 = -1187.1	963.2		
						b_7 = -703.9	548.5		
						b_8 = 1112.2*	330.6		
						b_9 = 510.4	408.2		
8	X_6	.6100	56561.7	.3721	.0027	b_1 = -2375.1	2092.5	X_2	.06042
						b_3 = 12.6*	3.4		
						b_4 = -645.4	451.7		
						b_5 = -956.3	1020.6		
						b_6 = -2817.3	4024.3		
						b_7 = -767.6	557.5		
						b_8 = 1110.0*	331.5		
						b_9 = 570.9	418.3		

FINAL STEP: MULTIPLE REGRESSION MODEL

TOTAL SAMPLE: 100 farms

X_2	R	standard error of the estimate	R^2	regression coefficients	standard error of the coefficient
	.6119	56,771.1	.3744	b_1 = -2198.9	2122.5
				b_2 = 7494.3	13050.8
		mean value of the dependent variable		b_3 = 12.6*	3.4
				b_4 = -509.2	463.5
		32,006.5		b_5 = -2905.7	4042.2
				b_6 = -2905.7	4042.2
				b_7 = -824.4	568.2
				b_8 = 1158.1*	343.1
				b_9 = 594.7	421.9

*Significant on the 99 percent level
+Significant on the 95 percent level

The coefficient of multiple determination (R^2) is a measure of the non-random variation of the dependent variable explained by the independent variables. Regression analysis performed on the 100 farms at the aggregate level yields poor results. Only thirty-seven percent of the variability in the dependent variable is explained by the regression. In addition, the standard error of the estimate is relatively large in comparison to the observed mean value of the dependent variable. The multiple regression model applied at the aggregate level, therefore, cannot be used as a reliable predictor of income per hectare on the farms.

Only two independent variables of the regression equation are statistically significant in the final step of the analysis; production cost (X_3) and income from pigs (X_7). The remaining variables are not significantly related to the level of income per hectare on the 100 farms, where all other variables are held statistically constant.

Production cost (X_3) has the highest simple correlation with the dependent variable (.354) and is the first variable entered in the regression equation. Alone, production cost explains thirteen percent of the variation in income on the 100 farms. The regression coefficient is positive indicating that,where the level of investment in methods of production is increased, there is an associated increase in productivity per hectare on the farms.

Income from pigs (X_8) is the other independent variable contributing significantly to variation in income per hectare. Together with production cost, income from pigs explains twenty-five percent of the variability in income on the 100 farms. The relationship is positive so that an increase in the proportion of income derived from pigs is identified with an increase in overall productivity where production cost is held statistically constant.

TABLE 14 SUMMARY TABLE FOR THE REGRESSION MODEL: YARUQUI

Included variables								Var. not included	
Step	Variable	R	Std. err.	R^2	Increase	Regr. coeff.	Std.err.	Variable	Partial corr. coeff
1	X_8	.5456	74675.1	.2977	.5456	b_8 = 2056.5*	586.6	X_1	-.05699
								X_2	.43501
								X_3	-.01615
								X_4	-.06989
								X_5	-.16218
								X_6	-.06811
								X_7	-.21039
								X_9	.26568
2	X_2	.6562	68429.5	.4306	.1106	b_2 = 67232.9*	26299.5	X_1	.10989
						b_8 = 2090.6*	537.7	X_3	.16945
								X_4	.18589
								X_5	.06153
								X_6	-.07153
								X_7	-.15039
								X_9	.22621
3	X_9	.6780	67878.9	.4597	.0218	b_2 = 62533.4+	26377.0	X_1	.19948
						b_8 = 2232.7*	546.3	X_3	.19944
						b_9 = 822.1	618.3	X_4	.30912
								X_5	.15255
								X_6	-.04167
								X_7	-.09675
4	X_4	.7151	65784.1	.5114	.0371	b_2 = 85844.2*	29176.8	X_1	.19302
						b_4 = 1335.2	805.6	X_3	.12110
						b_8 = 2740.9*	611.8	X_5	.16141
						b_9 = 1298.0+	720.0	X_6	.01130
								X_7	-.02843
5	X_1	.7277	65825.3	.5295	.0126	b_1 = 2925.2	2974.0	X_3	.12519
						b_2 = 93510.0*	30217.4	X_5	.16442
						b_4 = 1293.7	807.2	X_6	-.05935
						b_8 = 2956.5*	650.2	X_7	-.01081
						b_9 = 1507.8+	751.3		
6	X_5	.7364	66268.3	.5423	.0087	b_1 = 2924.2	2994.0	X_3	.05959
						b_2 = 104666.1*	33347.5	X_6	-.10561
						b_4 = 1295.7	812.6	X_7	-.01053
						b_5 = 1449.6	1775.1		
						b_8 = 3078.5*	671.4		
						b_9 = 1707.8+	795.1		
7	X_6	.7398	67315.0	.5473	.0034	b_1 = 3506.7	3249.3	X_3	.04339
						b_2 = 106832.5*	34140.2	X_7	.01098
						b_4 = 1208.6	843.0		
						b_5 = 1688.9	1863.4		
						b_6 = -3748.4	7359.2		
						b_8 = 3039.5*	686.3		
						b_9 = 1700.7+	807.8		

FINAL STEP: MULTIPLE REGRESSION MODEL

REGION 1 - YARUQUI: 31 farms

X_3	R	standard error of the estimate	R^2	regression coefficients	standard error of the coefficients
	.7404	68,763.0	.5482	b_1 = 3474.4	3322.9
				b_2 = 106643.8*	34887.0
		mean value of the dependent variable		b_3 = 2.4	11.5
				b_4 = 1155.7	899.4
		34,517.2		b_5 = 1486.5	2147.3
				b_6 = -3498.5	7616.0
				b_8 = 3017.2*	709.5
				b_9 = 1672.6+	836.6
				variable not included	partial coefficient
				X_7	.00233

*Significant on the 99 percent level
+Significant on the 95 percent level

The power of the multiple regression model is not greatly increased when performed on the set of farms in the Yaruqui region. Although the measure on non-explained variation in income per hectare is reduced, the set of independent variables accounts for only slightly over one half of the variability in the dependent variable (R^2=.5482). In addition, the standard error of the estimate is almost twice the size of the observed mean value of the dependent variable. The regression model, then, has poor potential as a predictor equation of income on farms in the Yaruqui region.

Three of the independent variables entered in the regression contribute significantly to variation in income per hectare on the farms in Yaruqui: income from pigs (X_8), use of chemicals (X_2) and income from chickens (X_9).

In the final step of the regression analysis, none of the crop productions on the thirty-one farms contributes significantly to variation in income. The two livestock productions, conversely, are among the first variables entered in the equation. Income from pigs (X_8) has the highest simple correlation (.5456) with the dependent variable for the region. It is the first variable entered in the regression, and, alone, it accounts for thirty percent of the variation in income. Income from chickens (X_9) enters the equation in step three, where it is statistically significant on the 95 percent level and positively related to the dependent variable. Farms in Yaruqui, earning larger portions of their total income from pig-raising or chicken-raising, experience an associated increase in the level of productivity on the farm where all other variables are held statistically constant.

Use of chemicals (X_2) is the second independent variable entered in the regression. The regression coefficient is positive and significant on the 99 percent level. Where income from pigs is held constant, then, there is an increase in productivity with an increase in the amount of chemicals used on the farms.

TABLE 15 SUMMARY TABLE FOR THE REGRESSION MODEL: TUMBACO

Included variables								Var. not included	
Step	Variable	R	Std. err.	R^2	Increase	Regr. coeff.	Std.err.	Variable	Partial corr. coeff
1	X_2	.6168	72379.4	.3804	.6168	$b_2 = -82964.3^{+}$	33482.0	X_1	-.56293
								X_3	.04285
								X_4	-.10256
								X_5	-.37728
								X_6	-.08101
								X_7	-.40051
								X_8	.10065
								X_9	.06250
2	X_1	.7694	63014.1	.5767	.1426	$b_1 = -19314.4^{+}$	9452.5	X_3	-.11021
						$b_2 = -78480.6^{+}$	29252.3	X_4	.67944
								X_5	.00886
								X_6	-.00610
								X_7	-.48839
								X_8	-.12353
								X_9	.19931
3	X_4	.8787	49040.2	.7721	.1193	$b_1 = -44280.0^{*}$	12040.6	X_3	-.02207
						$b_2 = -88576.9^{*}$	23089.4	X_5	.18162
						$b_4 = 18935.0^{+}$	7229.5	X_6	-.07502
								X_7	-.38348
								X_8	.01288
								X_9	-.20400
4	X_7	.8976	48418.3	.8057	.0189	$b_1 = -40743.1^{*}$	12316.1	X_3	.07766
						$b_2 = -86681.3^{*}$	22861.8	X_5	.28717
						$b_4 = 16216.7^{+}$	7554.6	X_6	.20141
						$b_7 = -1892.3$	1722.5	X_8	.02955
								X_9	-.26502
5	X_5	.9065	50094.9	.8217	.0089	$b_1 = -46880.3^{*}$	15238.8	X_3	.20796
						$b_2 = -92887.9^{*}$	25118.1	X_6	.18514
						$b_4 = 16838.8^{+}$	7862.0	X_8	.02443
						$b_5 = 944.3$	1285.9	X_9	-.54400
						$b_7 = -2154.3$	1820.2		
6	X_9	.9351	46045.8	.8744	.0286	$b_1 = -60330.6^{*}$	16801.2	X_3	.41488
						$b_2 = -107732.1^{*}$	25256.6	X_6	.44690
						$b_4 = 23880.0^{*}$	8707.0	X_8	-.65666
						$b_5 = 2130.3$	1437.4		
						$b_7 = -2804.7$	1730.4		
						$b_9 = -3048.5$	2102.9		
7	X_8	.9636	38825.9	.9285	.0285	$b_1 = -77443.7^{*}$	17241.6	X_3	.69407
						$b_2 = -125343.9^{*}$	23575.9	X_6	.33192
						$b_4 = 28876.8^{*}$	7882.6		
						$b_5 = 3481.1^{+}$	1439.0		
						$b_7 = -3387.4^{+}$	1497.0		
						$b_8 = -3294.3$	1891.8		
						$b_9 = -6380.0^{+}$	2608.5		

FINAL STEP: MULTIPLE REGRESSION MODEL

REGION 2 - TUMBACO: 12 farms

X_6	R	standard error of the estimate	R^2	regression coefficients	standard error of the coefficients
	.9813	37,500.6	.9629	b_1 = -82786.8*	17742.3
				b_2 = -145775.2*	26534.1
		mean value of the dependent variable		b_3 = 11.8	8.8
				b_4 = 30858.0*	8149.9
		53,893.8		b_5 = 4355.3+	1566.4
				b_6 = 2476.8	5254.7
				b_7 = -4752.7+	1859.4
				b_8 = -3393.2	1966.7
				b_9 = -7347.4+	2623.3

*Significant on the 99 percent level
+Significant on the 95 percent level

Ninety-six percent of the variability in income per hectare on farms in the Tumbaco region is explained by the regression on the nine independent variables. In addition, although the size of the standard error of the estimate remains substantial, it is smaller than the observed mean value of the dependent variable. The regression model applied to Tumbaco, then, has moderate power as a predictor equation of income on the farms.

Variation in income per hectare on the farms in Tumbaco is the result of a more complex interaction of variables. Six of the nine independent variables entered in the regression equation are significantly related to the level of income on the farms.

Use of chemicals (X_2) has the highest simple correlation with income per hectare in Tumbaco (-.6186). The negative sign attached to the coefficient indicates that investment in chemicals is not economical for the farms. Increased expenditure on chemicals is associated with a decrease in overall productivity. This paradox may be explained by the unusually small size of properties sampled in the region and the high rate of off-farm employment for farms in the region. The average size of farm plot sampled in Tumbaco is 1.9 hectares, and 10 of the 12 farms are engaged in off-farm employment. Investment in chemicals for such limited production may not prove as profitable as accumulated savings.

Farm size (X_1) significantly effects the level of income on farms in Tumbaco. The variable enters the regression in the second step and is inversely related to income per hectare. Where use of chemicals is held statistically constant, as size of farm increases, there is an associated decrease in productivity.

Three crop productions (X_4), (X_7) and (X_5) contribute significantly to variation in productivity in Tumbaco. Income from corn (X_4), and income from beans (X_5) are both positively related to the dependent variable. Where these two crops are grown, overall productivity rises (all other variables held statistically constant). Income from potatoes (X_7) is inversely related to the level of income on the farms.

Income from chickens (X_9) is inversely related to the dependent variable. Farms in Tumbaco earning larger of their total income from chickens experience an associated drop in productivity.

Included variables								Var. not included	
Step	Variable	R	Std. err.	R^2	Increase	Regr. coeff.	Std.err.	Variable	Partial corr. coef.
1	X_3	.9464	18151.0	.8957	.9464	b_3 = 21.6*	1.4	X_1	-.12945
								X_2	-.10115
								X_4	-.37562
								X_5	-.35599
								X_6	-.10637
								X_7	-.59870
								X_8	.13643
								X_9	.29541
2	X_7	.9660	14795.8	.9332	.0196	b_3 = 21.8*	1.1	X_1	-.40546
						b_7 = -619.4*	156.6	X_2	-.01770
								X_4	-.69469
								X_5	-.00667
								X_6	-.30951
								X_8	.06402
								X_9	.21900
3	X_4	.9825	10838.1	.9653	.0165	b_3 = 21.5*	.8	X_1	-.08228
						b_4 = -1661.8*	331.1	X_2	.15396
						b_7 = -779.5*	119.1	X_5	-.19791
								X_6	.15440
								X_8	-.03976
								X_9	.25033
4	X_9	.9836	10692.9	.9675	.0011	b_3 = 19.7*	1.6	X_1	-.01436
						b_4 = -1637.4*	327.2	X_2	.11774
						b_7 = -745.6*	120.3	X_5	-.17294
						b_9 = 299.9	227.5	X_6	.07269
								X_8	-.13200
5	X_5	.9841	10740.4	.9685	.0005	b_3 = 19.8*	1.6	X_1	-.09096
						b_4 = -1696.2*	335.4	X_2	.14245
						b_5 = -344.6	392.5	X_6	.07725
						b_7 = -679.6*	142.3	X_8	-.10366
6	X_2	.9845	10850.0	.9692	.0004	b_2 = 8183.3	11606.3	X_1	-.09096
						b_3 = 19.9*	1.7	X_6	.08898
						b_4 = -1748.7*	346.9	X_8	-.12126
						b_5 = -379.6	399.6		
						b_7 = -692.6*	144.9		
						b_9 = 244.0	236.7		
7	X_8	.9847	11001.6	.9696	.0002	b_2 = 8945.0	11840.0	X_1	-.09392
						b_3 = 19.6*	1.8	X_6	.05874
						b_4 = -1770.7*	353.8		
						b_5 = -338.8	411.1		
						b_7 = -710.4*	150.0		
						b_8 = -109.5	186.9		
						b_9 = 292.6	253.9		
8	X_1	.9848	11199.1	.9698	.0001	b_1 = -613.1	1385.4	X_6	.07673
						b_2 = 8753.4	12060.4		
						b_3 = 19.7*	1.8		
						b_4 = -1683.7*	410.3		
						b_5 = -419.3	456.4		
						b_7 = -710.4*	152.7		
						b_8 = -111.1	190.3		
						b_9 = 254.7	272.2		

FINAL STEP: MULTIPLE REGRESSION MODEL

REGION 3 - CAYAMBE: 31 farms

X_6	R	standard error of the estimate	R^2	regression coefficients	standard error of the coefficients
	.9849	11,428.9	.9700	b_1 = -701.9	1436.1
				b_2 = 8928.3	12317.8
		mean value of the dependent variable		b_3 = 20.0*	2.1
				b_4 = -1770.9*	486.3
		19,183.5		b_5 = -442.7	470.5
				b_6 = 1128.9	3201.2
				b_7 = -706.9*	156.2
				b_8 = -91.7	201.8
				b_9 = 204.7	311.9

*Significant on the 99 percent level
+Significant on the 95 percent level

The power of the regression model as a predictor of income is greatly improved when applied to farms in the Cayambe region. Ninety-seven percent of the variability in income per hectare is explained by the regression of the nine independent variables. In addition, the size of the standard error of the estimate relative to the observed mean value of the dependent variable is reduced.

Three variables contribute significantly to the level of productivity on the farms in Cayambe: production cost (X_3), income from potatoes (X_7) and income from corn (X_4).

Production cost (X_3) has the highest simple correlation with the dependent variable (.9464). It is the first variable entered in the regression equation, and, alone, it accounts for ninety percent of the variability in income per hectare on farms in Cayambe. The coefficient is positive and significant on the 99 percent level. Where more capital is invested in the methods of production, there is a direct increase in farm productivity.

Each of the two crop productions significant in the final regression equation (X_7) and (X_4) is inversely related to the dependent variable. Income from potatoes (X_7) is the second variable entered in the equation. The coefficient is negative and significant on the 99 percent level. Income from corn (X_4) is the third variable included in the regression. Farms in Cayambe, engaged in either potato or corn production, experience a drop in overall productivity.

Neither of the two livestock productions is statistically significant in the final equation. This indicates that for farms in Cayambe pig-raising and chicken-raising do not contribute significantly to changes in farm productivity (where all remaining variables are held statistically constant).

TABLE 17 SUMMARY TABLE FOR THE REGRESSION MODEL: PUELLARO

Included variables								Var. not included	
Step	Variable	R	Std. err.	R^2	Increase	Regr. coeff.	Std.err.	Variable	Partial corr. coeff.
1	X_1	.6620	32890.9	.4382	.6620	b_1 = -15813.5*	3654.2	X_2	.17992
								X_3	.52075
								X_4	.28610
								X_5	.01818
								X_6	-.27493
								X_7	.04985
								X_8	.37013
								X_9	-.11553
2	X_3	.7685	28683.1	.5906	.1065	b_1 = -13340.0*	3297.0	X_2	.28641
						b_3 = 9.7*	3.3	X_4	.32582
								X_5	.05730
								X_6	-.17687
								X_7	.04472
								X_8	.39159
								X_9	-.08073
3	X_8	.8083	26986.1	.6533	.0398	b_1 = -13459.5*	3102.5	X_2	.35914
						b_3 = 9.3*	3.1	X_4	.30541
						b_8 = 637.6+	319.4	X_5	.03824
								X_6	-.19070
								X_7	.00172
								X_9	-.08340
4	X_2	.8355	25778.3	.6981	.0272	b_1 = -11088.6*	3254.4	X_4	.17954
						b_2 = 22196.1+	12586.8	X_5	-.05736
						b_3 = 9.9*	3.0	X_6	-.27267
						b_8 = 695.8+	306.9	X_7	-.07357
								X_9	-.03749
5	X_6	.8488	25414.0	.7205	.0133	b_1 = -7397.7+	3471.5	X_4	.10543
						b_2 = 24869.5+	12586.8	X_5	.22681
						b_3 = 9.0*	3.1	X_7	.13126
						b_6 = -3694.0	2914.5	X_9	.07732
						b_8 = 701.5+	302.6		
6	X_5	.8573	25394.6	.7350	.0085	b_1 = -9496.2*	3469.9	X_4	.15975
						b_2 = 22371.1+	12815.8	X_7	-.01986
						b_3 = 8.4*	3.1	X_9	.04257
						b_5 = 1625.8	1601.6		
						b_6 = -6991.5	4367.8		
						b_8 = 666.9+	304.3		
7	X_4	.8612	25755.5	.7417	.0039	b_1 = -11652.4+	4716.8	X_7	.01983
						b_2 = 17133.1	15071.6	X_9	.04313
						b_3 = 8.3*	3.2		
						b_4 = 1567.2	2282.7		
						b_5 = 1861.0	1660.0		
						b_6 = -6807.1	4432.9		
						b_8 = 619.4+	316.3		

FINAL STEP: MULTIPLE REGRESSION MODEL

REGION 4 - PUELLARO: 26 farms

X_9	R	standard error of the estimate	R^2	regression coefficients	standard error of the coefficients
	.8615	26,477.5	.7417	b_1 = -11690.9+	4853.9
		mean value of the dependent variable		b_2 = 17721.2	15842.4
				b_3 = 8.3*	3.3
		34,200.2		b_4 = 1567.2	2346.7
				b_5 = 1812.6	1728.0
				b_6 = -6940.2	4618.1
				b_8 = 622.3+	325.6
				b_9 = 131.9	741.2
				variable not included	partial coefficient
				X_7	.01425

*Significant on the 99 percent level
+Significant on the 95 percent level

The measure of explained variability of the dependent variable decreases when the regression model is applied to farms in the Puellaro region. Only seventy-four percent of the variation in income per hectare on the farms is explained by the regression. The standard error of the estimate, however, is smaller than the observed mean value of the dependent variable which increases the usefulness of the model as a predictor equation.

Farm size (X_1), production cost (X_3) and income from pigs (X_8) are the three variables which significantly effect the level of income per hectare on farms in Puellaro.

Farm size (X_1) has the highest simple correlation with income per hectare in Puellaro (-.6620). Differences in farm size account for forty-four percent of the variation in income per hectare on the farms. The regression coefficient is negative in accord with the postulated relationship between farm size and income. Where farm size increases, there is a decrease in productivity per hectare.

Production cost (X_3) is the second independent variable included in the equation. Where farm size in Puellaro is held constant, there is an increase in income per hectare with higher investments in the methods of production.

None of the four types of crop production contributes significantly to variation in income on the farms, where all remaining variables are held statistically constant. Income from pigs (X_8), however, is positively related to overall productivity. Where farm size and production cost are held statistically constant, an increase in the proportion to total income earned from pig-raising results in an increase in income per hectare on the farms.

Included variables								Var. not included	
Step	Variable	R	Std. err.	R^2	Increase	Regr. coeff.	Std.err.	Variable	Partial corr. coeff
1	X_3	.7739	38960.9	.5989	.7739	b_3 = 18.2*	2.5	X_1	-.35985
								X_2	.36189
								X_4	-.50804
								X_5	-.34680
								X_6	-.11442
								X_7	-.27719
								X_8	.00737
								X_9	.50657
2	X_4	.8381	34021.3	.7024	.0642	b_3 = 19.3*	2.2	X_1	-.14396
						b_4 = -1276.0*	360.6	X_2	.22176
								X_3	-.22484
								X_6	-.06084
								X_7	-.38826
								X_8	-.10371
								X_9	.47110
3	X_9	.8766	30435.2	.7684	.0385	b_3 = 15.1*	2.4	X_1	-.15151
						b_4 = -1048.9*	330.5	X_2	.22762
						b_9 = 1091.5*	345.4	X_5	-.20879
								X_6	-.11878
								X_7	-.38710
								X_8	-.07405
4	X_7	.8962	28472.0	.8032	.0196	b_3 = 15.4*	2.2	X_1	-.14356
						b_4 = -1147.2*	311.8	X_2	.32487
						b_7 = -1076.4*	439.7	X_5	-.00795
						b_9 = 1009.4*	324.9	X_6	-.22084
								X_8	-.18301
5	X_2	.9077	27332.7	.8239	.0115	b_2 = 20405.1+	10340.9	X_1	-.24517
						b_3 = 15.3*	2.1	X_5	.09398
						b_4 = -941.0*	317.0	X_6	-.14111
						b_7 = -1223.5*	428.6	X_8	-.05248
						b_9 = 970.2*	312.5		
6	X_1	.9135	26909.3	.8345	.0058	b_1 = -3966.7	2772.8	X_5	.00546
						b_2 = 24154.4+	10512.7	X_6	-.12473
						b_3 = 14.3*	2.2	X_8	-.05878
						b_4 = -661.0+	368.4		
						b_7 = -1219.9*	422.0		
						b_9 = 955.4*	307.9		
7	X_6	.9149	27126.4	.8370	.0014	b_1 = -3801.7	2805.1	X_5	.03616
						b_2 = 21845.4+	11099.1	X_8	-.09102
						b_3 = 14.0*	2.3		
						b_4 = -669.2+	371.5		
						b_6 = -2088.0	2975.8		
						b_7 = -1269.8*	431.3		
						b_9 = 976.6*	311.8		
8	X_8	.9157	27460.3	.8385	.0008	b_1 = -3799.8	2839.7	X_5	.04926
						b_2 = 18958.9	12628.9		
						b_3 = 14.0*	2.3		
						b_4 = -735.0+	398.4		
						b_6 = -2444.0	3097.6		
						b_7 = -1318.0	4 7.1		
						b_8 = -160.0	319.6		
						b_9 = 965.6*	316.4		

FINAL STEP: MULTIPLE REGRESSION MODEL

GROUP 4: 39 farms

X_5	R	standard error of the estimate	R^2	regression coefficients	standard error of the coefficients
	.9159	27,895.9	.8389	b_1 = -3474.7	3133.6
				b_2 = 19166.4	12852.9
		mean value of the dependent variable		b_3 = 14.1*	2.4
				b_4 = -795.0+	463.5
		29,242.2		b_5 = 245.3	923.7
				b_6 = -2669.9	259.7
				b_7 = -1415.1+	583.1
				b_8 = -1711.9	327.7
				b_9 = 970.0*	321.9

*Significant on the 99 percent level
+Significant on the 95 percent level

Group 4 contains the largest number of farms of any subset considered (39 members). The regression model applied to Group 4 explains eighty-four percent of the variation in the dependent variable. The standard error of the estimate is smaller than the observed mean value of the dependent variable, but is still substantial. For farms in Group 4, then, the model has a moderate potential as a predictor equation of farm productivity.

Variation in income per hectare in Group 4 is the result of a slightly more complex interaction of variables. Four variables contribute significantly to the level of productivity on the farms: production cost (X_3), income from corn (X_4), income from chickens (X_9), and income from potatoes (X_7).

Production cost (X_3) has the highest simple correlation with income per hectare (.8176). It is the first independent variable included in the regression, and, alone, accounts for sixty-nine percent of the variation in productivity on the farms. Production cost is directly related to the level of income.

Income from corn (X_4) is the second independent variable included in the regression. The coefficient is positive and significant on the 95 percent level. Where production cost is held statistically constant, an increase in the amount of total income derived from corn production is accompanied by a rise in the level of income per hectare.

Use of chemicals (X_2) is the third variable included in the regression. Application of chemicals on farms in Group 9 positively affects the level of income on the farms where both production cost and income from corn are held constant.

TABLE 19 SUMMARY TABLE FOR THE REGRESSION MODEL: GP9

Included variables								Var. not included	
Step	Variable	R	Std. err.	R^2	Increase	Regr. coeff.	Std.err.	Variable	Partial corr. coeff.
1	X_3	.8176	16586.8	.6685	.8176	b_3 = 13.3	3.1	X_1 X_2 X_4 X_5 X_6 X_7 X_8 X_9	-.35756 .39753 .55866 -.20732 -.32608 -.52512 -.26908 -.31912
2	X_4	.8786	14591.5	.7719	.0610	b_3 = 14.8* b_4 = 2193.4+	2.9 1151.2	X_1 X_2 X_5 X_6 X_7 X_8 X_9	-.57704 .63644 -.07102 -.19396 -.48269 -.16055 -.44902
3	X_2	.9297	12032.0	.8643	.0511	b_2 = 16749.3+ b_3 = 13.9* b_4 = 2642.6+	7672.4 2.4 971.4	X_1 X_5 X_6 X_7 X_8 X_9	-.51622 -.37031 -.48937 -.74630 .16141 -.44109
4	X_7	.9695	8650.3	.9399	.0398	b_2 = 18851.6* b_3 = 13.1* b_4 = 2220.3* b_7 = -654.5+	5568.9 1.7 715.1 238.3	X_1 X_5 X_6 X_8 X_9	-.65168 .24529 -.55978 -.11074 -.48178
5	X_1	.9826	7187.5	.9655	.0231	b_1 = -2007.5+ b_2 = 15796.9* b_3 = 11.7* b_4 = 2405.3* b_7 = -610.7*	1044.9 4892.7 1.6 601.9 199.3	X_5 X_6 X_8 X_9	.23843 -.71528 -.28053 -.43129
6	X_6	.9915	5615.7	.9831	.0089	b_1 = -1962.8+ b_2 = 17754.5* b_3 = 11.3* b_4 = 2179.2* b_6 = -2663.9+ b_7 = -559.3*	816.7 3940.6 1.3 483.1 1301.3 157.7	X_5 X_8 X_9	-.51240 -.47661 -.30272
7	X_5	.9938		.9876	.0023	b_1 = -2058.3+ b_2 = 20154.9* b_3 = 10.9* b_4 = 2018.2* b_5 = -807.6 b_6 = -3948.8+ b_7 = -337.3	815.1 4545.6 1.4 503.7 781.5 1791.9 265.7	X_8 X_9	-.50504 -.18223
8	X_8	.9954		.9908	.0016	b_1 = -2160.1+ b_2 = 18433.3* b_3 = 10.7* b_4 = 1844.0* b_5 = -748.0 b_6 = -3936.0+ b_7 = -394.3 b_8 = -1.0	870.4 5236.1 1.4 572.6 829.2 1894.2 289.2 1.3	X_9	-.43637

FINAL STEP: MULTIPLE REGRESSION MODEL

GROUP 9: 11 farms

X_9	R	standard error of the estimate	R^2	regression coefficients	standard error of the coefficients
	.9962	7,490.1	.9924	b_1 = -2009.6	1150.1
				b_2 = 16887.0+	7386.3
		mean value of the dependent variable		b_3 = 10.9*	1.9
				b_4 = 1875.8+	731.5
		21,003.0		b_5 = -561.7	1122.8
				b_6 = -3341.6	2704.1
				b_7 = -445.5	382.8
				b_8 = -1.3	1.7
				b_9 -136.2	280.9

*Significant on the 99 percent level
+Significant on the 95 percent level

The best results of the multiple regression model are yielded when the model is applied to Group 9 farms. Ninety-nine percent of the variability in income is explained by the regression on independent variables, and the standard error of the estimate is approximately one third of the size of the observed mean value of the dependent variable. For farms in Group 9, then, the model has high potential as a predictor equation of income per hectare.

Three variables contribute significantly to variation in income: production cost (X_3), income from corn (X_4), and use of chemicals (X_2).

Production cost (X_3) has the highest simple correlation with income per hectare on the farms in Group 4. Sixty percent of the variation in income is explained by differences in production cost. The coefficient is positive and significant on the 99 percent level.

Each of the two crop productions significant in the final equation, (X_4) and (X_7), is inversely related to productivity. Where farms in Group 4 derive larger proportions of their total income from corn production (X_4), or from potato production (X_7), there is an associated drop in their overall income per hectare where all other variables are held statistically constant.

Income from chickens (X_9) is included in the regression equation in step three. The coefficient is positive and significant on the 99 percent level. Chicken-raising is identified with higher productivity on the farms, where all remaining variables are held constant.

Summary: Chapter IV; Multiple Step-Wise Regression Model

Selection of the Independent Variables:

A reduced set of nine independent variables was employed in the multiple step-wise regression model. The eight primary factors from principal axes factor analysis were used as a reference frame to identify a subset of eight explanatory variables. Farm size, not a part of any factor, was added to the set of independent variables in the regression.

The coefficient of determination, R^2, measures the variation of the dependent variable explained by the independent variables in the regression equation. Table 20 lists, for each sample, the difference in R^2 produced using alternate sets of independent variables. The reduced set of variables allows the regression to be performed on two additional samples.

TABLE 20

COEFFICIENT OF DETERMINATION: R^2

USING ALTERNATE SETS OF INDEPENDENT VARIABLES

SAMPLE	R^2 SET OF 24 VARIABLES	R^2 REDUCED SET OF 9 VARIABLES
TOTAL SAMPLE	.5126	.3744
YARUQUI	.8253	.5482
TUMBACO	sample too small	.9629
CAYAMBE	.9676	.9700
PUELLARO	.7227	.7417
GROUP 4	.8987	.8389
GROUP 9	sample too small	.9924

The R^2 produced by the regression model applied to the total sample of 100 farms at the aggregate level is small for both sets of independent variables. This indicates that, in order to increase the power of the model, the sample must be broken into more homogeneous subsets, or that an increased number or more informative set of explanatory variables must be used in the regression.

In the case of Yaruqui there is a substantial loss in R^2 when only nine independent variables are included in the regression. Here, the three variables contributing significantly to variation in the dependent variables are: income from pigs (X_8), use of chemicals (X_2), and income from chickens (X_9). Income from pigs corresponds to Factor VI. Income from chickens corresponds to Factor VIII. Daling and Tamura (1970) note that when the Factors correlated with the dependent variable are those corresponding to low eigenvalues a regression equation with high R^2 is unlikely.

For each of the remaining samples, the reduction of the original twenty-four variables to only eight variables did not produce material loss in R^2. In two regions, Cayambe and Puellaro, the R^2 was slightly increased using the reduced set of independent variables. In addition, the smaller number of explanatory variables allowed the model to be applied to two further samples.

Potential of the Model as a Predictor Equation:

The standard error of the estimate measures the accuracy with which the regression model can predict values of the dependent variable. The potential of the model as a predictor equation is increased where the standard error is relatively small in comparison with the observed mean value of the dependent variable. Table 21 lists the mean value of the dependent variable, the standard error of the estimate, and the error expressed as a percentage of the mean value, for each sample.

TABLE 21

STANDARD ERROR OF THE ESTIMATE

SAMPLE	MEAN VALUE OF DEPENDENT VARIABLE	STANDARD ERROR OF THE ESTIMATE	ERROR AS A PERCENTAGE
TOTAL	32,006.5	56,771.0	177.4 %
YARUQUI	34,517.2	68,763.0	199.2 %
TUMBACO	53,893.8	37,500.6	69.6 %
CAYAMBE	19,183.0	11,428.9	59.6 %
PUELLARO	34,200.2	26,477.0	77.4 %
GROUP 4	29,242.0	27,895.0	95.4 %
GROUP 9	21,003.0	7,490.1	35.7 %

The potential of the regression model as a predictor equation is very poor when applied to the 100 farms at the aggregate level. The power of the model is substantially increased when the sample is disaggregated by physical region (with the exception of Yaruqui). The best results occur when the regression model is applied to the Group 9 farming type. For the farms in Group 4 (the largest subset considered), however, the power of the model is not as strong as Group 9.

Contribution of the Independent Variables: Simple Correlations

The simple correlation coefficients give a preliminary indication of the strength and direction of relationship of the set of independent variables with the dependent variable. Table 22 demonstrates for each sample those independent variables with a significant simple correlation with income per hectare, and that variable for the sample with the highest correlation coefficient.

TABLE 22

SIMPLE CORRELATION COEFFICIENTS WITH DEPENDENT VARIABLE:

INDEPENDENT VARIABLE:	TOTAL SAMPLE:	YARUQUI	TUMBACO	CAYAMBE	PUELLARO	GROUP 4	GROUP 9
X_1	-.306*	-.215	-.488	-.333	<u>-.662*</u>	-.434*	-.625+
X_2	.031	.315	<u>-.617+</u>	.022	.387+	.238	.416
X_3	<u>.354*</u>	-.046	-.155	<u>.946*</u>	.547*	<u>.774*</u>	<u>.818*</u>
X_4	-.197+	-.250	-.461	-.192	-.148	-.206	.089
X_5	-.180	-.218	-.237	-.110	-.151	-.198	-.160
X_6	-.177	-.166	-.026	-.099	-.454+	-.228	-.227
X_7	-.184	-.218	-.326	.150	-.205	-.179	-.347
X_8	.345*	<u>.546*</u>	.125	-.019	.277	-.019	-.170
X_9	.266*	.099	.094	.866*	-.294	.694*	-.330

*Significant on the 99 percent level
+Significant on the 95 percent level
___Highest simple coefficient for sample

Farm size (X_1), is negatively correlated with the dependent variable in all seven samples. This inverse correlation between farm size and total income, is in agreement with the original hypothesis. Where size of farm incresses, there is an associated decrease in income per hectare.

Use of chemicals (X_2), is directly correlated with the dependent variable in all samples except Tumbaco. For all samples except Tumbaco, increased use of chemicals yields higher returns per hectare.

Production cost (X_3) has the highest simple correlation with the dependent variable in four of the seven samples. In all seven samples, production cost is positively correlated with income per hectare. Increased investment in methods of production is directly correlated to the level of productivity on the farm.

The four crop productions (X_4, X_5, X_6, and X_7) generally are negatively correlated with the level of income on the farms. Where the correlation coefficient is statistically significant, the relationship is inverse indicating that where the proportion of total income derived from crop production is increased, there is an associated drop in overall farm productivity.

Conversely, the two livestock productions (X_8, X_9) tend to be directly correlated to the level of income on the 100 farms. In all cases where the simple correlation coefficient is statistically significant, the relationship is positive. Where larger proportions of total income are earned by livestock-raising, there is an accompanying rise in productivity per hectare.

Contribution of the Independent Variables: Step-Wise Regression Model

The order in which the independent variables are entered into the regression equation is an indication of the importance of the contribution of each independent variable to observed variation in the dependent variable. Table 23 summarizes, for each regression model, those independent variables in the final step of the regression equation that make a statistically significant contribution to the variation in income per hectare.

TABLE 23

ORDERING OF THE INDEPENDENT VARIABLES

MULTIPLE STEP-WISE REGRESSION MODEL

TOTAL SAMPLE 100 farms	YARUQUI 31 farms	TUMBACO 12 farms	CAYAMBE 31 farms	PUELLARO 26 farms	GROUP 4 39 farms	GROUP 9 11 farms
X_3(+)	X_8(+)	X_2(-)	X_3(+)	X_1(-)	X_3(+)	X_3(+)
X_8(+)	X_2(+)	X_1(-)	X_7(-)	X_3(+)	X_4(-)	X_4(+)
	X_9(+)	X_4(+)	X_4(-)	X_8(+)	X_9(+)	X_2(+)
		X_7(-)			X_7(-)	
		X_5(+)				
		X_9(-)				

X_1 Farm size
X_2 Use of chemicals
X_3 Production
X_4 % Income from corn
X_5 % Income from beans
X_6 % Income from lima beans
X_7 % Income from potatoes
X_8 % Income from pigs
X_9 % Income from chickens

FARM SIZE:

Farm size (X_1) is not highly significant in explaining variation in income per hectare on the 100 farms. Farm size enters significantly into the final regression equation in only two of the seven models (Tumbaco and Puellaro), and only in the case of the Puellaro region does farm size have the highest simple correlation with the dependent variable. Here, however, it is the first variable entered in the regression equation and, independently, it accounts for 66% of the variation in income per hectare on the farms.

In both regression equations where farm size is statistically significant, the relationship is inverse. Where there is an increase in farm size, there is an associated decrease in overall productivity on the farms.

PRODUCTION COST:

Production cost (X_3) has the highest simple correlation with the dependent variable in four of the seven models. Alone, it accounts for the following proportion of variation in income per hectare: 13% of the variation in income for the total sample, 90% of the variation in income on farms in Cayambe, 60% of the variation in productivity within Group 4, and 67% of the variation in income per hectare on farms in Group 9.

Production cost contributes significantly to variation in income on the farms in five of the seven samples (excluding Yaruqui and Tumbaco). In all five cases, production cost is directly related to level of productivity. The larger the investment in methods of production, the higher the returns per hectare. Direct investment in the farming operation in terms of improved feeding and veterinary care for the livestock, and increased technology for the crops, then, is more influential in determining the level of productivity per hectare on the farms than variations in farm size.

USE OF CHEMICALS:

Use of chemicals (X_2) is statistically significant in three of the seven regression equations. In four of the samples, Cayambe, Puellaro, Group 4 and the Total Sample, application of chemicals does not significantly affect the level of income per hectare on the farms. On the farms in Yaruqui and Group 9, increased use of chemicals is identified with an increase in overall productivity. Within Tumbaco, however, the relationship is inverse. Increased expenditure on chemicals does not prove to be an economical investment for the farms. This anomaly in the Tumbaco region, may be the product of the unusually small size of farm plot in the region, and the extremely high rate of off-farm employment. Additional capital expenditure may not be economical where size of production is so limited. Excessive or incorrect application of chemicals may also adversely effect productivity.

CROP PRODUCTION:

Income from corn (X_4) is statistically significant in four of the seven regression equations. In two samples, Tumbaco and Group 9, corn production is directly related to the level of income per hectare. Conversely, within Cayambe and Group 4, corn production is inversely related to productivity. Generally, corn production provides relatively weaker economic support to total income (Table 3), and the negative regression coefficients (Cayambe and Group 4) demonstrate that the crop can adversely affect overall productivity. Unlike potato production, however, corn production in two cases (Tumbaco and Group 9) is directly related to the level of income on the farms. The average size of farm in both Tumbaco and Group 9 is smaller than the sample average. In addition, the rate of off-farm employment is extremely high for both samples. Where production is very limited, then, the sale and consumption of this staple crop appears to influence positively overall productivity.

Income from potatoes (X_7), in all three cases where it is statistically significant (Tumbaco, Cayambe, and Group 4), is inversely related to income per hectare. The larger the proportion of total income derived from potato production, the lower the overall productivity (all other variables held statistically constant). Table 3 earlier illustrated the secondary role potato production had in the 100 farming operations. No farm earned more than 54% of its total income from potatoes. The inverse relationship with productivity yielded by regression analysis could reflect the less intensive and secondary nature of this form of agriculture on the 100 sample farms.

Income from the two types of bean production (X_5) and (X_6) provides relatively weak economic support to total income on the 100 farms (Table 3). The mean income from both types of bean production does not exceed 4% of the total income on the farms. In regression analysis, income from lima beans (X_6) does not contribute significantly to variation in income in any sample. Income from beans (X_5) is significant in only one regression equation.

LIVESTOCK PRODUCTION:

Pig-raising is the second most common enterprise on the 100 farms; one quarter of the farms derive at least twenty-five percent of their total income from pigs (Table 3). Income from pigs (X_8) contributes significantly to variation in farm income in three of the seven regression models (total sample, Yaruqui and Puellaro). In Yaruqui, pig-raising has the highest correlation coefficient with the dependent variable, and, alone, it accounts for thirty percent of the variation in income on the farms in the region. In all three cases, pig production is directly related to the level of income per hectare reflecting the more intensive nature of the farming enterprise.

Chicken-raising is the most common farming activity in the sample and, generally, provides around one-sixth of the total farm income where it is practiced (Table 3). In Yaruqui and in Group 4, income from chickens (X_9) is directly related to the level of income per hectare indicating, as in pig production, the intensive nature of the enterprise. In Tumbaco, however, income from chickens is inversely related to productivity. This contradiction may be explained by the unusually small size of farm plot sampled and the high rate of off-farm employment. Those farms attempting to create a viable farm income from chickens, generally, have reduced income from 'other' sources. This drop in supplementary income may not be subsidized adequately by the increase in income from chicken-raising. Thus, chicken-raising (generally a more intensive form of agriculture) may appear to affect adversely overall productivity.

CHAPTER V:

CONCLUSIONS

A. The Methodological Approach:

a. The Data Base

Twenty-four primary characteristics were selected to describe all observed forms of agriculture. Four of these variables, however, were found infrequently on the 100 farms. The fact that these rarer sources of income (vegetables, mixed beans, alfalfa, and sheep-raising) were included in the subsequent analysis must be kept in mind in interpreting the results. For example, in the factor analysis, these four particular variables loaded fairly high on Factors II, V, and VIII and thereby weighted the scores on these factors for those farms possessing these four types of production. The subsequent grouping analysis, which was based on the scores for the first eight factors, would undoubtedly have produced different results had these four variables been excluded.

b. The Typology of Farms

The results of simple linear regression analysis applied to the total sample, and to the sample disaggregated by region, were weak. The amount of variability of the dependent variable explained by the regression equation was small, and the size of the standard error of the estimate remained substantial. In an attempt to improve the results of the subsequent analysis, the sample was disaggregated according to farm type.

Given the results of this grouping, the relationship between farm size and farm income was reconsidered by farming type. Although the results of the regression model were generally stronger, the standard error of estimate remained large in comparison to the observed mean value of the dependent variable. Variations in productivity, then, could not be satisfactorily explained by differences in farm size even when the sample was appraised according to type of farming enterprise.

The potential of a set of independent variables as a predictor of the dependent variable was then examined in a multiple regression model performed on the total sample, the sample subdivided by region, and two major farm groupings. The most accurate results were obtained when the model was applied to the set of farms in Group 9. Ninety-nine percent of the variation in income was explained by the regression, and the standard error of the estimate was reduced to approximately one third the size of the observed mean value of the dependent variable. The results of the model applied to Group 4, however, were much weaker. The size of the standard error for this group was much more substantial than the error produced by the regression performed on three of the four natural regions: Tumbaco, Cayambe, and Puellaro. In addition, the multiple coefficient of determination (R^2), in two of the regions (Tumbaco and Cayambe) was much higher than that of Group 4.

The typology of farms, then, did not consistently yield more accurate results in regression analysis than the more simple disaggregation of the sample by natural region.

c. The Independent Variables

To eliminate multicollinearity among the explanatory variables used in the regression analysis a reduced set of variables was selected. The eight primary Factors from principal axes factor analysis were used as a framework to choose eight independent variables. Farm size, not a part of any Factor, was included as a ninth variable.

Only in the case of Yaruqui was there a substantial loss in R^2 using the reduced number of independent variables. Here, two of the variables significantly affecting the dependent variable corresponded to Factors with lower eigenvalues. For both Cayambe and Puellaro, the R^2 was slightly increased when the reduced set of variables was employed. In addition, when only nine variables were used, the regression could be applied to two further samples.

B. Results of Analysis:

a. Characteristics of the Farms

There was a large variation in the distribution and spread of the twenty-four primary characteristics over the 100 farms. In general, however, the farms recorded a moderate level of technology, and,in a majority of cases, supplemented their incomes with off-farm employment. The most commonly practised farm enterprises were: chicken-raising, pig-raising, corn production, potato production, and cattle-raising. The four most infrequently practiced activities were: vegetable growing, mixed bean production, alfalfa production, and sheep-raising.

b. Regionalization of Farming Types

Farming activity on the 100 peasant farms surveyed was quite varied. A typology of the farms using factor analysis and hierarchical grouping analysis produced fourteen classes of farming. In general, there was no clear grouping of the farms on the Factors according to region. In addition, there was a high mixture of farming types within each of the four areas. Yaruqui, Tumbaco, Cayambe and Puellaro each contained at least seven different types of farming operations. Farms sampled in each region were relatively contiguous, and, in no case, represented seven distinct climatic variations. The heterogeneous nature of farming activities, then, cannot be explained solely in terms of physical-environmental factors.

c. Contribution of Independent Variables to Variations in Income

Crop productions $((X_4)(X_5)(X_6)(X_7))$ contributed significantly to variations in income in four of the seven regression equations. Livestock productions $((X_8)(X_9))$ contributed significantly to variation in the dependent variable in six of the seven models. Generally, then, the two types of livestock production were much more important in affecting the level of productivity on the farms than the four crop productions. In addition, where livestock production entered significantly into the regression equation, in all cases but one the production was directly related to the dependent variable. Crop production, conversely, generally inversely affected the level of income. These results reflect the more intensive nature of the two forms of livestock agriculture.

Production cost (X_3) was the most highly significant independent variable contributing to variation in income per hectare on the 100 farms. In four of the seven regression equations, production cost had the highest simple correlation coefficient with the dependent variable explaining the following amounts of variability in income: 13% of the variation in income for the total sample considered at the aggregate level, 90% of the variation in income in Cayambe, 60% of the variation in Group 4, and 67% of variation in income on farms in Group 9.

In all cases production cost was directly related to the dependent variable. Increased investment in the methods of production inferred higher productivity on the farms.

Farm size (X_1) was not highly significant in explaining variation in income per hectare on the 100 farms. In nine of the fifteen simple regression models, there was no significant regression of the dependent variable on the independent variable. Where the results of the regression equation were statistically significant, however, the relationship between farm size and total income was inverse as postulated;as farm size decreased, there was an associated increase in overall productivity. The phenomenon of higher production on smaller plots represents an adjustment to relatively small amounts of land per family worker.

Farm size alone, however, failed to explain substantial amounts of variation in the dependent variable. The value of R^2 remained small, and in addition, the size of the standard error of the estimate in comparison to the observed mean value of the dependent variable, was large in all samples.

Before concluding much about the comparative efficiency of farms of differing size, the relative importance of a wider set of independent variables to variation in income was considered in a multiple step-wise regression model. Farm size was statistically significant in only two of the seven regression models. In the remaining five samples, farm size did not significantly contribute to variations in income per hectare. Production cost, in contrast, was highly significant in five of the seven models.

The present study has demonstrated, then, for the 100 farms sampled in Andean Ecuador, that the most influential variable contributing to variation in income per hectare, is production cost. Development characterized by the adaptation of yield increasing technology in the farm of improved feeding and veterinary care for the livestock, and increased availability of chemicals for the crops appears to have the most positive effect on farm productivity.

Whether this conclusion would be a useful concept in the theory of rural planning is not answered by this one study. Instead of using the primary twenty-four characteristics as static measures of the structure of peasant agriculture, subsequent studies might use measures of changes which have occurred in the characteristics over a period of time. In this manner, the findings of this study might be empirically affirmed and theoretically useful in land reform policy for Andean Ecuador.

Appendix I: Factor Scores on Principal Eight Factors by Farming Type

FACTOR SCORES OF FARMS IN GROUP 1

FARM	I	II	III	IV	V	VI	VII	VIII
(1:1)	-.14245	1.76949	.67814	.43796	.41701	.10052	-.56895	.26120
(1:3)	.68038	-.09783	.67476	1.60376	-.10450	.63495	-.99553	1.26189
(1:13)	-.56481	1.79995	-.15245	.91085	-.05074	.75126	-.85607	.82860
(1:14)	.55937	-.29753	.31675	1.39414	-1.42806	-.71472	-.51349	1.24399
(3:6)	-.09962	1.33193	.44731	1.64568	.49983	.75440	-.11703	1.46037
(3:8)	.44901	-.25365	.28828	1.18284	-.28403	-.91993	-.79353	.55700
(4:1)	.90261	.75305	.65226	2.90968	-.16620	.71334	-.35683	1.70825
(4:11)	-.27791	1.58504	-.01751	.94466	-1.52525	.04345	.76646	.31116
(4:23)	-.66607	.65472	.01385	.98471	.06575	.20110	.34770	.80004

FACTOR SCORES OF FARMS IN GROUP 2

FARM	I	II	III	IV	V	VI	VII	VIII
(1:2)	.42620	.17306	.53620	.59242	-2.53323	.83109	-1.69633	.94174
(1:10)	-.46948	-.28028	.61701	-1.71591	-2.09082	.71631	-1.23602	1.36614
(3:13)	.21801	.11460	1.19183	-3.17676	-2.55214	1.59969	1.54861	1.23993
(3:25)	.20128	-.09001	.47497	-.60746	-3.26361	.64405	.79426	.23377

FACTOR SCORES OF FARMS IN GROUP 3

FARM	I	II	III	IV	V	VI	VII	VIII
(1:4)	-4.18827	-.40880	.34835	-.30049	.29538	-.20237	-.44310	-.03685
(1:28)	-3.70214	-.57338	.15993	.11097	.22177	.14456	-.65808	.41243
(2:10)	-4.09792	-.28284	.43932	-.44234	.05959	.01352	-.07237	.40022
(4:14)	-4.34590	-.53162	-.03009	.16682	-.03612	.08607	.59405	.01464
(4:26)	-3.60953	-.57389	.38731	.13180	.16530	.07835	.82892	-.97528

FACTOR SCORES: GROUP 5

FARM	I	II	III	IV	V	VI	VII	VIII
(1:9)	.48999	.14772	-.13822	-2.94326	.76142	-.07487	-1.00792	-.13458
(1:21)	.39677	-.11511	-.86692	-2.29701	.72947	-.75661	-1.16984	-.30276
(2:2)	.41429	.07117	.03010	-4.16698	.31969	-.04349	-.80450	.31306
(3:2)	.34267	-.13008	-.47016	-2.39903	1.68055	-1.45205	-1.04609	.52654
(3:14)	.46604	.30585	-.48109	-2.59428	.62160	-.00392	-.08559	-.32741

FACTOR SCORES: GROUP 6

FARM	I	II	III	IV	V	VI	VII	VIII
(1:11)	.36919	.02580	-4.18689	-.58998	.36000	.07171	-.49323	.10449
(1:23)	.38588	-.32363	-3.61930	.08924	.29621	.25016	-.37668	.24533
(2:1)	.45386	-.69893	-1.11837	.64653	-.01175	.56224	-.52061	.29720
(3:4)	.46799	-.54406	-1.96634	-.00133	.44622	.34270	.00645	-.07173
(3:28)	.44401	-.83191	-2.37157	.72945	.29158	.44867	.19087	.14850
(4:9)	-.96377	-.11504	-5.55406	.64695	-.39373	.10599	.84174	.58856
(4:21)	.42300	-.56144	-2.08030	.29976	.21527	.39987	.83395	-.22433

FACTOR SCORES: GROUP 4

FARM	I	II	III	IV	V	VI	VII	VIII
(1:5)	.35675	-.25929	.70817	-.43366	.03762	.85267	.07936	.17061
(1:6)	.22983	-.31316	.59357	-1.68437	.01377	-.23945	-.03752	.98886
(1:7)	.47716	-.31641	.29524	.26979	.34987	.49654	-.54556	-.04024
(1:8)	.44616	-.33675	.50424	-.11788	-.47047	.66470	-.77812	.31529
(1:16)	-.98986	-.05204	.17567	-.05892	-.01912	.37118	-.42060	.30806
(1:19)	.48727	-.22202	.38571	.27616	.38822	.59323	-.53013	.03656
(1:20)	.45212	-.29089	.51346	.05258	-.51512	.72675	-.68898	.29842
(1:22)	-.40563	.13196	-.21083	.68856	.29283	.55138	-.70285	.54375
(1:25)	-.63167	.33672	.33374	.56288	.40131	.13048	-.79955	.78660
(1:29)	.27251	-.25153	.86521	-.76522	-.15326	1.03293	.46793	.22487
(2:4)	.45210	-.35550	-.18604	.04315	.43087	.45525	-.32951	-.13657
(2:8)	.45633	-.35761	.32556	.29431	.38075	.56785	-.33598	-.02341
(2:9)	-.92516	-.50342	.40115	.27573	.35001	.44125	-.35896	.22407
(2:13)	.47517	-.15250	.26191	.22176	.35039	.55118	-.27254	-.13768
(2:15)	.45594	-.35711	.31191	.30178	.34988	.53196	-.30841	-.06607
(3:1)	.38989	-.18947	.04950	.09607	-1.42389	.28172	-.26201	-.08687
(3:3)	.26319	-.34360	.26284	.30316	.25424	.53241	-.35491	-.03572
(3:9)	.44016	-.32686	.30434	.19754	.21979	.60059	.05511	-.06291
(3:10)	-.23015	-.48837	.87033	.04440	1.18075	.07286	2.77476	-.56660
(3:11)	.24837	-.18995	.29949	.21807	.36374	.49978	.04473	-.54225
(3:12)	.45654	-.32215	.30176	.25119	.26187	.59553	.00607	-.17966
(3:15)	-.11080	-.36763	.23276	.28720	.25328	.46311	-.05515	-.21084
(3:16)	.47491	-.31071	-1.12378	-.32995	.49124	.36266	-.07175	-.21475
(3:20)	.45005	-.25270	.26860	.56439	.16189	.26446	-.20517	.05943
(3:21)	.44564	-.09293	.23021	.23514	.30107	.40523	-.01597	-.28488
(3:22)	.41684	-.45501	.05985	.26232	.30]94	.02281	.17652	-.05436
(3:23)	.44362	-.34207	.24081	.32907	.29778	.53428	-.03119	-.13121
(3:24)	-.24787	-.36272	.44626	-.01676	.10155	.68440	.25538	.10169
(3:26)	.44808	-.09043	-.35263	-.47679	.15120	.61636	.30700	-.05392
(3:27)	.24187	-.33778	.18133	.32455	.23220	.50660	-.04873	-.04377
(4:6)	.37735	-.17961	.74690	-1.29985	-1.15000	1.12682	.53789	.71265
(4:7)	.40248	-.26108	-.62445	-.71463	.04348	.47101	.71511	-.14442
(4:8)	.41014	-.30026	.06238	.39791	.11165	.54651	.68405	-.28983
(4:16)	.40993	-.29992	.05454	.40141	.14717	.54147	.71793	-.30624
(4:17)	.40019	-.25130	.17401	.07634	-.14680	.60119	1.06209	-.27538
(4:18)	.40849	-.17497	.08484	.33151	-.22064	.59803	.60702	-.25757
(4:19)	.36478	-.22000	-.51618	-1.82319	-.27061	.53440	.78504	.18790
(4:20)	.36502	-.30518	.06941	.39576	.11895	.53510	.72601	-.36496
(4:22)	.46320	-.38951	.44051	.23624	.45831	.51002	-.84896	.02425

FACTOR SCORES: GROUP 7

FARM	I	II	III	IV	V	VI	VII	VIII
(1:12)	.37989	-.44397	.63454	.09518	1.14747	-1.16007	-.48253	1.11560
(1:18)	.44953	-.50925	.35873	.22239	.56066	-.59524	.04212	.53992
(1:24)	.42589	-.40614	.56092	.15400	.87241	-.25923	-.52143	.56263
(2:5)	.41949	-.45077	.52425	.17533	.80837	-.43661	-.70703	.61202
(3:5)	.45107	-.62382	.45982	.24429	.58993	-.45732	-.37018	.58463
(3:17)	.38872	-.34162	.68509	.31998	1.23693	-1.22704	-.83121	1.39597
(3:29)	.41054	-.32871	.56072	.11044	.92311	-.27338	-.88297	.59760
(4:10)	.35822	-.27491	.61324	.06354	1.19126	-.73488	-1.06397	.87134

FACTOR SCORES: GROUP 8

FARM	I	II	III	IV	V	VI	VII	VIII
(1:15)	.28005	1.48782	.43132	-.02389	-.07069	-3.00364	-.89450	-.11634
(1:27)	.08287	.83582	.42725	-.50900	.65569	-5.15188	-.18665	.67109
(4:13)	.38594	-.49649	.38058	.95805	.76924	-3.54661	2.32515	1.82872
(4:25)	.30179	-.71753	-.01305	.43861	.10338	-2.02410	1.69849	.17074

FACTOR SCORES: GROUP 9

FARM	I	II	III	IV	V	VI	VII	VIII
(1:17)	-.38210	-.47479	.64579	.17392	.62023	.31318	-.29685	-1.33363
(1:26)	-.22662	-.57788	.11596	.01833	-.51100	-1.96248	-.83839	-1.62278
(1:30)	.08457	-.19051	.49099	.13351	.50012	.38492	-.36691	-.72847
(1:31)	.69895	-.24233	.21355	.64357	-.41375	-.48397	-.46216	-2.74099
(2:3)	-1.00363	-.28321	-.41931	.15586	.49493	.23170	-.27823	-.82563
(2:12)	.28990	-.38395	.03267	.19596	-.48748	-.43712	.06171	-1.29374
(3:7)	.43829	-.29795	-.16276	.46699	-.28001	-.21554	.10552	-.87066
(3:19)	.03279	-.52915	-.00189	.10173	-.43753	-1.68332	-.49670	-1.12952
(4:2)	-.20945	-.06601	.45105	.10921	.56056	-.01158	.10757	-.90200
(4:4)	.00469	-.39474	.37591	.27823	.40437	.42410	.12888	-.81992
(4:5)	.47184	-.26589	.14181	.32762	-.11418	.06971	.10579	-.74975

FACTOR SCORES: GROUP 10

FARM	I	II	III	IV	V	VI	VII	VIII
(2:6)	-.02369	4.60968	.30504	.03349	.48270	.39315	.10853	.05254
(3:18)	-.09123	5.92395	.10420	-1.39883	.15557	-.13748	.63698	-1.47869
(3:30)	-.31983	4.08696	-1.46322	1.10384	-.03147	.54562	.27518	.72693

FACTOR SCORES: GROUP 11

FARM	I	II	III	IV	V	VI	VII	VIII
(3:31)	.13966	-.42038	-.13065	.13360	-5.26584	-1.63897	-.88373	-.01305

FACTOR SCORES: GROUP 12

FARM	I	II	III	IV	V	VI	VII	VIII
(4:3)	.67235	.10562	1.15531	.78871	.96713	1.17085	-.56462	-5.73179

FACTOR SCORES: GROUP 13

FARM	I	II	III	IV	V	VI	VII	VIII
(4:12)	.20110	-.35290	-.58960	.55670	-3.32980	-2.05280	1.79997	-1.46112
(4:24)	-.13701	.40022	-.13063	.22841	-.84206	-1.54409	1.31786	-3.09602

FACTOR SCORES: GROUP 14

FARM	I	II	III	IV	V	VI	VII	VIII
(4:15)	.72180	-.25473	.99697	-.39919	1.25457	.54666	6.47362	1.51931

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES

VAR.	GROUP 10: 3 MEMBERS			GROUP 11: 1 MEMBER	GROUP 12: 1 MEMBER	GROUP 13: 2 MEMBERS		GROUP 14: 1 MEMBER
	(2:6)	(3:18)	(3:30)	(3:31)	(4:3)	(4:12)	(4:24)	(4:15)
1	13	7	4	6	4	5	3	4
2	no	no	no	no	yes	no	no	no
3	yes	yes	yes	yes	yes	no	no	no
4	yes	no	no	no	no	no	no	no
5	no	yes	yes	yes	yes	no	no	no
6	no	yes	yes	no	yes	yes	yes	yes
7	145	—	—	—	—	—	—	—
8	1655	1128	1970	1966	907	250	300	—
9	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—
11	—	3.39	—	—	—	—	—	—
12	—	73.10	—	—	—	—	—	—
13	47.85	—	—	21.74	—	—	—	—
14	4.78	5.72	12.68	—	—	—	—	—
15	—	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—
17	22.97	14.24	28.98	—	—	—	—	—
18	—	—	—	78.26	—	—	2.18	—
19	1.44	—	—	—	29.45	7.65	—	1.50
20	22.97	—	32.60	—	12.60	—	28.03	62.91
21	—	—	15.55	—	6.24	13.69	4.39	5.63
22	—	2.03	—	—	23.30	17.48	28.03	11.98
23	—	—	—	—	1.00	—	—	—
24	—	1.53	—	—	27.40	61.18	37.37	17.97

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 1: 9 MEMBERS

VAR.	(1:1)	(1:3)	(1:13)	(1:14)	(3:6)	(3:8)	(4:1)	(4:11)	(4:23)
1	8	4	8	8	1	13	5	13	1
2	yes	yes	yes	yes	no	no	no	no	no
3	yes	yes	yes	yes	yes	yes	no	no	no
4	yes	yes	yes	yes	no	no	no	no	no
5	yes	yes	yes	yes	yes	yes	no	no	no
6	yes	no	no	yes	no	yes	yes	yes	yes
7	33		292	85					
8	1600	1560	1465	1062	906	1000	1600		400
9									13.68
10									
11									
12					4.56				
13	28.74	74.53	51.34	13.17	9.78	5.52			
14	7.76		10.54	4.70					
15			17.83	3.14					
16			.29	1.41	1.56	2.52		.63	
17	7.18		2.70	20.90		3.94		1.10	
18					23.47	14.20		3.94	
19			2.52	1.57	9.13	6.31	3.32	2.36	
20		10.87		27.52	11.73				
21		14.60			.65	29.65		11.85	
22	29.50		14.77	25.08	39.11	18.93		62.63	37.53
23								2.36	
24	26.82			2.51		18.93	96.77	15.13	48.79

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 3: 5 MEMBERS

VAR.	(1:4)	(1:28)	(2:11)	(4:14)	(4:26)
1	6	5	4	5	4
2	yes	yes	no	no	no
3	yes	yes	yes	no	no
4	yes	yes	no	no	no
5	yes	yes	yes	no	no
6	no	yes	yes	yes	yes
7	____	____	____	____	____
8	1560	1340	3700		13
9	____	____	____	14.31	____
10	____	____	____	____	____
11	____	____	____	____	____
12	____	____	____	____	____
13	28.74	4.76	8.83	____	____
14	7.76	5.29	10.30	____	25.92
15	____	1.19	____	____	____
16	____	.95	____	3.58	8.64
17	7.18	2.65	15.45	3.91	16.20
18	____	____	____	.56	____
19	____	____	____	1.70	____
20	____	66.17	____	____	19.44
21	____	1.51	12.45	30.32	25.92
22	29.50	____	____	____	____
23	____	____	____	____	____
24	26.82	17.47	52.97	45.62	3.89

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 2: 4 MEMBERS

VAR.	(1:2)	(1:10)	(3:13)	(3:25)
1	4	5	7	8
2	yes	no	no	no
3	yes	no	yes	no
4	yes	no	yes	no
5	yes	no	yes	yes
6	no	yes	yes	yes
7	248	—	—	—
8	2976	800	2383	460
9	—	—	—	.59
10	—	—	—	—
11	—	—	3.99	—
12	—	—	17.22	74.66
13	30.93	8.92	6.46	1.42
14	18.56	2.03	9.57	5.72
15	3.87	—	—	—
16	6.19	—	—	—
17	2.58	—	18.04	—
18	—	—	—	—
19	2.32	—	—	—
20	1.80	—	21.53	3.11
21	—	12.84	11.24	1.61
22	1.55	—	4.78	8.67
23	—	—	—	—
24	30.07	76.21	7.18	4.11

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 4: 39 MEMBERS

VAR.	(1:5)	(1:6)	(1:7)	(1:8)	(1:16)	(1:19)	(1:20)	(1:22)	(1:25)
1	5	1	2	9	4	8	10	4	8
2	no	yes	yes	yes	yes	yes	no	yes	yes
3	no	yes	yes	yes	yes	no	no	yes	no
4	no	yes	yes	yes	yes	no	no	yes	yes
5	yes	yes	yes	yes	yes	no	no	yes	no
6	yes	yes	no	no	yes	no	yes	yes	no
7	____	200	____	225	250	____	____	____	____
8	2020	2096	3250	5583	2230	410	217	48	930
9	3.23	3.80	____	____	____	____	____	____	____
10	____	____	____	____	____	____	____	____	____
11	____	1.67	____	____	____	____	____	____	____
12	____	9.51	____	____	____	____	____	____	____
13	1.44	____	30.41	77.42	26.02	20.18	20.94	8.62	17.21
14	2.15	____	22.81	12.90	18.21	____	____	16.16	13.08
15	1.35	____	10.86	____	____	15.14	2.27	____	4.47
16	____	____	____	____	6.94	____	1.70	3.45	1.38
17	____	____	____	6.45	____	____	1.01	3.45	8.26
18	____	____	____	____	____	____	12.59	____	____
19	____	____	____	3.23	____	3.33	1.89	2.59	1.38
20	34.48	54.07	28.24	____	____	____	19.83	36.63	44.74
21	37.53	3.57	7.68	____	17.61	18.97	11.82	8.10	9.48
22	____	____	____	____	____	43.38	18.89	19.39	____
23	____	____	____	____	____	____	____	____	____
24	19.82	27.38	____	____	31.22	____	9.07	1.62	____

GROUPING FROM ORTHOGONAL FACTOR SCORES
GROUP 4: 39 MEMBERS (continued)

VAR.	(1:29)	(2:4)	(2:8)	(2:9)	(2:13)	(2:15)	(3:1)	(3:3)	(3:9)	(3:10)
1	3	7	7	10	7	11	8	7	10	10
2	no	no	no	no	no	yes	no	no	no	no
3	no	no	no	no	no	yes	yes	yes	yes	yes
4	yes	yes	yes	yes	no	yes	no	no	no	no
5	no	no	no	no	no	yes	yes	no	yes	yes
6	yes	yes	yes	yes	yes	yes	yes	no	no	no
7	360	200	220	79	___	___	___	___	___	___
8	660	3083	5680	857	___	2184	1054	936	1097	1315
9	___	___	___	___	___	___	___	___	___	___
10	___	___	___	___	11.21	5.98	___	___	___	___
11	___	___	___	___	10.03	5.23	___	___	___	___
12	___	___	___	11.75	___	___	___	___	___	___
13	1.42	1.42	4.09	41.74	2.55	22.42	6.24	___	11.98	5.82
14	1.68	.80	___	3.51	___	___	___	___	___	___
15	___	___	8.87	2.63	___	___	___	___	___	___
16	___	___	___	___	___	___	___	___	___	___
17	___	___	5.97	___	.82	___	12.49	___	___	19.39
18	___	___	___	___	___	___	6.36	16.86	11.55	8.73
19	___	___	___	___	___	___	1.45	___	6.84	10.34
20	___	6.65	16.37	___	14.27	10.76	___	___	8.55	11.64
21	60.32	___	9.62	19.33	___	___	7.86	___	8.04	18.23
22	___	___	___	8.42	___	10.76	28.03	83.14	53.04	25.86
23	___	___	___	___	___	___	___	___	___	___
24	36.58	91.13	49.11	12.63	61.14	44.84	37.57	___	___	___

GROUPING FROM ORTHOGONAL FACTOR SCORES
GROUP 4: 39 MEMBERS (continued)

VAR.	(3:11)	(3:12)	(3:15)	(3:16)	(3:20)	(3:21)	(3:22)	(3:23)	(3:24)	(3:26)
1	4	10	1	8	7	3	7	5	6	10
2	no	no	no	no	no	no	no	no	no	no
3	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
4	no	no	yes	no	no	no	no	no	no	no
5	yes	no	no	no	yes	no	yes	yes	yes	yes
6	no	no	yes	no	no	no	yes	no	no	no
7	___	___	___	___	___	___	___	___	___	___
8	14088	703	784	428	1920	805	580	732	56	1207
9	.16	___	21.26	___	___	___	___	___	___	___
10	___	___	___	___	___	___	___	___	___	___
11	.08	19.51	___	___	___	___	3.50	___	1.32	___
12	.80	4.91	___	87.16	___	59.28	49.51	56.69	88.79	___
13	___	5.46	___	___	6.17	___	___	2.20	___	25.96
14	___	___	23.62	3.31	12.62	6.31	___	5.65	1.06	___
15	___	___	___	___	___	___	___	___	___	___
16	___	___	___	___	___	___	___	___	___	4.40
17	___	7.28	19.69	5.54	42.64	14.31	___	___	4.62	___
18	___	___	___	___	14.14	___	___	___	___	42.88
19	___	___	___	___	___	___	___	___	___	___
20	5.72	49.14	___	2.02	___	20.11	25.17	16.95	___	___
21	93.24	13.69	___	.86	24.43	___	13.43	16.52	___	11.48
22	___	___	___	1.10	___	___	___	___	4.22	15.27
23	___	___	___	___	___	___	___	___	___	___
24	___	___	35.43	___	___	___	8.39	___	___	___

GROUPING FROM ORTHOGONAL FACTOR SCORES
GROUP 4: 39 MEMBERS (continued)

VAR.	(3:27)	(4:6)	(4:7)	(4:8)	(4:16)	(4:17)	(4:18)	(4:19)	(4:20)	(4:22)
1	7	9	8	8	4	5	9	5	10	4
2	no	no	no	yes	no	no	no	yes	yes	yes
3	yes	no	no	no	no	no	no	no	yes	yes
4	no	no	no	no	no	no	no	no	no	no
5	yes	no	no	no	no	no	no	no	yes	yes
6	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
7	____	____	____	____	____	____	____	____	____	____
8	2340	109	____	241	140	6500	413	120	2622	651
9	____	____	____	.65	4.61	____	____	____	____	____
10	____	____	____	____	____	____	____	____	____	____
11	____	____	____	____	____	____	____	____	____	____
12	____	____	____	____	____	____	____	____	____	____
13	____	____	____	____	____	____	____	____	____	____
14	18.20	____	____	____	____	____	____	____	____	____
15	____	____	____	____	____	____	____	____	____	____
16	____	.95	3.99	2.08	.77	____	2.50	2.2	____	3.79
17	46.63	.83	____	____	2.02	____	3.64	____	9.46	2.21
18	17.52	2.39	2.49	14.64	____	4.56	46.48	2.86	7.26	15.81
19	____	6.71	3.74	2.44	____	____	4.69	1.50	____	17.79
20	____	10.67	____	47.75	25.94	34.18	____	____	30.28	28.46
21	8.55	9.57	____	15.26	9.03	7.71	____	16.13	9.88	14.86
22	9.10	26.66	____	____	35.54	36.46	____	50.05	5.26	____
23	____	6.44	____	____	.96	3.42	2.08	1.43	____	____
24	____	35.78	89.78	17.18	21.13	13.67	40.61	25.74	37.85	17.08

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 5: 5 MEMBERS

VAR.	(1:9)	(1:21)	(2:2)	(3:2)	(3:14)
1	4	7	11	4	7
2	yes	no	no	no	no
3	yes	no	yes	yes	yes
4	yes	no	yes	no	no
5	yes	no	yes	no	yes
6	yes	yes	yes	yes	yes
7	83	____	____	____	____
8	1320	218	1207	1505	267
9	____	____	____	____	____
10	____	____	____	____	____
11	1.93	____	2.09	____	____
12	____	____	____	____	5.89
13	2.41	____	5.36	____	7.57
14	1.54	____	____	____	1.68
15	2.03	____	____	____	____
16	____	____	____	____	____
17	____	____	1.25	53.32	.84
18	____	____	____	17.06	____
19	.68	____	.45	____	2.02
20	38.02	31.09	16.38	____	15.14
21	41.80	____	____	____	6.32
22	____	27.46	____	____	____
23	____	____	____	____	____
24	11.59	41.45	74.47	29.62	60.54

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 6: 7 MEMBERS

VAR.	(1:11)	(1:23)	(2:1)	(3:4)	(3:28)	(4:9)	(4:21)
1	8	9	7	8	6	7	7
2	yes	no	no	no	no	no	no
3	yes	yes	yes	no	yes	no	yes
4	yes	yes	yes	no	no	no	no
5	yes	no	no	no	yes	no	no
6	no	no	no	yes	no	yes	yes
7	420	______	128	______	______	______	______
8	5760	447	567	116	1304	200	160
9	______	______	______	______	10.32	______	______
10	______	______	______	______	______	______	______
11	______	______	______	______	______	______	______
12	______	______	______	______	______	______	______
13	18.18	2.42	6.24	3.23	3.87	______	______
14	21.20	.42	______	______	4.21	______	______
15	15.15	12.71	______	______	______	______	______
16	______	2.91	______	______	______	.82	______
17	9.09	3.87	12.49	______	43.84	1.19	______
18	______	______	6.36	______	______	______	30.90
19	3.64	______	1.45	______	______	______	______
20	10.91	______	______	______	______	30.62	14.04
21	______	19.56	7.86	______	14.55	______	17.60
22	21.82	58.10	28.03	______	23.21	______	______
23	______	______	______	______	______	______	______
24	______	______	37.57	96.77	______	67.37	37.45

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 7: 8 MEMBERS

VAR.	(1:12)	(1:18)	(1:24)	(2:5)	(3:5)	(3:17)	(3:29)	(4:10)
1	8	1	8	8	12	1	8	13
2	yes	yes	no	no	no	yes	no	no
3	no	yes	no	yes	yes	yes	yes	no
4	yes	yes	no	yes	no	no	no	no
5	yes	yes	no	no	no	yes	yes	no
6	yes	no	yes	yes	no	no	yes	yes
7	___	200	___	___	___	___	___	___
8	1791	2900	2400	___	1262	801	2565	35
9	___	___	26.10	___	___	___	___	___
10	___	___	___	___	___	___	___	___
11	___	___	___	___	___	1.76	___	___
12	___	13.51	___	___	___	90.91	___	___
13	15.79	13.51	___	___	6.99	___	3.73	15.93
14	2.37	8.11	___	___	___	___	11.62	___
15	5.92	8.11	___	___	___	___	___	___
16	___	___	___	___	___	___	___	1.70
17	6.31	___	___	___	___	___	44.81	1.12
18	___	___	___	___	93.01	7.34	___	5.31
19	3.31	___	___	___	___	___	___	5.31
20	47.36	56.75	26.10	15.68	___	___	___	23.90
21	___	___	16.49	16.38	___	___	___	9.98
22	___	___	___	___	___	___	___	25.49
23	___	___	___	___	___	___	___	1.06
24	18.94	___	31.32	67.94	___	___	39.83	10.20

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VARIABLES
GROUP 8: 4 MEMBERS

VAR.	(1:15)	(1:27)	(3:18)	(3:30)
1	5	9	7	4
2	yes	no	no	no
3	yes	yes	yes	yes
4	yes	yes	no	no
5	yes	yes	yes	yes
6	yes	yes	yes	yes
7	64	800	____	____
8	27.20	1520	1128	1970
9	____	____	____	____
10	____	____	____	____
11	____	____	3.39	____
12	____	____	73.10	____
13	27.47	1.49	____	____
14	30.93	.33	5.72	12.68
15	8.14	____	____	____
16	____	____	____	____
17	9.77	____	14.24	28.98
18	____	____	____	____
19	2.93	____	____	____
20	13.43	89.14	____	32.60
21	____	3.10	____	15.55
22	____	____	2.03	____
23	____	____	____	____
24	7.33	5.94	1.53	____

GROUPING FROM ORTHOGONAL FACTOR SCORES
INDIVIDUAL FARM SCORES ON PRIMARY VAIIABLES
GROUP 9: 11 MEMBERS

VAR.	(1:17)	(1:26)	(1:30)	(1:31)	(2:3)	(2:12)	(3:7)	(3:19)	(4:2)	(4:4)	(4:5)
1	1	4	7	9	4	9	9	5	6	9	8
2	yes	no	no	yes	no	yes	no	no	no	yes	yes
3	yes	yes	no	yes	yes	yes	yes	yes	no	yes	yes
4	yes	no	no	yes	yes	yes	no	no	no	no	no
5	yes	yes	no	yes	no	yes	yes	yes	yes	yes	yes
6	no	yes	yes	yes	yes	yes	no	yes	yes	yes	yes
7	22	___	___	233	1128	160	___	___	___	___	___
8	278	1850	280	2080	2121	1900	479	2060	6400	1755	1181
9	2.17	___	___	___	___	___	___	___	___	___	___
10	___	___	___	___	___	___	___	___	___	___	___
11	___	___	___	___	.61	6.31	___	___	___	___	___
12	___	___	___	___	___	___	___	___	___	___	___
13	11.69	___	1.73	5.45	9.44	3.60	1.19	___	___	___	___
14	___	___	4.33	2.18	___	___	.50	15.22	___	___	___
15	1.93	___	___	5.09	___	___	___	___	___	___	___
16	___	5.07	___	___	___	___	.63	___	___	___	.51
17	5.29	19.02	___	7.27	___	21.62	8.91	36.70	___	___	.90
18	53.43	___	___	3.60	___	___	10.89	13.99	___	___	15.87
19	___	___	___	3.64	___	___	4.75	___	2.62	33.02	2.57
20	15.03	13.47	___	20.00	33.19	12.97	10.70	___	10.48	___	7.72
21	10.46	14.90	___	35.31	___	___	14.89	6.39	___	20.07	8.07
22	___	9.51	___	___	32.04	8.65	47.53	18.52	24.03	19.21	25.74
23	___	___	___	___	___	___	___	___	___	4.00	___
24	___	38.03	93.94	17.45	24.72	46.85	___	9.18	62.87	23.70	38.61

BIBLIOGRAPHY

Ackerman, J. "Development of Economic Criteria for Classifying Farms", Journal of Farm Economics, (1964), pp. 1232-1237.

Adams, D.W. "Colombia's Land Tenure System: Antecedents and Problems", Land Economics, Vol. 42, No. 1, (1966), pp. 43-52.

Adams, D.W. and Montero, L.E. "Land Parcelization in Agrarian Reform: A Colombian Example", Inter-American Economic Affairs, Vol. 19, No. 3, (1965), pp. 67-71.

Ahmad, Q. "Indian Cities: Characteristics and Correlates", The University of Chicago Department of Geography Research Paper No. 102, (1965).

Anderson, C.W. "Political Factors in Latin American Economic Development", Journal of International Affairs, Vol. 20, No. 2, (1966).

Batchelor, B.E. "An Investigation into the Use of an Optimal Grouping Procedure in Land Use Capability Analysis, Pichincha Province, Ecuador", Unpublished M.A. Thesis, McMaster University, (1971).

Berry, B.J.L. "An Inductive Approach to the Regionalization of Economic Development", University of Chicago Papers, (1960), pp. 78-11 .

Berry, B.J.L. and Rees, P.H. "The Factorial Ecology of Calcutta", The American Journal of Sociology, (1969), pp. 445-491.

Cattell, R.B. "Factor Analysis: An Introduction to Essentials", Biometrics, Vol. 21, No. 1, March (1965).

Chisholm, M. "Problems in the Classification and Use of Farming Type Regions", Transactions of the British Institute of Geographers, (1964), pp. 91-103.

Coppock, J.T. "Crop, Livestock, and Enterprise Combinations in England and Wales", Economic Geography, (1964), pp. 65-81.

Daling, J.R. and Tamura, H, "Use of Orthogonal Factors for Selection of Variables in a Regression Equation - An Illustration", Applied Statistics, Vol. A, No. 3, (1970), pp. 260-268.

Dorner, P. "Needed Redirections in Economic Analysis for Agricultural Development Policy", American Journal of Agricultural Economics, Vol. 53, (1971), pp. 8-16.

Dorner, P. "Land Tenure Reform and Agricultural Development in Latin America", Land Tenure Center, University of Wisconsin, (1966).

_________ "Fourteen Million Rural Poor", The Yale Review, Vol. LVIII, No. 2, (1969).

Draper, N.R. and Smith, H. Applied Regression Analysis, New York: John Wiley and Sons, Inc., 1966.

Erasmus, C. "Upper Limits of Peasantry and Agrarian Reform: Bolivia, Venezuela and Mexico Compared", Ethnology, Vol. VI, No. 4, (1967), pp. 349-380.

Fisher, W.D. "On Grouping for Maximum Homogeneity" Journal of American Statistical Association, (1958), pp. 789-798.

Found, W.C. "A Multivariate Analysis of Farm Output in Selected Land Reform Areas of Jamaica", The Canadian Geographer, (1968), pp. 41-52.

Freund, J.E. Modern Elementary Statistics Englewood Cliffs: Prentice-Hall Inc., 1967.

Gilmour, J.S.L. "The Development of Taxonomic Theory Since 1851", Nature, (1951), pp. 400-403.

Gould, P.R. "On the Geographic Interpretation of Eigenvalues", Transactions of the Institute of British Geographers, (1967), pp. 53-86.

Gregory, C.L. "Advanced Techniques in the Delineation of Rural Regions", Rural Sociology, (1949), pp. 58-63.

Grunig, J.E. "The Minifundio Problem in Colombia: Development Alternatives", Inter-American Economic Affairs, Vol. 12, No. 23, (1969), pp. 3-23.

Hagwood, M.J. "Statistical Methods for Delineation of Regions Applied to Data on Agriculture and Population", Social Forces, (1941), pp. 287-299.

Hagwood, M.J. and Danilevsky, N. and Beum, C.O. "An Examination of the Use of Factor Analysis in the Problem of Subregional Delineation", Rural Sociology, (1941), pp. 216-233.

Haney, E.B. "The Minifundia Dilemma: A Colombian Case Study", Lecture No. 65, The Land Tenure Center, University of Wisconsin, (1969).

Harman, H.H. Modern Factor Analysis, The University of Chicago Press, 1967.

Henshall, J.D. "The Demographic Factor in the Structure of Agriculture in Barbados", Transactions of the Institute of British Geographers, (1966).

Kanel, D. "Size of Farm and Economic Development", Indian Journal of Agricultural Economics, Vol. 22, No. 2, (1967), pp. 26-44.

Karst, K.L. "Latin American Land Reform: The Uses of Confiscation", Michigan Law Review, Vol. 63, No. 2, (1964), pp. 327-372.

King, L.J. Statistical Analysis in Geography, Englewood Cliffs: Prentice-Hall Inc., 1969.

__________ "Cross Sectional Analysis of Canadian Urban Dimensions: 1951 and 1961", Canadian Geographer, (1966), pp. 205-224.

Long, E.J. "The Economic Basis of Land Reform in Underdeveloped Economies", Land Economics, (1961).

Olsson, G. "Distance and Human Interaction A Migration Study", Geografiska Annaler, (1965), pp. 3-43.

Pocock, D.C.D. and Wishart, D. "Methods of Deriving Multi-Factor Uniform Regions", Transactions of the British Institute of Geographers, (1969), pp. 73-97.

Ratford, B.E. "Transportation and Commercial Development in Pichincha Province, Ecuador", Unpublished B.A. Thesis, McMaster University, (1971).

Reeds, L.G. "Agricultural Regions of Southern Ontario", Economic Geography, Vol. 35 (1959), pp. 219-227.

Renner, G.T. "The Statistical Approach to Regions", Annals of the Association of American Geographers, (1936), pp. 137-153.

Rikkinen, K. "Typology of Farms in Central Finland", Societas Geographica Fenniae: Helsinki, (1971), pp. 1-43.

Rummel, R.J. "Understanding Factor Analysis", Journal of Conflict Resolution, Vol. II, (1967), pp. 444-477.

Sneath, P.H.A. and Sokal, R.R. "Numerical Taxonomy", Nature, (1962), pp. 855-860.

Spence, N.A. and Taylor, P.J. Progress in Geography, Vol. 2, Edward Arnold, London, (1970).

Stone, R. "A Comparison of the Economic Structure of Regions Based on the Concept of Distance", Journal of Regional Science, (1958), pp. 1-20.

Sweetsner, F.L. "Factorial Ecology: Helsinki, 1960", Demography, Vol. 2, (1965), pp. 372-385.

Thiesenhusen, W.C. "Technological Change and Income Distribution in Latin American Agriculture", Lecture No. 78, The Land Tenure Center, University of Wisconsin, (1971).

Thiesenhusen, W. and Brown, M. "Survey of the Alliance for Progress: Problems in Agriculture" Land Tenure Center, University of Wisconsin, (1967).

Thome, J.R. "Expropriation in Chile Under the Frei Agrarian Reform", The American Journal of Comparative Law, Vol. XIX, No. 3, (1971).

Ward, J.H. "Hierarchical Grouping to Optimize an Objective Function", Journal of American Statistical Association, (1963), pp. 236-244.

Weaver, J.C. "Livestock Units and Combination Regions in the Middle West", Economic Geography, (1954), pp. 236-259.

__________ "A Design for Research in the Geography of Agriculture", The Professional Geographer, Vol. X, No. 1, (1958), pp. 34-41.

Whittlesey, D.W. "Major Agricultural Regions of the World", Annals of the Association of American Geographers, Vol. 26, (1936), pp. 199-108.

Wood, H.A. "A Land Use Classification for the American Tropics", A Report Prepared for the Natural Resources Unit, Pan American Union, Washingron, D.C., (1966).