SMALL-SCALE FARMING IN SAINT ANN, JAMAICA

SMALL-SCALE FARMING IN SAINT ANN, JAMAICA:
A CROSS-SECTION ANALYSIS OF GROSS CASH INCOME ON A SELECTED NUMBER OF FARMS

By

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SCOPE AND CONTENTS:

This study appraises the significance of a selected number of variables - economic demographic, and physical - in explaining the inter-farm variation in gross cash income on a sample of small-scale multiple enterprize farms, Jamaica, West Indies. Chapter I outlines the purpose and methodology of the analysis, while Chapter II describes the physical geography and farming systems of the area. A review of literature germane to the main body of the study is covered in Chapter III. Specifying a model that traces out the relative significance of those variables which are hypothesized as influences on the inter-farm variation in gross cash income is the focus of Chapter IV. The final chapter summarizes and interprets the main findings of the study.

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CHAPTER I

OBJECTIVE AND METHODOLOGY OF THE STUDY

(A) Purpose:

The primary purpose of this study is to appraise the extent to which a selected number of factors - economic, demographic, and physical - can satisfactorily account for the inter-farm variation in gross cash income on a sample of small-scale multiple enterprize farms in a specific area of the Parish of Saint Ann, Jamaica, West Indies.

To this end a special function - Cobb-Douglas - will be fitted to the data derived from farms sampled. The Cobb-Douglas[1] function is a multiplicative model of the order:

$$Y = AX_1^{b_1}X_2^{b_2}\ldots\ldots X_k^{b_k}\,q$$

When transformed logarithmically, this function becomes:

$$\text{Log } Y = \text{Log } a + b_1 \log X_1 + \ldots\ldots\ldots + b_k \log X_k + \log q$$

This function has certain advantages, notably:

(a) it is "a relatively efficient user of degrees of freedom", and consequently leaves "sufficient degrees of freedom unused to allow for statistical testing."[2]

(b) in so far as the function allows data to be aggregated geometrically, it tends to reduce bias in resultant estimates. Moreover, whereas

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[1] Heady, E.O., and Dillon, J.L., Agricultural Production Functions, Iowa State University Press, Ames, Iowa, 1961, p. 120.

[2] Ibid., p. 228.

it is possible to calculate the biases resultant upon the geometric aggregation of data, it is "virtually impossible" to estimate the biases arising from the arithmetic aggregation of data.[3]

(c) in diagnostic analyses, it facilitates the calculation of the marginal productivities of resources of the geometric means of respective inputs.[4] This point will be amplified in Chapter 5 where the marginal value productivities of labour and total cash expenses are approximated.

(d) the summation of the estimated regression coefficients gives an indication of the returns to scale, for example; where the summation of the estimated input coefficients is equal to unit, constant returns to scale prevail. Increasing returns to scale prevail when the summation of the related coefficients are greater than unity. If the summation of the estimated input coefficients are less than unity, diminishing returns to scale prevail.[5]

In the case of this analysis, the Cobb-Douglas equation seems logically appropriate for a number of reasons:

(a) since the statistical distributions of the data upon which the analysis is based are strongly skewed towards the right, the logarithmic transformation, which the function allows, will help to normalize the data. Consequently, estimates are likely to be more precise.

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[3]*Ibid.*, p. 228-229.

[4]*Ibid.*, p. 228, 231.

[5]*Ibid.*, p. 230.

(B) Methodology:

Basic Hypothesis.

The factors, which were observed, and which are hypothesized as significant variables affecting the inter-farm variation in gross cash income, are cropland, total labour input, total cash expenses, number of dependents on the farm, number of livestock on farm, and the average distance of respective plots from the farmer's home.

Definition and Measurement of Variables

(i) Gross Cash Income.

Expressed in Jamaican dollars (one Jamaican dollar is approximately 1.30 Canadian dollars), this is the aggregate sum of money which individual farmers derive from the sale of different cash crops, the most important of which are bananas, plantains, vegetables, corn, peas, yams and potatoes.

(ii) Cropland.

Measured in acres, this is the total area planted in crops; it includes land owned, rented, leased or occupied under other forms of tenure.

(iii) Total Cash Expenses.

Measured in Jamaican dollars, this is the farmer's overall expenditure on farm supplies - seeds, other planting materials, artificial fertilizers, pesticides - rent, hired labour, interest, and marketing.

(iv) Total Labour Input.

Measured in adult man-days per year, this is the total amount of time which is expended on the production of different crops.

(v) Number of Dependents.

This is the total number of individuals who reside on the farm, and who are dependent upon the farm for support.

(vi) Distance of Plots

Measured in miles, this is the average distance respective plots are located from the farmer's home.

(vii) Number of Livestock

Used rather restrictively, this is the number of cows on the farm.

Data Collection.

Data for this study were collected from a sample of small-scale multiple enterprise farms in a definable area of the Parish of Saint Ann, Jamaica, West Indies, during the summer of 1969.

Farms were randomly selected over a number of dominant soil types, notably heavy clays, brown earth, and red earth. The soil type on which individual farms were located, was identified through the use of a Land Capability Map which was prepared through the courtesy of the Soil Survey Division, Ministry of Agriculture and Lands. Each farm was visited at least twice, and information was derived from farmers by means of a questionnaire. Farmers were asked to supply information about gross cash income, total cash expenses, labour input for the respective operations which the production of specific enterprises entail, number of dependents, number of livestock, total area cultivated, area devoted to respective enterprises, (where intercropping made this impossible, an attempt was made to estimate the respective populations of the crops interplanted); in the case of fragmentation, the respective distance of plots from the farmer's home.

A Note on the Estimation of Labour.

In the case of 24 farms, total labour input was estimated by the use of Enterprise Analysis Tables (Appendix 1) which were compiled from data collected in the field, and with the help of the groups of farmers, and the local Agricultural Extension Officers. These tables show the various labour operations which the production of specific crops entail; the average number of days spent on each operation; the aggregate number of days which are required to produce an acre of a specific crop. These tables also include other relevant information such as, average output per acre, average costs per acre, average total return per acre, and the average net return per acre.

For each of the 24 farms, the method of estimating labour involved:

(a) allocating to each crop, according to either its area or population, the respective number of days spent on the enterprise; for example, in the case of a quarter of an acre of tomatoes, the total number of days allocated to that enterprise is approximately one quarter of the total number of days which the production of an acre of the same enterprise entailed. In the case of intercropping, the time spent on certain tasks had to be jointly allocated either between or among the enterprises which were interplanted.

(b) summating for the farm as a whole the number of days spent on the production of varying acreage or population of different enterprises.

The functional relation between total labour input and the acreage of land operated by the farm was then expressed as:

$$Y = f(X)$$

where Y = total labour input

X = acreage of land operated by the farmer. Plotting of the data revealed a curvilinear relationship between the two variables. A polynomial function of the order:

$Y = -22.9415 + 89.9797\ X - 4.0101X^2$ was then derived as the best fit for the data. The derived function was then used to predict labour input for the remaining 21 farms.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

(A) <u>Location</u>:

The area in which this investigation was conducted is located in the north eastern section of the Parish of Saint Ann, Jamaica, West Indies. Maps 1 and 2 show the location of the study area.

(B) <u>Physical Attributes</u>:

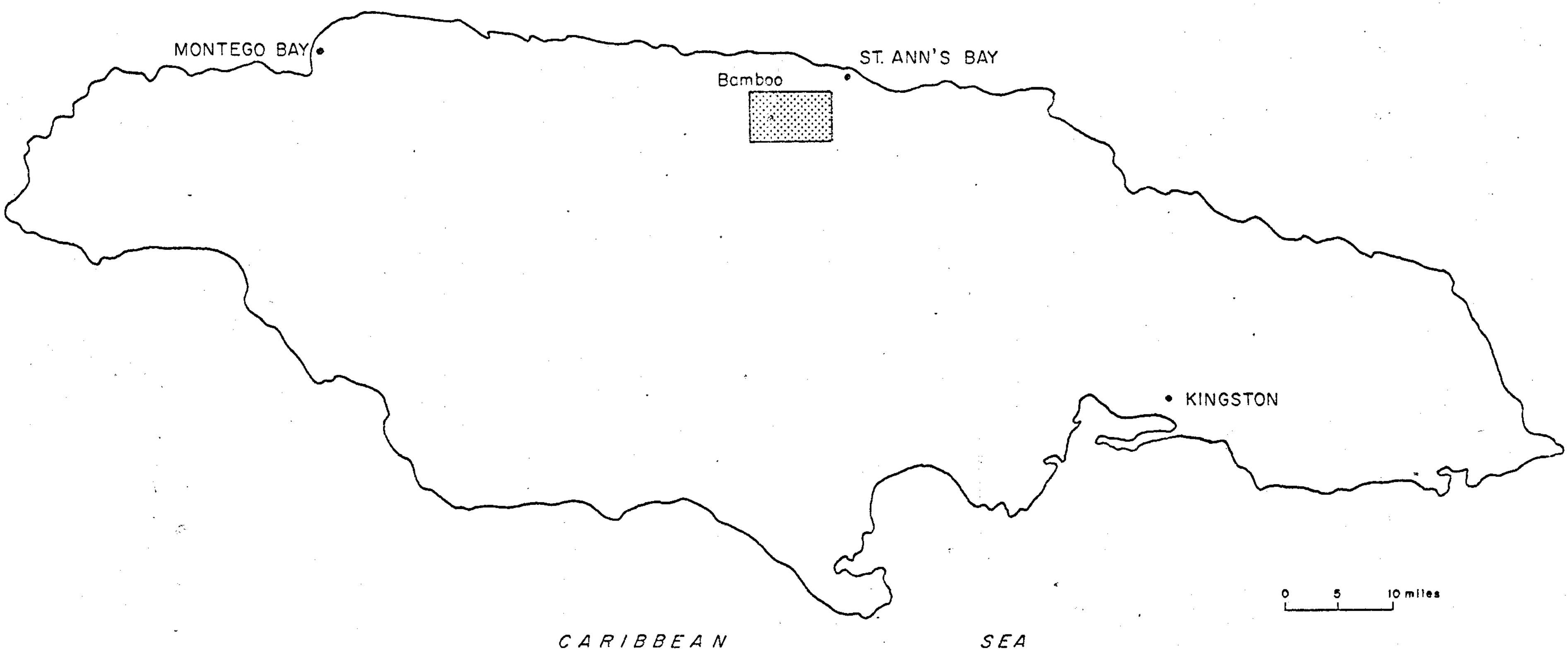
(i) <u>Geology</u>

Geologically, practically the entire area is dominated by white limestone formation of the Middle Eocene to the Lower Eocene Period. There is only one exception, notably the Bamboo-Canaan area which is characterized by yellow limestone formation of the Middle Eocene Period. This material seems to have been extruded between two roughly V-shape faults. The south eastern section of the area is also criss-crossed by a number of fault lines.

(ii) <u>Physiography</u>

Physically undulating to steep, the average altitude of the area ranges from 700 feet to a spot-height of 2,388 feet. Karst tends to dominate the area. In the westernmost section of the area, pepinos or haystack hills represent the most striking feature of the topography. Structurally limestone, these oval-shaped hills are generally overlain with either red or brown bauxitic soils. Depressions are widespread, but occur most frequently in the central and western parts of the region.

LOCATION OF STUDY AREA, ST. ANN, JAMAICA, WEST INDIES. Map : I



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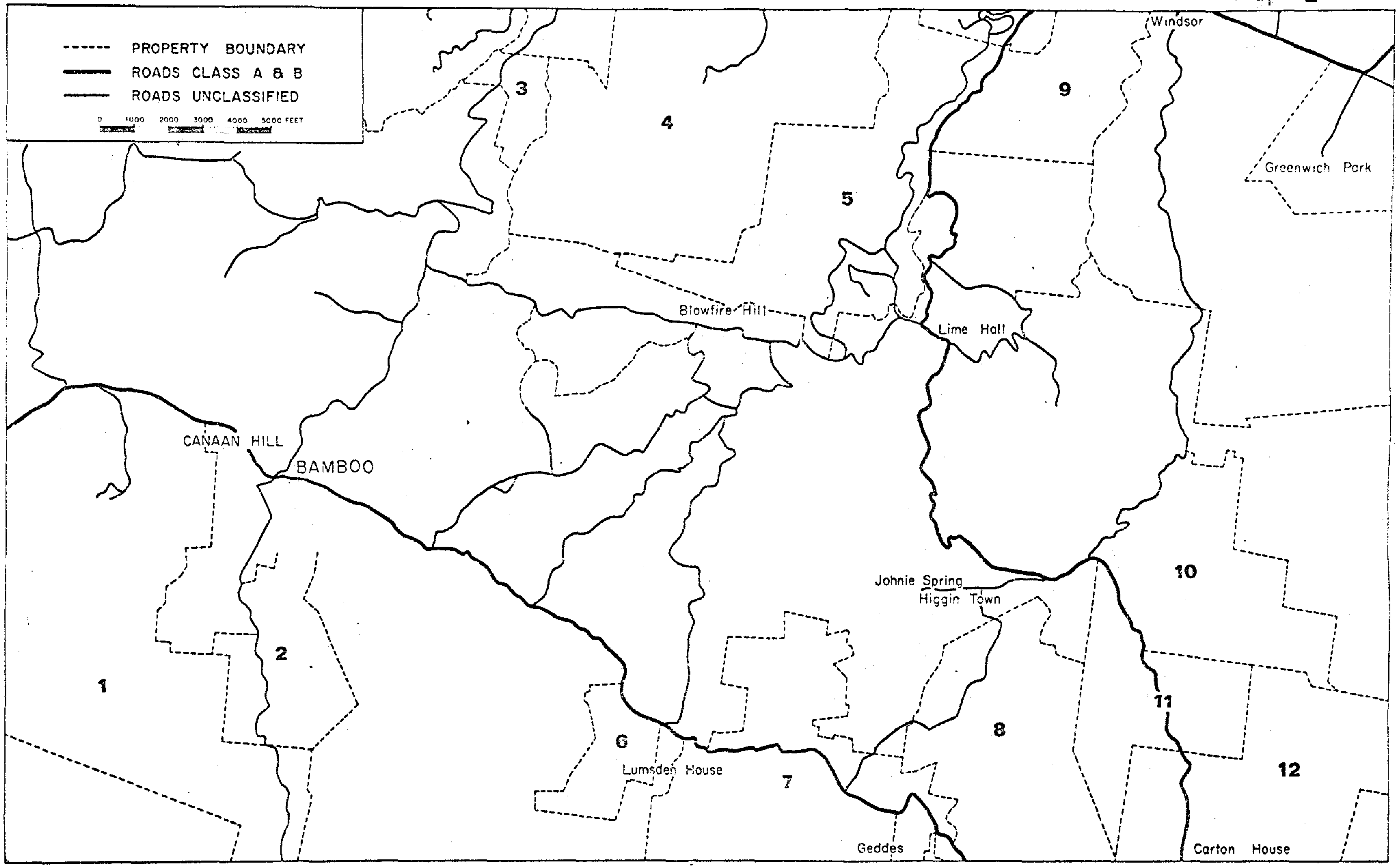
THE STUDY AREA

Map : 2



Sinkholes and underground caverns, which are concentrated in the centre and easternmost sections of the area, are also important features of the landscape. Comprehensive networks of underground caverns are to be found in two vicinities, notably, Spring Garden, and Johnnie Spring. Several roughly circular slopes envelop saucer-shaped areas which are generally covered with medium to heavy clays, and which, in some cases, are honey-combed with springs and sinkholes. These well-watered spots are the most productive parts of the area, and farming is characterized by a wide range of cash crops, the most important of which are bananas, and a diversity of vegetables.

Because of the porous substrata, drainage tends to be subterranean. There are only a few streamlets, and these tend to be intermittent. Springs are generally found at points where the porous substrata is covered with relatively impermeable materials.

(iii) Soils

Within the area, the following types of soils may be identified.[6]

(a) Bonny Gate Strong Loam. A very shallow brown or red brown loam, or clay loam in crevices or as a thin veneer over hard limestone. Not really a soil, but rough stony land which may be droughty and easily eroded. The surface is usually 50 percent or more of bare limestone. Very shallow, mildly alkaline, very low in moisture retention, low in nitrogen, phosphate and potash.

(b) St. Ann Clay Loam (Red Bauxitic Soil). A red brown clay over red or dusky red clay loam with poor structure. Added phosphates are fixed readily by this soil. Medium to very deep, neutral to slightly acid, low in moisture retention, low in potash, very low in phosphate, medium in nitrogen.

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[6] Soil Technical Guide Sheets, Agricultural Chemistry Division, Ministry of Agriculture and Lands, Jamaica, 1964.

(c) Chudleigh Clay Loam (Brown Bauxitic Soil). A brown clay loam with good structure which may be slightly plastic when moist. Generally underlain by white limestone. Medium to very deep, slightly acid, moisture retention fair, low in nitrogen, medium in phosphate, very low in potash.

(d) Non-Such Clay. Very dark grey clay with moderate structure over, at about eleven inches, a pale brown clay with poor structure, and brownish yellow mottles over, at least three to six feet, yellow limestone parent material. Deep, slightly acid, high in moisture rententivity, low in nitrogen, low in phosphate, medium in potash.

(e) Carron Hall Clay. Dark grey brown clay with good structure over yellow limestone at one to three feet, medium deep, slightly alkaline, high in moisture retentivity, low in nitrogen, low in phosphate, high in potash.

(f) Killancholly Clay. Very dark grey clay with good structure over, at six inches, brownish yellow gravelly loam with good structure passing into impure limestone at about twenty inches. Shallow to medium in depth, strongly alkaline, high in moisture retentivity, low in nitrogen, low in potash, medium in phosphate.

(g) Bundo Clay. A brown or red brown clay over a deep red, yellow brown and grey mottled clay subsoil. A colluvial soil usually in hollows and/or basins in hard limestone areas. Deep, strongly acid, high in moisture retentivity, low in nitrogen. Very low in phosphate, low in potash.

(h) Deepdene Clay. Very dark grey brown clay with good structure over, at four inches, reddish yellow clay with moderate structure over, at eight inches, a yellowish red clay with poor structure. At twenty-one inches, a yellowish red clay with poor structure and distinct light grey clay with poor structure and red mottles over yellow limestone shales parent material. Very deep, strongly acid, high in moisture retentivity, low in nitrogen, low in phosphate, high in potash.

(i) Lucky Hill Clay Loam. Dark brown clay loam, top soil with good structure over pale compact stiff clay which may be very deep. Subsoil may be mottled. A colluvial soil usually in small hollows and basins in hard limestone areas. Deep, neutral to slightly acid, fair to high in moisture retentivity, low in phosphate, low in potash, medium in phosphate.

(iv) Rainfall

The average annual rainfall varies from 40 to 75 inches with maxima in the months of May and November. Within these two months the average precipitation varies from 5 to 15 inches. The seasonality of rainfall gives rise to seasonablity of production and resource use.

(C) General Characteristics of Farming:

(i) Small Scale of Operations.

Farmers in this area, like their counterparts in the rest of the island, cultivate holdings which were less than 5 acres in size. Approximately 85 percent of the farms sampled were less than 5 acres in size.

(ii) Seasonality of Production and Resource Use.

The seasonality in the distribution of rainfall invariably leads to seasonality in production and resource use. Since most of the crops are planted to receive the benefit of rainfall which is pronounced at two specific periods of the year, there are extremely busy periods alternating with periods of slack. For example, the months of March to August are extremely busy because during this period land is prepared for the planting of a wide range of root crops, legumes and vegetables. In the earlier part of spring, root crops, which were planted in the previous year, are reaped; land is prepared for the planting of important cash crops which are reaped in the forthcoming summer. Activities tend to reach their peak towards the end of August tapering off to a minimum by about mid October. Excessive rainfall in the Autumn, and drought in the winter months tend to reduce activities to the minimum - only maintainance work and some reaping being done.

The packing of production activities within certain months is, therefore, responsible for the uneven distribution of resource use throughout the year. It is during the period of intensive activity that the farmer expends most of his operating capital on farm supplies, hired labour, and bringing of additional land under cultivation. Personal and family labour are taxed to the maximum, and must, in many cases, be supplemented by either hired labour or "social" labour which is labour exchange freely on a "day for day" basis.

(iii) Fragmentation.

This is not simply a regional, but an island wide problem. However, within the study area, the predominance of large properties seems to have aggravated the problem. The majority of the farms sampled consisted of two to three pieces of land which were located at varying distances from the farmer's home. Distance did not always lead to decrease in land use intensity. In very many cases, farmers, who did not possess either sufficient land or land suitable for intensive crops, travelled several miles to cultivate vegetables - especially tomatoes and carrots. The relatively high margin per acre, which is realized on these crops, compensates adequately for the extra time spent travelling.

(iv) Diversity of Tenure.

Within the study area, the most common bases of occupancy were outright ownership, joint ownership (as in the case of family land), rent, lease, squatting, share-holding, and "grass ground" - a condition of tenure without monetary obligations, but which requires the tenant to return the land planted in grass. The majority of farmers held land under a mixture of tenures. It was not uncommon to find a farmer cultivating three to four pieces of land, each under a different tenure. Concomitant with this diversity of tenure, is a diversity of land use. Land rented, leased or occupied under any other form of short-term tenure is usually confined to short term cash crops. The type of cash crop grown is also dependent upon the length of tenure; where this is less than a year, quick maturing crops - vegetables and legumes are grown; where the tenure is a year, annuals are planted. Semi-permanent and permanent crops are only cultivated on land which is outrightly owned.

(v) Predominance of Crops.

All of the farms studied emphasized crops; livestock is mainly a supplementary activity. On most of the farms, the number of livestock kept is confined to a cow, one or two pigs, and a small number of chickens. Concomitant with the predominance of crops, is also a diversity in the range of crops cultivated. The majority of farmers sampled cultivated eight to twelve crops, but in a few cases, this number was exceeded. The standard enterprises are root crops and vegetables.

(vi) Mixed Cropping.

Mixed or intercropping, as opposed to pure cropping, is widely practiced. Some of the more popular crop combinations are yams, cocoes and potatoes; corn and peas; yam, cocoes and vegetables; bananas, coffee and cocoes. A familiar type of mixed cropping is also the "food forest" - a two or three tier association of plants, which, at the highest level, consists of tall economic trees notably, coconut, breadfruit, avocado, pear, or other food trees, with shorter economic trees - coffee, cocoa or bananas - at a lower level, and food crops at ground level.

Although partially based on tradition, the reasons[7] behind intercropping are very enlightening, and these may be enumerated as follows:

(a) Land space is optimized because at no one time is the land left "bare". A piece of land intercropped is always generating yields since the crops interplanted usually mature at different periods of the year.

(b) There is economy in time because when land is being prepared for one crop, it is also being prepared for other crops. Certain other activities such as maintenance are also jointly

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[7] Edwards, David, An Economic Study of Small Farming, pp. 235-41.

shared, for example, weeding of yam interplanted with cocoes and vegetables invariably involves weeding all the companion crops.

(c) The risks of crop losses are minimized. When several crops are interplanted, either poor yield or the failure of one crop may be offset by the yields of the other crops.

(d) The aggregate yield per unit area is also increased. This is one of the most powerful arguments which farmers advance in defense of the practice. When two or more crops are interplanted, the average yield per unit area tends to decrease, but the aggregate yield per unit area increases. This is significant for farmers because land is an important constraint.

(vii) Rudimentary Technology.

The small farm sector is characterized by a relatively low level of technology. Cultivation is characterized by the use of simple tools, and scanty use of fertilizers, insecticides, and pesticides. Conservation practices, for reasons both valid and invalid, are very often neglected.

(D) Farming Types.

In terms of crop emphases, farming in the area is virtually homogeneous. Most of the farmers tend to emphasize a combination of the following enterprises:

(i) Semi-Permanent Crops - bananas, plantains

(ii) Root Crops - yams, sweet potatoes, irish potatoes, cocoes, dasheen

(iii) Vegetables - tomatoes, carrots, turnips, cabbages, string beans, cho-cho

(iv) Legumes - corn and peas

Tree crops such as breadfruit, coconut, coffee, and cocoa often occur in conujnction with some of the above crop combinations to form "food forests" which are located all over the area, but more prominently on the heavier soils.

The degree of crop emphasis varies among soil types. On the heavier, well watered clays, which are usually located in saucer-shaped areas, a wider range of crops are grown. Practically all the root crops are found, and bananas and vegetables are the prominent cash crops. Legumes are relatively insignificant. The range of crops grown on the poor soils - red earth, and brown bauxitic soils - is more restricted. Yams, cocoes and sweet potatoes are the root crops stressed, legumes are more important than on the heavier soils, but bananas and vegetables are insignificant. Root crops, legumes and a few vegetables are the main cash crops.

(E) Land Use Adjustments:

In recent years, land use in the area has been undergoing certain dynamic adjustments which have been induced by two factors, notably the declining gross margin per acre realized on the production of bananas, and increasing shortage of labour. Because of the declining profitability of bananas, farmers, who emphasized this crop, have been reducing their effective acreage; the lands phased out are being switched either to the production of vegetables and plantains or used to rear cattle. Farmers, who are switching to the production of vegetables and plantains are doing so not only because the realized net margin per acre of these crops is considerably higher than bananas, but also because the long-term prospects are very good - the domestic demand for vegetables is increasing, especially with the growth of the tourist industry, while both local and overseas demand for plantains are on the upswing.

Most of the farmers who elect to switch, in part, to livestock production, argue that this activity is less labour demanding and consequently fits in well with the increasing shortage of hired labour. Increasing shortage of labour is, therefore, inducing adjustments in the form of land use extensity.

(F) Problems:

The most pressing problems confronting farmers in the area are:

(i) Inadequate land room

(ii) Insufficient cash operating expenses

(iii) Increasing shortage of hired labour

(iv) Insecurity of tenure

CHAPTER III

REVIEW OF THE LITERATURE

This chapter summarizes some of the major land use studies which are germane to the main body of the study.

One of the most recent and most elaborate studies seeking to explain the spatial variation in agricultural income has been done by W. K. Bryant[8] for the United States of America. Basing his analysis on a cross-sectional sample of agricultural income at different county levels throughout the United States, Bryant hypothesized that the variations in the income level of farmers in a community could be attributed to two broad sets of factors:

(1) The community's location relative to industrial urban concentrations

(2) Local demographic and economic factors

(1) Location relative to industrial-urban concentrations

Casting this Schutzian hypothesis in a spatial mould, Bryant elaborates:

> Economic development occurs in specific locations in a country, and these centres of development are primarily industrial-urban in composition. Input and product markets work better near the centres of such concentrations than at their peripheries. At any point in time,

[8] Bryant, W.K., "Inter-County Variations in Farmers' Earnings", Journal of Farm Economics, 48:557-577, 1966.

therefore, the closer a community is to an industrial-urban concentration, and the larger the concentration, the higher is the income level of farmers in the community.[9]

A further amplification of the hypothesis is that the increasing technological character of United States' agriculture, as evidenced by the increasing use of capital and credit, and a concomitant decrease in labour input, has invariably created spatial "lag" in the adjustment process. Consequently, those farmers who live near big and highly diversified labour and financial markets adjust more readily than those more remotely located. This spatial maladjustment is partly the result of discrepancies in the costs of transportation, transfer, and market information, as well as more rigid rationing of credit, and non-farm jobs to farmers located far from the metropolitan areas. But, it is not only location relative industrial-urban complex which is important. The size of such concentrations also affects the income level of farmers. Since the extent of specialization is dependent upon the size of the market which is directly related to the size of the metropolitan area, insofar as specialization generates higher income, farmers located near to large industrial-urban complexes will have higher incomes than their counterparts in relatively smaller centres.

Locational effects were measured by two proxy variables, notably:

(a) Distance to the nearest Standard Metropolitan Statistical Area

(b) Population size of Standard Metropolitan Statistical Area

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[9] Ibid., p. 458.

(2) Local demographic and economic factors

Differences among counties with respect to colour, age, and education of the farmers are postulated as the significant local demographic factors influencing inter-county discrepancies in farmers' incomes. Land and capital inputs per farm, overall demand for local labour, and availability of non-farm employment for craftsmen and operatives are hypothesized as the local economic factors affecting farmers' income level.

Non-white farmers usually have lower incomes than their white counterparts. Discrimination robs non-white farmers of equal access to local credit and capital markets, and also to local non-farm jobs.

Young farmers, although lacking in experience, generally have higher incomes than their middle-aged counterparts.

The more educated farmers, who are presumably better managers and who have greater knowledge of, and greater access to, local capital and credit markets, usually have higher incomes than farmers with little education.

Land and capital per farm are very significant factors affecting the income level of farmers in a specified community. Consequently, the higher the level of these basic inputs, the higher is the realized income of the farmer.

Overall local demand for labour is a significant factor affecting the job mobility of farmers. Counties with a high ratio of unemployed offer farmers little prospects of finding non-farm jobs. However, it is not only the percentage of unemployed in a county which affects farmers chances at obtaining non-farm employment, but also the relative abundance of outlets in which farmers usually find employment.

Results of the Analysis

(a) Locational factors.

The impact which locational forces exerted on farmers earning power varied from one division to another. For the divisions east of the Mississippi River, the nearer a county to an industrial urban complex, and the larger the related complex, the higher the realized earnings of the farmers. However, west of the Mississippi River, the reverse is true, the closer a county to an industrial-urban complex, and the larger the related complex, the smaller the earnings of the farmer. In the Pacific and Middle Atlantic divisions, location factors exert a negative influence on income.

(b) Local demographic factors.

On the national scale differences in colour, age, and education of the farm population account for a significant proportion of the variation in farmers' earnings. These factors exert their strongest influence in the Southern divisions and the West North Central division. Elsewhere, the local demographic influences are insignificant; a possible explanation is that the average level of education is above the minimum required for non-farm employment.

(c) Local economic factors.

On the national and divisional level, these are the most significant factors explaining inter-county differences in farmers' earnings. Land and capital inputs per farm account for the largest proportion of the variation in farmers' earnings.

In an attempt to provide a more total explanation of the geographical variation in agricultural income in areas west of the Mississippi River, United States, Norman and Castle[10] have developed a similar but more elaborate model which incorporates the characteristics of the natural resource complex. In addition to the socio-economic factors, the authors maintain that the "versatility or the range of choice in production that is permitted by the resource complex",[11] is an important factor affecting the income level of farmers in a region. When amplified, the hypothesis states that where the resource base allows the diversification of crop and livestock activities, there is a higher probability of low income persisting for larger periods of time than in areas where the range of choice is limited. The narrower the range of choice in a region, the higher the penalty for failing to adopt new technology. Consequently, a greater degree of commercialization and a resultant higher level of income would be expected in areas of relatively unfavourable farming conditions.

The range of choice hypothesis is predicated upon the following assumptions:

(1) Specialization and market dependence are directly related to agricultural income.

(2) A change or breakup of traditional agriculture poses disutility to the majority of farmers who surrender their self-sufficiency unwillingly for two reasons; (a) the greater physical-economic risks and uncertainty which are attendant upon greater market dependence and specialization, (b) preference for the traditional as against the new.

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[10] Norman, D.W., and Castle, E.M., "Geography and Agricultural Income, "Journal of Farm Economics, 49 : 571-83, 1967.

[11] Ibid., p. 572.

(3) The spatial variation in the natural resource phenomena invariably leads to discrepancies in the penalty for preserving traditional agricultural patterns.

(4) In terms of the income which the farmer foregoes, the opportunity cost of not adopting new technology and economic conditions ultimately overwhelms the resistance to change.

Defining the total income of the farmer as income derived jointly from agricultural activities, and from part-time non-agricultural work, the model is specified as:[12]

$$I = I_A + I_{NA}$$

where

I is the total income of the farmer

I_A is the agricultural income of the farmer

I_{NA} is income derived from non-agricultural work.

I_A, the level of agricultural income, is further defined as:

$$I_A = G_I \ (I_R, Q, A, E, R, C)$$

where

I_R is the amount of irrigation

Q is the land quality

A is age of the farmer

E is the education of the farmer

R is the race of the farmer

C is the range of choice which is further defined in terms of climatic variables defined by Thornwaite and Mather.

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[12] *Ibid.*, pp. 574-77.

The realized non-agricultural income of the farmer, I_{NA} is defined as:

$$I_{NA} = K\ (L,\ T,\ A,\ E,\ R)$$

where L is location as defined by Bryant

T is the time available for non-farm employment

A, E, R have already been defined.

Oregon and Kansas states were the testing ground for the model. The range of choice hypothesis was upheld for Kansas, but was found to be invalid for Oregon. In western Kansas where rainfall is sparse and uncertain, farming is not only specialized, but the latest technology is used, and farmers are relatively progressive, hence the range of choice hypothesis is supported. For the state as a whole, climatic interaction, irrigation, and age were the most significant variables explaining the variation in farmers' incomes.

Education was the most significant determinant of off-farm employment. Next in order of significance was the time available for off-farm employment. Of the two measures of location, the distance of a county relative to a Metropolitan area was the main bottleneck to off-farm employment. The farther a county from an urban area, the smaller was the amount of off-farm employment available. This is compatible with the location matrix hypothesis because in all but relatively few areas (parts of Oregon), the non-farm labour market coincided with the urban-industrial areas. Although distance significantly affected off-farm employment, off-farm employment was not a major determinant of farm income in Kansas. This finding confirms Bryant's conclusion that the location-matrix hypothesis is valid only for areas east of the Mississippi River.

The failure of the "range of choice hypothesis" to provide satisfactory supplementary explanation of the variation in agricultural income in western United States has led the authors to conclude that a satisfactory explanation for the variation of agricultural income in the related area is yet to be advanced.

W. C. Found[13] has also made a less sophisticated attempt at evaluating the factors affecting agricultural income in another spatial setting, notably, Land Reform Areas in the Island of Jamaica, West Indies. The study had a twin objective:

(a) To formulate and test a series of hypotheses concerning the influence of (1) size of the farm, (2) land use diversity, (3) distance of farm from farmstead, (4) size of farm family, (5) farmer's income from non-agricultural source, (6) additional acreage of land utilized by the farm operator.

(b) To develop a series of equations which could be used to predict the agricultural income of farmers in the study area.

Of all the factors considered, only two - size of the farm, and distance from farm to farmer's home - were found to be consistently related to farm output. Although some of the hypotheses were valid for three of the six study areas, they were found wanting for the areas as a whole, and consequently had to be reformulated. The multiple correlation of determination (R^2) is less than fifty percent for four of the six study areas; this reveals that the analysis is inadequate. Obviously, some of the most significant variables - cash operating expenses, labour input, farm capital - which significantly determine

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[13] Found, W.C., "A Multivariate Analysis of Farm Output in Selected Land Reform Areas of Jamaica", Canadian Geographer, XII, 1, 1968, pp. 41-42.

the level of productivity on the farm, have been omitted from the model. Edwards[14] has graphically demonstrated that there are strong positive correlations between the realized level of farm income, and the respective levels of land, labour, cash expenses, and farm capital used on the farm. Since the study fails to identify the real variables affecting the level of income realised on the farm, the predictive powers of the equations are extremely limited. The differentiation between the size of the farm, and the additional acreage of land used by the farm operator is also an unnecessary dichotomy. In farm management studies, the size of the farm is popularly defined[15] either as cropland or the total area of land (area owned, rented, leased, or occupied under other forms of tenure, minus areas subletted to others) operated by the farmer.

Whereas some land use studies have merely sought to evaluate the factors responsible for inter-area, and intra-area variation in agricultural income, others, including all those to be subsequently discussed, employ the Cobb-Douglas equation in the study of the production function. Farm-firm production studies are diagnostic in the sense that they give us an indication of the degree of equilibrium in farming. The coefficients derived from these response studies indicate very broadly: (a) the extent to which returns to the basic production inputs equate their market prices, (b) the balance or imbalance which exists either within or between areas with respect to the productivity of resources.

Since the literature dealing with the production function is too comprehensive to be covered here, only a few of the more popularly

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[14]Edwards, David, An Economic Study of Small Farming in Jamaica

[15]See Methods of Farm Management Investigations, F.A.O. Development Paper, No. 64, Rome, 1958, p. 59.

known as well as few of the more recent studies will be mentioned. Heady and Brown,[16] in a study of 255 farms on Toma-Muscatine soils of east-central Iowa, United States of America, found that 90 percent of the variation in crop income was associated with changes in input quantities - cropland, annual labour input, expenditure on machine services, expenditure on fertilizers, and miscellaneous crop services. Farms were efficient since they all experienced increasing returns to scale. With the exception of machine services, the marginal return to land, labour, fertilizer, and crop services more than offset marginal costs. As compared to previous studies, this analysis confirmed that labour used in the production of corn yielded a very high marginal productivity when combined with complementary inputs.

Heady and Shaw[17] have also done an inter-regional comparative study of resource productivity for a number of regions - Alabama, Piedmont, Northern Iowa, Southern Iowa, and the dry-farming areas of Montana - of the United States. Input and output were reckoned in dollars, and the data were similarly aggregated in all the regions. Individual functions were calculated for crops and livestock. The study revealed significant variation in the marginal productivity of land, labour, and capital among the four areas. The marginal productivity of labour was highest in Montana and Northern Iowa where the per-capita of land and labour was highest. The realized returns to capital was highest in Montana and Southern Iowa where a smaller proportion of this input was

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[16] Heady, E.O., and Dillon, J.L., Agricultural Production Functions, pp. 564-566.

[17] Ibid., pp. 576-584.

used relative to other areas. Capital realized its lowest return in Alabama. In addition to comparing resource return between areas, the study also compared resource return within areas.

A study of the production function on family farms, ranging in size from 10 to 25 acres, has also been done by Agrawal and Foreman[18] for the state of Uttah Pradesh in India. Farms concentrated on the production of sugar cane and wheat. The results of the analysis revealed a serious deficiency of capital services and a surplus of labour. Analysis of individual enterprizes showed that wheat production could be streamlined with the use of more capital and a corresponding reduction in labour input, while the profitability of sugar cane could be increased with the use of more labour and a corresponding contraction of capital inputs.

A companion study of subsistent crop production in the state of Andhra Pradesh[19] revealed severe diminishing returns to land, labour and capital services. The derived marginal rate of return for the respective inputs, when compared to their opportunity costs, showed that the farms sampled were using too much land, labour and capital.

More recently, Saini[20] has done a very comprehensive evaluation of resource efficiency and returns to scale for different categories of farms in the states of Uttah Pradesh and Punjab, India. The study reported that approximately 78 to 83 percent of the variations in the

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[18] Ibid., pp. 620-22.

[19] Ibid., pp. 623-624.

[20] Saini, G.R., "Resource Efficiency in Agriculture", India Journal of Agricultural Economics, Vol. XXIV, April to June, 1969, No. 2, pp. 1-18.

gross value of crop output could be attributed to input variations in land (acres), human labour (adult-man-days), bullock labour (pair dogs), farm manures and fertilizers, and irrigation expenditure. Elasticity coefficients for the various inputs indicated that land and human labour were the most significant variables. The high positive elasticity of response for human labour is very significant since it helps to dispel the myth that the marginal productivity of labour in Indian agriculture is either very low or near to zero. The marginal productivity of labour was not only positive, but also corresponded to the market wage rate. A very significant finding of the study is that the marginal value product of labour is highest on small farms, and tends to decrease as farm size increases. By implication, land is used more intensively on the smaller farms. By comparing the ratios of marginal value products of respective inputs to their factor costs, the author demonstrated that farmers tend to make adjustments and move towards the optimum. The divergence of the ratios from unity demonstrated, however, that farmers were not operating at the optimum which could be realized within the limits of their resources.

Schmitz,[21] in a study of grain and livestock farms in north western Saskatchewan revealed:

(a) An oversupply of labour on farms in certain areas.

(b) A relatively high profitability of land compared to livestock investment.

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[21]Schmitz, A., "Resource Use Efficiency in N.W. Saskatchewan," Canadian Journal of Agricultural Economics, Vol. 13, No. 2, 1965, pp. 34-39.

(c) As the size of the farm increases, diminishing returns accrue to cash expenditure.

(d) Overinvestment in machinery on specialized grain farms.

(e) Money invested in either cash expenditure or real estate generates a higher marginal productivity than money invested in either labour or machinery.

In a study aimed at estimating the marginal productivity of capital, and also assessing the effect of management performance on capital productivity, Sorensen[22] has highlighted that additional land resources are not the main preconditions to the achievement of increased agricultural production on farms in southern Brazil, but rather the increased use of operating expenses and working capital combined with improved managerial performance. The crux of the analysis is that significant gains in agricultural productivity in the related area can only be realized by increasing capitalization of farming. By implication, programmes aimed at increasing agricultural production should initially motivate farmers to make more efficient use of high return capital inputs.

B.F. Massel[23] has also explored the effect of management on output of staple food crops in a sample of peasant farms in Rhodesia. In order to assess the managerial factor, farmers were accordingly

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[22]Sorensen, D.M., "Capital Productivity and Management Performance in Small-Scale Agriculture in Southern Brazil", World Agricultural Economics and Sociology Abstracts, December 1969, Vol. II, No. 4, Abstract 3243-4351, pp.

[23]Massel, B.F., "Farm Management in Peasant Agriculture: An Empirical Study", Food Research Institute Studies, Vol. 7, 1967, pp. 205-215.

classified as: (a) skilled, (b) semi-skilled, (c) unskilled. The different levels of managerial skill, which farmers respectively exercised, were compared to (a) output of each crop, (b) differences in the levels of inputs used, (c) realized net output. The results of the analysis showed that, on the average, skilled farmers realized a significantly higher output than either semi-skilled or unskilled farmers. For all crops combined, the skilled farmers realized 47 percent and 200 percent more output, respectively, than either the semi-skilled or unskilled. The output of the semi-skilled farmers was 40 percent higher than the unskilled. These inter-group discrepancies stemmed from differences in the acreage of land cultivated, quantity of input used, soil factors, and yields. When compared to either the semi-skilled or unskilled farmers, the skilled farmers had larger farms, used more organic and chemical fertilizers, and were also technically more efficient. When adjustments were made for differences in soil quality, on the basis of acreage, the average yield of the skilled farmers was only 5 percent higher than the semi-skilled. Net output of the semi-skilled farmers was also 2.7 percent lower than that of the skilled farmers. In the case of the semi-skilled vis-a-vis the unskilled farmers, the average yield and net output of the former were 16.7 percent and 2.7 percent, respectively, higher than the latter.

Although the majority of studies, which have been reviewed, do not apply to the study area, the methodology employed in those studies that utilize the Cobb-Douglas function is relevant to the formal analysis to be conducted in the subsequent chapter.

CHAPTER IV

FORMAL ANALYSIS

Table 1 shows the data which was analysed by the technique of multiple stepwise regression.

<u>Model Specification</u>:

It is postulated that a model of the order:

$$Y = AX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} q \text{ will satisfactorily}$$

account for the variation in the response factor. When transformed logarithmically, this function becomes:

$$\log Y = \log A + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + \log q$$

where Y = gross cash income

X_1 = cropland

X_2 = total cash expenses

X_3 = total labour input

X_4 = number of dependents

X_5 = average distance of plots from farmer's home

X_6 = number of livestock

q = a stochastic error variate

and b_o, b_1, b_2, b_3, b_4, b_5, b_6 are regression parameters estimated by least squares.

An initial analysis revealed that only two variables were significant notably, total labour input, and total cash expenses which

TABLE 1

DATA FOR ANALYSIS OF INTER-FARM VARIATION

IN GROSS CASH INCOME

Observation Number	Gross Cash Income $Jamaican	Cropland	Total Cash Expenses $Jamaican	Total Labour Input	Number of Dependents	Average Distance of Plots From Home	Number of Livestock on Farm
1	240.0	3.55	90.0	234.0	10.	1.40	0.
2	220.0	5.10	96.0	226.0	10.	2.50	2.
3	300.0	3.10	140.0	246.0	5.	1.05	0.
4	310.0	4.35	130.0	264.0	9.	1.20	0.
5	1200.0	5.925	400.0	346.0	9.	0.10	3.
6	220.0	5.50	60.0	420.0	14.	2.00	2.
7	1000.0	10.0	400.0	464.0	7.	1.00	3.
8	40.0	0.60	50.0	37.0	2.	0.25	0.
9	90.0	1.15	40.0	64.0	4.	0.25	0.
10	20.0	1.10	32.0	69.0	10.	1.35	0.
11	178.0	6.50	110.0	468.0	12.	0.00	0.
12	170.0	2.20	90.0	168.0	8.	0.65	0.
13	185.0	3.00	100.0	232.0	6.	0.75	0.
14	400.0	5.00	200.0	322.0	5.	0.25	2.
15	460.0	3.25	140.0	256.0	8.	1.00	1.
16	300.0	4.50	160.0	283.0	5.	2.00	6.
17	120.0	2.50	40.0	196.0	14.	0.75	4.
18	85.0	3.45	32.5	184.0	10.	2.00	2.
19	50.0	2.50	30.0	159.0	10.	0.50	1.
20	30.0	1.75	50.0	103.0	8.	0.25	0.
21	200.0	1.70	96.0	149.0	4.	0.45	3.
22	60.0	1.30	32.0	54.0	7.	1.00	0.
23	120.0	1.30	60.0	90.0	6.	3.00	8.
24	170.0	2.50	72.5	222.0	10.	1.00	0.
25	190.0	5.50	90.0	355.0	9.	1.50	4.
26	400.0	4.50	210.0	301.0	5.	3.00	0.
27	120.0	3.50	100.0	240.0	10.	3.50	0.
28	330.0	4.50	170.0	301.0	11.	1.50	0.

Table 1 - cont'd.

Observation Number	Gross Cash Income $Jamaican	Cropland	Total Cash Expenses $Jamaican	Total Labour Input	Number of Dependents	Average Distance of Plots From Home	Number of Livestock on Farm
29	1100.0	6.50	350.0	400.0	5.	3.25	0.
30	100.0	4.50	30.0	301.0	11.	0.25	1.
31	210.0	3.50	90.0	240.0	5.	0.25	0.
32	20.0	2.20	50.0	153.0	12.	0.00	0.
33	16.0	0.75	50.0	48.0	10.	0.25	0.
34	12.0	1.00	20.0	67.0	5.	0.10	0.
35	11.5	0.50	18.5	29.0	10.	0.25	0.
36	100.0	1.55	40.0	107.0	5.	0.10	0.
37	50.0	0.30	30.0	15.0	2.	0.00	0.
38	20.0	1.00	40.0	66.0	4.	1.50	0.
39	16.0	0.80	40.0	52.0	10.	1.75	0.
40	24.0	0.75	30.0	48.0	8.	0.25	0.
41	200.0	2.00	80.0	139.0	0.	1.00	1.
42	280.0	3.50	80.0	240.0	7.	1.50	0.
43	176.0	3.00	100.0	208.0	10.	0.25	4.
44	30.0	2.00	10.0	139.0	1.	1.00	0.
45	220.0	4.20	40.0	283.0	10.	0.00	4.

is a dominant variable. On the basis of preliminary results, all the non-significant variables, with the exception of cropland, were dropped from the analysis. This left the function:

$$Y = AX^{b1} X_2^{b2} X_3^{b3} q$$

At the next stage of the analysis, the residuals were plotted against the three independent variables as well as against the dependent variable - observed and estimated. This was done primarily to check for non-linearity in the related variables, as well as for the presence of outliers, and non-additivity. Figures 1 to 5 show the plot of the residuals. The plots were carefully examined, and with the exception of X_2 (total labour input), there were no anomalies. In the case of X_2 (total labour input), the pattern of the residuals suggested that the related variable should have been introduced into the analysis as a second order polynomial and not simply as a linear variable.

At this point, it was decided to modify the model along the following lines:

(a) Exclude X_1 (cropland) which was insignificant because of the high collinearity with X_2 (total labour input).

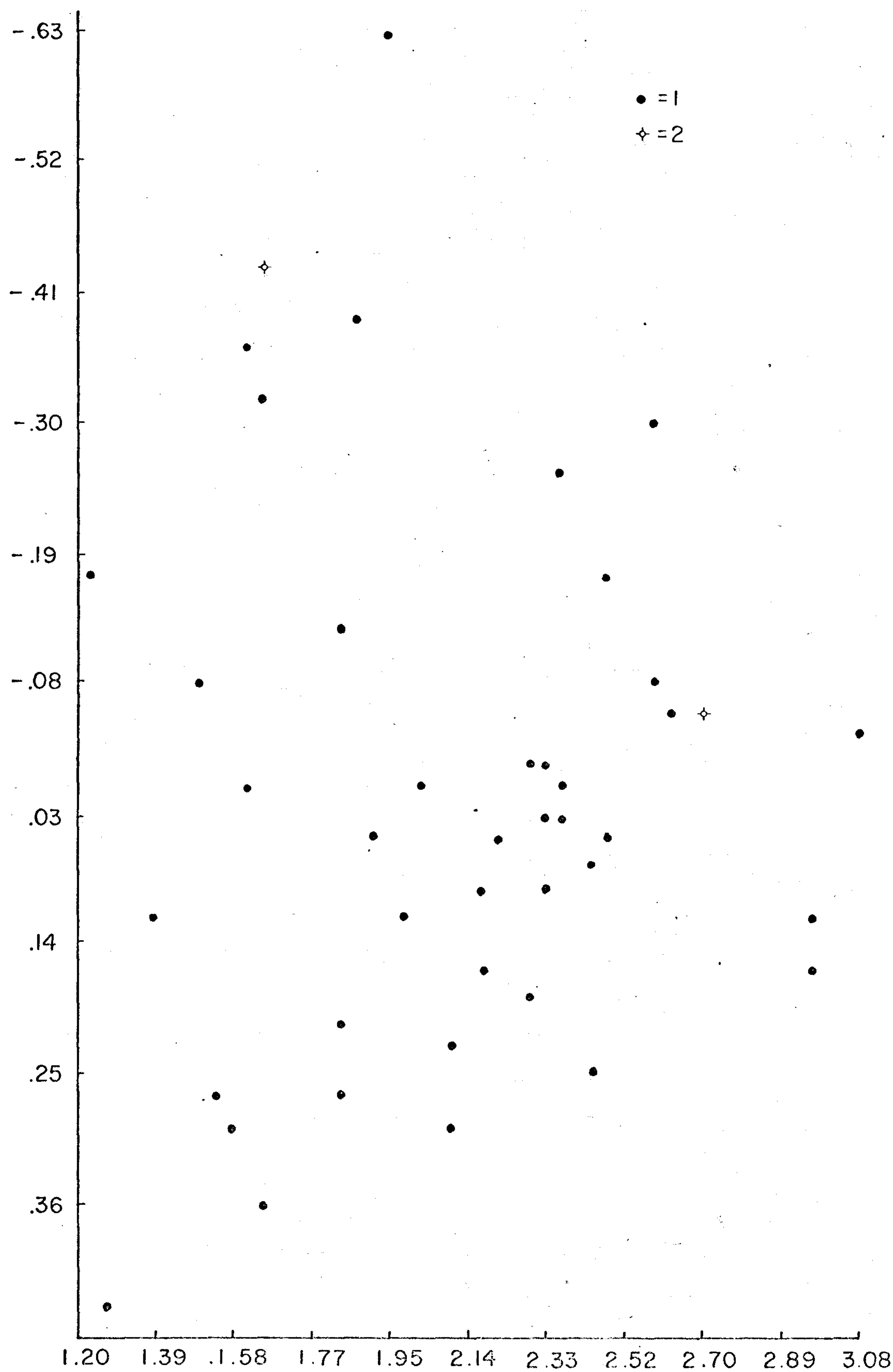
(b) Introduce X_2 into the analysis both as a linear variable and a second order polynomial.

(c) Add new input factors in the form of dummy variables.

The soil types on which farms were located as well as the level of specialization on farms were represented by four dummy variables. For the purpose of convenience, the various soil types were aggregated into three classes notably, clays, red earth, and brown earth. Each

PLOT OF RESIDUALS VS. COMPUTED Y

Figure : I



PLOT OF RESIDUALS VS. OBSERVED Y

Figure : 2

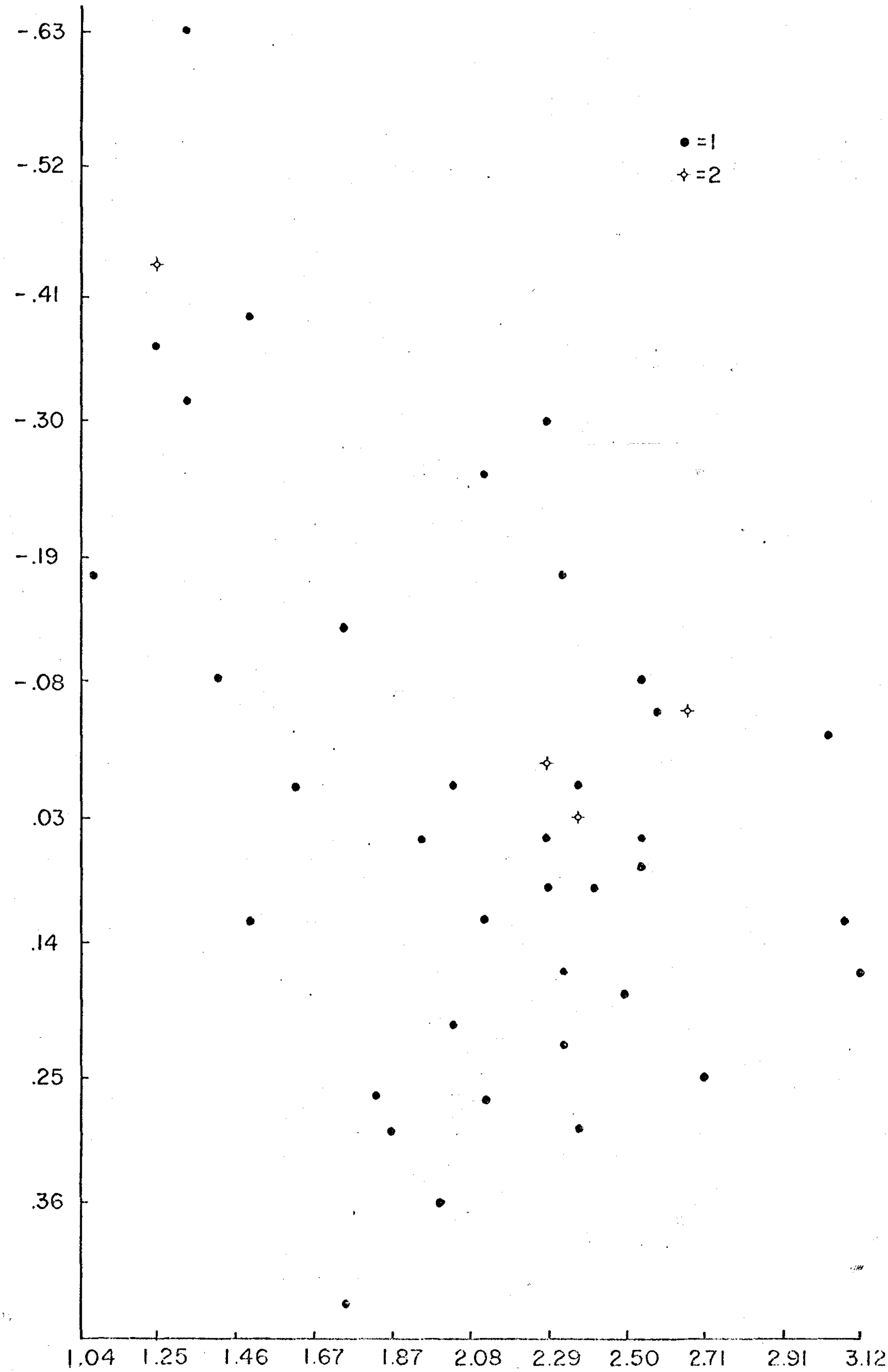


Figure 3

PLOT OF RESIDUALS VS. VARIABLE 2 (Cropland)

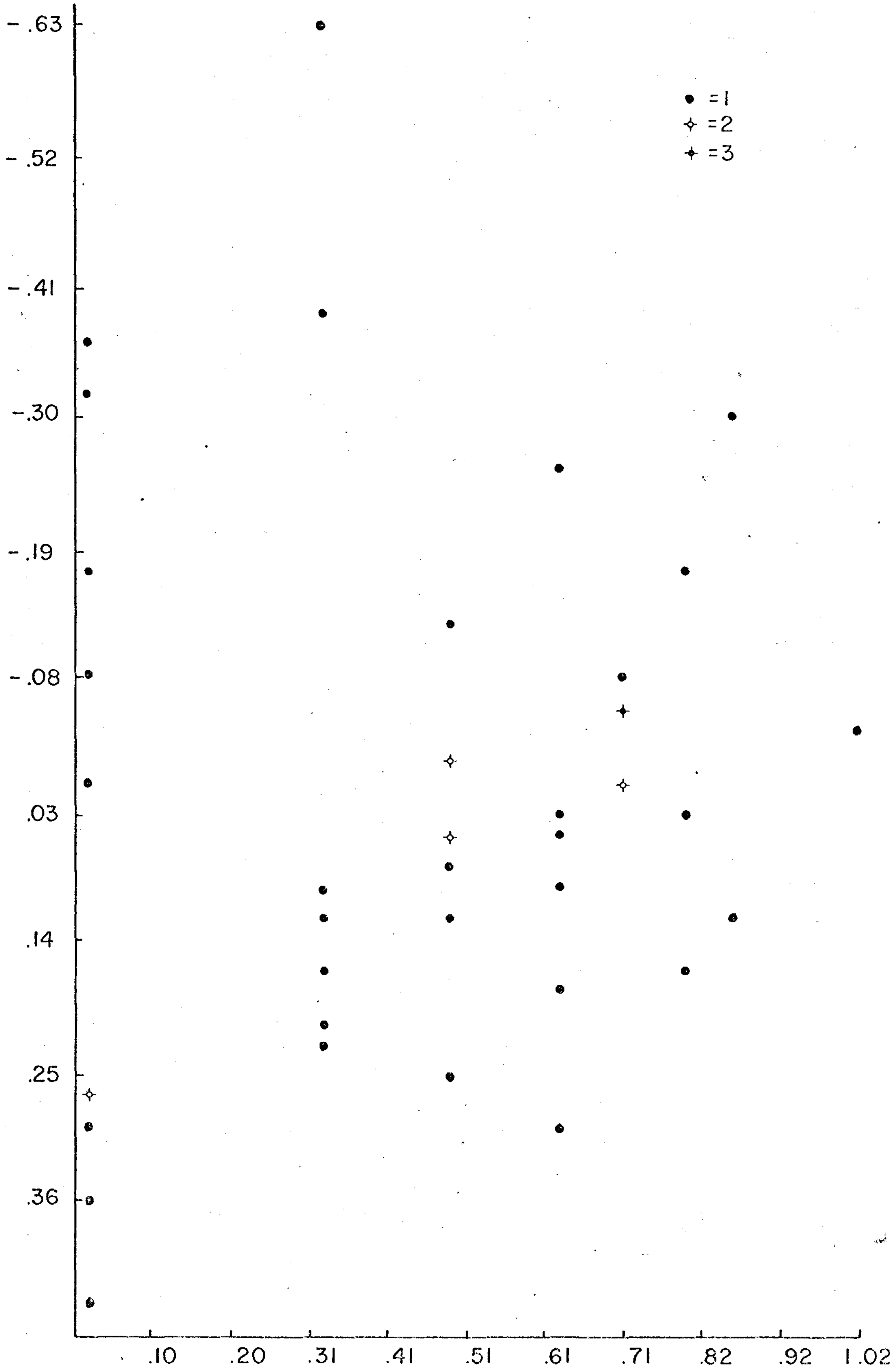


Figure 4

PLOT OF RESIDUALS VS. VARIABLE 3 (Cash Operating Expenses)

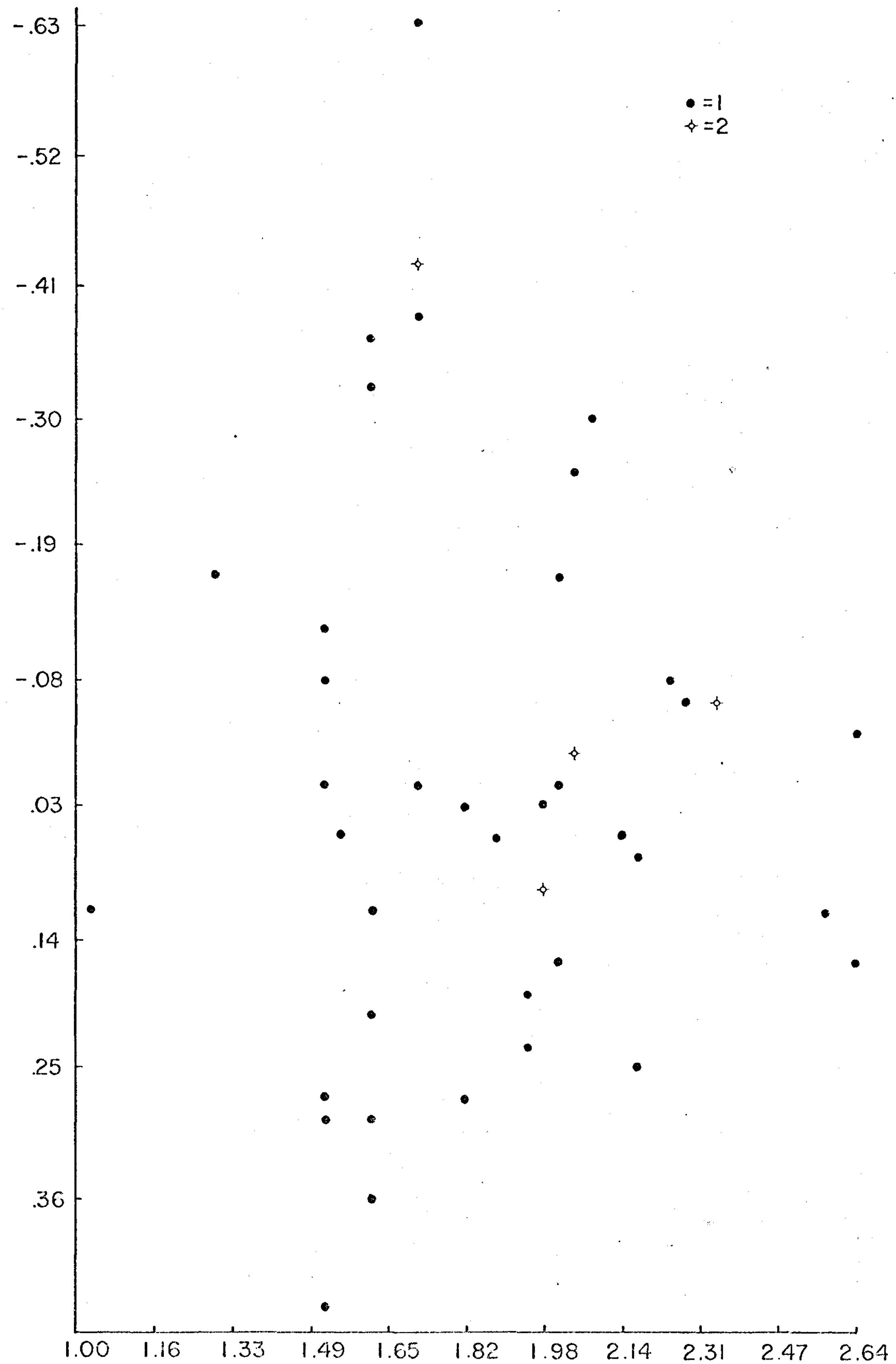
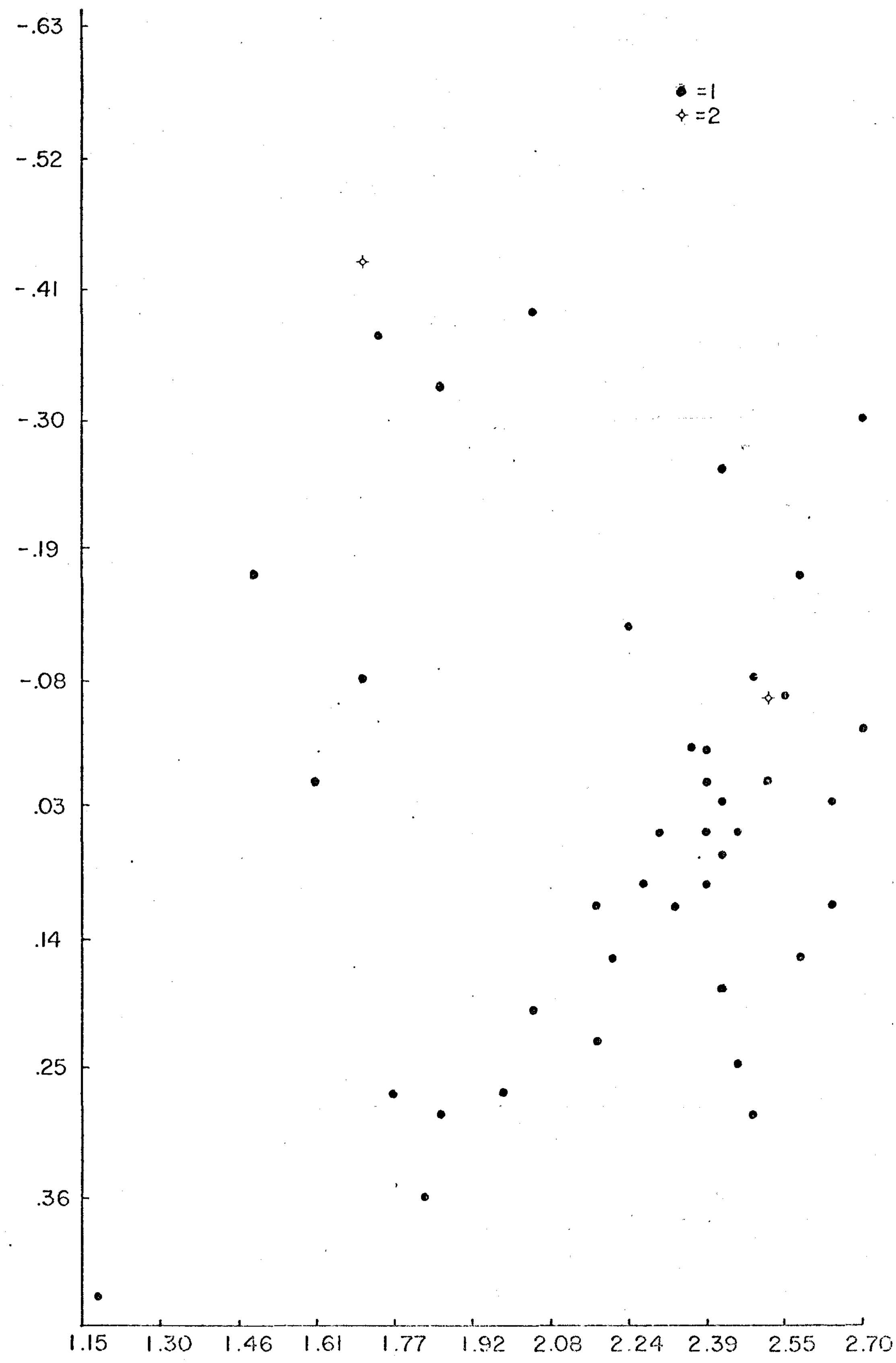


Figure : 5

PLOT OF RESIDUALS VS. VARIABLE 4 (Total Labour Input)



soil type was represented by a dummy variable. Where a farm was located on a specific soil type, the symbol 1 was used, and 0 otherwise. If a farm was very specialized, as in the case of two members of the sample, the symbol 1 was used, and 0 otherwise.

When all these modifications were made, the new postulated model became:

$$Y^* = b_o + b_1 X^*_1 + b_2 X^*_2 + b_{2_1} (X^*_2)^2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + q$$

where Y = gross cash income

X_1 = total cash expenses

X_2 = total labour input

X_3 = dummy variable representing the level of specialization on farm

X_4 = dummy variable denoting farm is located on clay soil

X_5 = dummy variable denoting farm is located on red earth

X_6 = dummy variable denoting farm is located on brown earth

q = a stochastic random variate

The asterisk denotes that these variables have been transformed logarithmically.

Further analysis revealed that the model:

$$Y^* = b_o + b_1 X^*_1 + b_2 X^*_2 + b_{2_1} (X^*_2)^2 + b_3 X_3 + q$$

would perform satisfactorily. With the exception of $b_3 X_3$ which is now $b_5 X_5$ redefined, the other terms are exactly the same as those in the preceding function.

CHAPTER V

EMPIRICAL RESULTS AND INTERPRETATION

General Findings:

The final results of the analysis are shown in Tables 2 and 3 respectively. Appendix I and Appendix II give some of the preliminary results. The final model, which is the best possible fit that the author could obtain, takes the form:

$$\log \hat{Y} = .6339 + .8352 \log X_1 - .7140 \log X_2 + .3114(\log X_2)^2 - .2153\, X_3.$$

With a multiple R which is statistically significant beyond the one percent level, this model explains approximately 87 percent of the interfarm variation in gross cash income. The standard error of estimate -.2018, when expressed as a percentage of the mean response, is 9.773 percent which appears to be relatively small; however, the author can find no prior documentary evidence to confirm this. It is hoped, however, that future studies will enlighten us. A final examination of the residuals, both in their original form and their normal deviate form reveals that the model has performed satisfactorily over the range of observations. Table 2 shows that 93.3 percent of the normal deviate residuals fall within the range of (-2, 2). Normally, this should have been 95 percent, however, the author thinks there is no cause for alarm because there is nothing peculiar about those normal deviate residuals that fall outside the limits (-2, 2). Moreover, one of the three normal deviate residuals that fell outside the limits (-2, 2) is only marginally greater than (2).

TABLE 2a

MEANS AND STANDARD DEVIATIONS OF VARIABLES

Variable	Mean	Standard Deviation
Y	2.06485	.52996
X_1	1.83894	.35339
X_2	2.16792	.41081
$(X_2)^2$	4.86490	1.54194
X_3	.04440	.20841
X_4	.55556	1.51591
X_5	.33333	.47673
X_6	.31111	.46818

TABLE 2b

CORRELATION MATRIX

Variable	Y	X_1	X_2	$(X_2)^2$	X_3	X_4	X_5	X_6
Y	1.000	.853	.728	.791	.231	.246	-.412	-.200
X_1		1.000	.624	.673	.298	.192	-.162	-.315
X_2			1.000	.983	.296	.298	-.225	-.334
$(X_2)^2$				1.000	.319	.332	-.279	-.333
X_3					1.000	-.008	.076	-.145
X_4						1.000	-.262	-.249
X_5							1.000	-.475
X_6								1.000

TABLE 2c

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sums of Squares	Mean Square	Overall F
Regression	4	10.729	2.682	65.892
Residual	40	1.628	.041	

TABLE 2d

ESTIMATED REGRESSION COEFFICIENTS, STANDARD ERRORS AND CONFIDENCE LIMITS (99%)

Variable	Coefficient	Standard Error	Limits Upper/Lower	Partial F-Test
Constant	.63387			
X_1	.83523**	.12218	1.21560 .55486	219.1707
X_2	-.71400*	.44230	.48197 -1.90997	2.5853
$(X_2)^2$	.31136**	.12639	.65268 .02996	25.9024
X_3	-.21540**	.06985	-.04140 -.26660	14.0244

** Significant at the 1 percent level

* Significant at the 20 percent level

TABLE 2e

SUMMARY TABLE

Variable Entered	Multiple R	Multiple R^2	Increase in R^2	F Value to Enter or Remove
X_1	.8527	.7271	.7271	114.5854
$(X_2)^2$	.9017	.8131	.0860	19.3215
X_3	.9272	.8597	.0465	13.5960
X_2	.9318	.8682	.0086	2.6059

TABLE 3

RESIDUAL ANALYSIS FOR LOG $\hat{Y} = f(\text{Log } X_1, \text{Log } X_2, X_3)$.

Observation Number	Observed Y	Predicted Y	Residual	Normal Deviate
1	2.0000	2.0104	-.0104	-.0515
2	2.0000	1.8050	.1950	.9663
3	2.4914	2.4963	-.0050	-.0247
4	3.0792	3.0016	.0776	.3845
5	2.3424	2.3887	-.0462	-.2289
6	3.0000	3.1172	-.1173	-.5809
7	1.9542	1.4827	.4716	2.2897
8	2.2504	2.4370	-.1866	-.9246
9	2.2304	2.0037	.2268	1.1238
10	2.2304	2.2191	.0113	.0559
11	2.2672	2.3576	-.0904	-.4479
12	2.6021	2.5080	.0941	.4663
13	2.6628	2.5127	.1501	.7538
14	2.4771	2.5959	-.1188	-.5887
15	2.0792	1.9713	.1079	.5346
16	2.5185	2.6396	-.1211	-.6000
17	2.3010	2.2083	.0927	.4593
18	2.0792	1.9128	.1664	.1664
19	3.0414	3.0016	.0398	.1972
20	2.3222	2.3346	-.0124	-.0614
21	2.3010	1.9116	.3894	1.9296
22	2.3424	2.0946	.2478	1.2259
23	2.0792	2.1574	-.0782	-.3875
24	2.2788	2.4656	-.1868	-.9256
25	2.6021	2.7163	-.1142	-.5659
26	2.2455	2.1113	.1342	.6650
27	2.4478	2.2919	.1553	.7695

Table 3 - continued

Observation Number	Observed Y	Predicted Y	Residual	Normal Deviate
28	2.4771	2.4992	-.0221	-.1095
29	2.3424	2.3342	.0082	.0406
30	2.3802	2.3222	.0082	.0406
31	1.9294	1.8710	.0584	.2893
32	1.6990	1.8047	-.1057	-.5237
33	1.6990	1.5628	.1362	.6749
34	1.7782	1.3731	.4050	2.0069
35	1.6021	1.6989	-.0969	-.4901
36	1.8010	1.6309	-.3299	-1.6347
37	1.2041	1.4998	-.2957	-1.4653
38	1.0792	1.2285	-.1494	-.7403
39	1.2041	1.4316	-.2275	-1.1273
40	1.3802	1.3327	.0475	.2353
41	1.0607	1.2926	-.2319	-1.1491
42	1.4771	1.3727	.1044	.5173
43	1.3010	1.7685	-.4674	-2.3161
44	1.3010	1.4800	-.1789	-.8865
45	1.4771	1.6618	-.1847	-.9152

The variables found to be statistically significant in explaining the variation in gross cash income are X_1 (total cash expenses), X_2 (total labour input), and X_3 (soil type - specifically, the red earth). All these variables are statistically significant at the one percent level. Total cash expenses, the most significant variable, accounts for approximately 73 percent of the interfarm variation in gross cash income. Next in order of significance is total labour input. Soil type is the least significant.

The regression parameters give us a "partial"[24] measure of the elasticity of response with respect to the factors of production. Elasticity of response with respect to a specific input, X, indicates the percentage increase in output (Y) resultant upon a percentage increase in the ith input. Production is most responsive to total cash expenses (X_2); for example, other factors being held constant, a one percent increase in X_2, will, on the average, generate an increase in gross cash income ranging from .72 to .96 percent (.84 plus or minus .12). Here it is presupposed that the increment of production is marketed. In the case of X_2, which is quadratically related to Y, the elasticity of response varies, depending upon the level of X_2. Consequently, the regression coefficient of log $(X_2)^2$, as given in the final model, cannot be taken as the elasticity of response. It is possible, however, to approximate the elasticity of log $(X_2)^2$, by using the formula:[25]

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[24] The word "partial" is used since only one component of the farmers' income is being analyzed. Hence, the elasticities are not precise estimates of production response.

[25] Dillon, J. L., The Analysis of Response in Crop and Livestock Production, Pergamon Press, Oxford, 1968, p. 7.

$$E_i = (dY/dX_i)(X_i/Y)$$

where X and Y are taken at their geometric means.

Taking the partial derivative of the equation:

$$\log \hat{Y} = .6339 + .8352 \log X_1 - .7140 \log X_2 + .3114 \log (X_2)^2 - .2153 X_3.$$

$$\frac{dY}{dX_2} = -.7140 + .6228 X_2$$

Substituting in the above expression the value of X_2 at its geometric mean,

$$\frac{dY}{dX_2} = -.7140 + .6228 (2.1679)$$

$$\frac{dY}{dX_2} = .636$$

Denoted by E_{X_2}, the elasticity of response for X_2 is,

$$E_{X_2} = .636 \frac{(2.1679)}{(2.0649)}$$

$$E_{X_2} = .6677$$

For the "average" farm, the elasticity of production is .6677 which implies that a one percent increase in total labour input will generate a .67 percent increase in gross cash income.

Functionally, the soil dummy variable implies that farmers located on the red earth are likely to have lower gross cash incomes than their counterparts on other soil types. This seems logical for two reasons:

(1) Farmers on the red earth, a relatively very poor soil, are likely to realize a lower productivity than their counterparts on relatively fertile soils. This lower productivity is consequent on,

(a) an infertile soil which is less responsive to treatment (the red bauxitic soil tends to fix very rapidly and thus render ineffective any application of chemical fertilizers), (b) the incidence of crop failure which is more frequent and more severe for farmers located on the red earth. Figures 6 and 7 illustrate the different levels of production which may be realized by farmers on soils of differing fertility. A lower level of productivity, given the small-scale of farm operations, implies that farmers on the red earth are likely to have a smaller marketable surplus, and consequently realize lower gross cash incomes.

(2) Because of the unfavourable ecological conditions, farmers on the red earth cannot cultivate as wide a range of crops astheir counterparts elsewhere. The major crop emphases are yams, sweet potatoes, corn, and peas. The relatively more profitable crops, especially vegetables, are cultivated only on a minimum scale. Although vegetables are very profitable, they are high-risk crops, consequently, preference is given to those crops that are less lucrative, but more certain to generate returns. Specialization on relatively fewer crops as opposed to diversification on other soil types seems, in part, to be responsible for the lower gross cash income realized by farmers located on the red earth.

A relatively poor environment is not a sufficient condition for low income in an area. Given the proper technology, the correct price structure, and adequate supplies of capital and labour, it is possible for farmers in a relatively poor environment to realize a level of income which is equal or greater than that of their counterparts in relatively more favourable environment. However, in the case of the

FIGURE : 6

Hypothetical labour production function, high productivity soils.

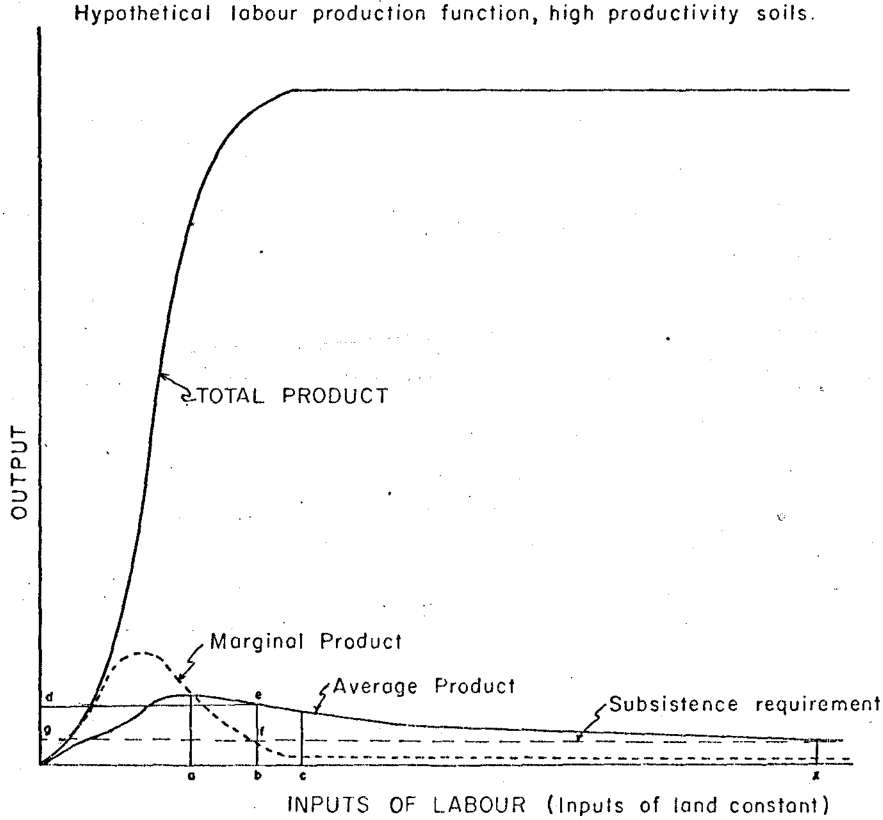
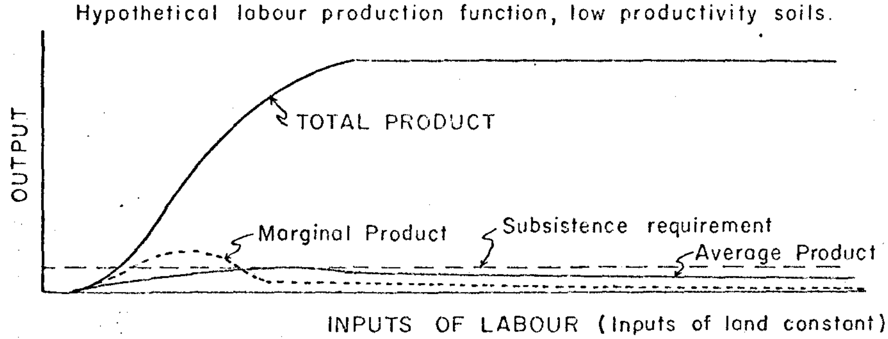


FIGURE : 7

Hypothetical labour production function, low productivity soils.



Source: John W. Mellor, The Economics of Agricultural Development, Cornell University Press, Ithaca, New York, 1966, pp 162-163.

study area, farmers on the poorer soils have no decisive advantages in terms of capital, labour, and technology. It is, therefore, possible that farmers located on the red earth will have a lower production, and consequently a smaller marketable surplus which yields a relatively lower level of gross cash income. Since the overall sample is small, the suggested discrepancy in the gross cash incomes of farmers located on different soil types is subject to reservation.

Returns to Resources:

Marginal value productivities for the two basic inputs - total cash expenses and total labour input - are also approximated. According to Heady, one of the most precise and possibly the most useful estimate of the marginal value product of the X_i, the ith input, is given by the formula:[26]

$$\frac{dY}{dX} = b_i \frac{X_i}{Y}$$

where b_i = the elasticity of the ith input

Y = the value of output at its geometric mean

X_i = the value of the ith input at its geometric mean

The marginal value product of total cash expenses (X_1) is derived by the use of this formula. However, in the case of total labour, the marginal value product is approximated by taking the partial derivative of the equation given at the outset of the chapter.

The variances of the marginal value product of X_1 and X_2 are also obtained from the formula:[27]

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[26] See Heady, E. O., and Dillon, J. L., Agricultural Production Functions, Iowa State University Press, Iowa, 1961, p. 231.

[27] See Massel, B. F., and Johnson, R. W. M., "Economics of Small-Scale Farming in Rhodesia, A Cross-Section Analysis of Two Areas", Food Research Institute Studies, Stanford University, Supplement to Vol. VIII, 1968, p. 49.

$$\hat{Var}(f_i) = \left(\frac{Y}{X_i}\right)^2 \left(\hat{Var}(E_i) + \frac{(S_i)^2 (E_i)^2}{n}\right)$$

where (f_i) = the marginal value product of the ith factor of production

$(S_i)^2$ = the unexplained variance of log (Y)

n = the number of observations

E_i = the elasticity of the ith input, and Y and X_i are chosen at their geometric means.

Table 4 gives the estimated marginal value products and their respective variances.

TABLE 4

ESTIMATED MARGINAL VALUE PRODUCTIVITIES

Input		
Total cash expenses	.94	(.0263)*
Total labour input	.64	(.0029)*

* The figures in parentheses are the variances of the estimated marginal products.

Since the marginal value products of the respective production inputs are less than unity, diminishing returns prevail. Consequently, the use of an additional unit of a specified input generates a less than proportionate return. Accordingly, a Jamaican dollar invested in the form of cash expenditure yields a return of 94 cents. In the case of labour, a dollar invested realizes a return of 64 cents. More realistically, it is better to compare the marginal value productivity of each resource to its acquisition cost. If the cost of labour is calculated at the ongoing regional agricultural wage rate of 1.5 Jamaican dollar per day, then the returns to labour would be 94 cents, just a little more than one half of its acquisition cost. In the case of total cash expenses, when the cost of capital is discounted at 5 percent per annum (the prevailing interest rate charged by the Cooperative Bank from which most farmers contracted loans), then for every $1.05 Jamaican dollar invested, there is a return of 94 cents.

It should be remembered that these figures have been underestimated because the consumption component of income has not been reckoned. If it were possible to take this component into account, there would be a substantial narrowing of the discrepancy between factor return and factor cost. It may be found that the realized return to capital is either equal or greater than its acquisition cost. This depends, however, on the precision of the estimated marginal product. It is often argued that the returns to capital tend to be overestimated when the management factor is omitted from the response function.[28] If this is true, the extent to which the estimated marginal product of total cash expenses approximates its acquisition cost, depends upon the bias of the estimate. However, it would not be surprising if a total analysis of income on a similar sample of small-scale farms did reveal that increasing returns accrue to capital. A specific input tends to realize increasing returns when it is used on a small scale. This is true of capital when the same input is used on

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[28] Heady, E. O., and Dillon, J. L., Agricultural Production Functions, Iowa State University Press, Iowa, 1961, pp. 204-5.

small farms.[29] In the case of labour there would be less chances of an equalization between marginal return and marginal factor cost. Since small-scale agriculture is highly labour intensive, and production is relatively low because of rudimentary technology, it is conceivable that the marginal value product of labour might be less than its acquisition cost. But even if this were the case, the discrepancy is likely to be very small.

Although a statement on the returns to scale or the overall elasticity is not forthcoming, this does not detract seriously from the analysis; in spite of the data limitations the author feels that very meaningful results have been obtained. Apart from isolating the really significant variables affecting the variation in gross cash income, the study has also derived meaningful estimates of both the elasticities of production, and the marginal products of the two basic inputs - total cash expenses, and total labour input. In so far as the study demonstrates that the realized level of gross cash income is dominantly determined by the respective level of total expenses, and that the realized returns to this input is relatively high, this has implication for regional plans aimed at raising the income of farmers in the related area.

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[29] See Heady, E. O., Agricultural Production and Resource Use, Prentice Hall, Englewood Cliffs, N.J., 1952, p. 38.

APPENDIX I

ENTERPRIZE ANALYSIS TABLES

CROP - POTATOES AREA - 1 ACRE POP. - 1200

Labour Operations	Man Days	Rates	Total Cost (£.S.D.)
Preparation of the Land	8	$1.50	12.00
Digging Mounds	12	$3.50 per 100	42.00
Selecting and Cutting Slips	4	$1.50 per day	6.00
Applying Fertilizer	1	" " "	1.50
Planting	3	" " "	4.50
Weeding	8	" " "	12.00
Reaping	8	" " "	12.00
Sub Total	41		90.00

Materials

4 cwt. Fertilizer @ $4.00 per cwt.	16.00
Total Cost of Production	106.00

Estimated yield per acre 12,000 lbs.

Value of estimated yield @ $2.00 per 100 = $240.00

Estimated net value per acre = $240.00 - $106.00 = $134.00

Total Return to farm family = $134.00 + $ 90.00 = $224.00

Estimated yield without use of fertilizer = 6,000 lbs.

Estimated value of output = $120.00

Estimated net value = $120.00 - $106.00 = $ 14.00

Appendix I - continued

CROP - YAM	AREA - 1 ACRE	POP. 1000	
Labour Operations	**Man Days**	**Rates**	**Cost $ Jamaican**
Preparing the land	8	$1.50 per day	$12.00
Digging hills @ £2.10. per 100	20	$5.00 per 100	50.00
Applying fertilizer	1	$1.50 per day	1.50
Planting	7	" " "	10.50
Cutting & transporting stick	14	" " "	21.00
Sticking & tying	7	" " "	10.50
Weeding	10	" " "	15.00
Reaping, etc.	14	" " "	21.00
Sub Total	81		$141.50
Materials			
66 cwt Yam Heads @ $5.00 per cwt			$330.00
4 cwt fertilizer @ $4.00 per cwt			16.00
Sub Total			$346.50
Total Production Costs			$488.00

Estimated yield per acre = 16,000 lbs.	
Value of estimated yield @ $4.00 per 100 lbs.	= $640.00
Estimated net value per acre = $640.00 - $488.00	= $152.00
Total return to farm family = $152.00 + $141.50	= $293.50
Estimated yield without fertilizer = 10,000 lbs.	
Value of estimated output	= $400.00
Estimated net value per acre = $400.00 - $472.00	= -$ 72.00
Total return to farm family = $141.50 - $72.00	= $ 69.50

Appendix I - continued

CROP - COCOES	AREA - 1 ACRE	POP. - 2000	
Labour Operations	Man Days	Rates	Cost $ Jamaican
Preparing the land	5	$1.50 per day	$ 7.50
Forking the land	20	" " "	30.00
Digging holes	7	" " "	10.50
Applying fertilizer	1	" " "	1.50
Bitting & planting	4	" " "	12.00
Weeding, desuckering & molding	8	" " "	12.00
Reaping	8	" " "	12.00
Total	55		$79.50

Materials

12 cwt cocoe heads @ $1.50 per cwt	18.00
Mulch - (free)	-
Total Production Costs	$97.50

Estimated output = 50 cwt	
Value of estimated output @ $3.60 per cwt	$180.00
Estimated net value per acre = $180.00 - $97.00	= $ 83.00
Total return to farm family = $ 83.00 + $79.00	= $162.00

CROP - TOMATO	AREA - 1 ACRE	POP. - 4000	
Labour Operations	**Man Days**	**Rate**	**Cost $ Jamaican**
Preparing the land	5	$1.50 per day	$ 7.50
Forking	20	$6.00 per sq.	60.00
Nursery work	4	$1.50 per day	6.00
Furrowing	10	" " "	15.00
Applying fertilizer	2	" " "	3.00
Transplanting	14	" " "	21.00
Sticking	15	" " "	22.50
Tying	14	" " "	21.00
Pruning	10	" " "	15.00
Weeding & moulding	16	" " "	24.00
Spraying	9	" " "	13.50
Reaping, etc.	20	" " "	30.00
Sub Total	139		$239.50

Materials

5 ozs. seeds @ $1.00 per oz.	$ 5.00
5 bags of fertilizer @ $4.00 per bag	20.00
Spraying Material - 15 lbs. Dithcone @ .80 per lb.	12.00
4 tins Couerabit Blue @ $1.40 per tin	5.60
Sub Total	$ 42.60
Total Production Costs	$282.10

Estimated output - 12,000 lbs.

Value of estimated output @ $7.50 per 100 lbs. = $600.00

Estimated net value per acre = $600.00 - $282.10 = $317.90

Total return to farm family = $317.90 + $239.50 = $556.40

Appendix 1 - continued

CROP - CABBAGE	AREA - 1 ACRE	POP. - 10,000	
Labour Operations	Man Days	Rate	Cost $ Jamaican
Preparing the land	8	$1.50 per day	$12.00
Forking	20	$6.00 per sq.	60.00
Furrowing	10	$1.50 per day	15.00
Nursery work	10	" " "	15.00
Transplanting	20	" " "	30.00
Applying fertilizer	2	" " "	3.00
Watering	20	" " "	6.00
Weeding & moulding	20	" " "	30.00
Spraying	21	" " "	31.50
Reaping	20	" " "	30.00
Sub Total	151		$242.50
Materials			
1/4 lb. Cabbage seed			$ 1.80
4 bags fertilizer @ $2.00 per bag			8.00
Spray materials			4.00
Sub Total			$ 13.80
Total Production Costs			$256.30

Estimated output - 10,000 lbs.

Value of estimated output @ $4.00 per 100 lbs. = $400.00

Estimated net value per acre = $400.00 - $256.30 = $143.70

Total return to farm family = $242.50 + $143.70 = $386.20

Appendix I - continued

CROP - CARROTS	AREA - 1 ACRE	POP. - APPROX. 100,000	
Labour Operations	Man Days	Rate	Cost $Jamaican
Preparing the land	8	$1.50 per day	$12.00
Forking	20	$6.00 per sq.	60.00
Refining	6	$1.50 per day	9.00
Furrowing	6	" " "	9.00
Planting	3	" " "	4.50
Fertilizing	2	" " "	3.00
Weeding & thinning	16	" " "	24.00
Reaping, etc.	15	" " "	22.50
Sub Total	76		$144.00
Materials			
3 lbs. seed @ $2.40 per lb.			7.20
4 cwt fertilizer @ $4.00 per cwt.			16.00
Weedicide			12.95
Sub Total			$ 36.15
Total Production Cost			$180.15

Estimated output - 7,000 lbs.

Value of estimated output @ $5.00 per 100 lbs. = $350.00

Estimated net margin per acre = $350.00 - $180.15 = $169.85

Total return to farm family = $144.00 + 169.85 = $313.85

CROP - CORN	AREA - 1 ACRE		POP. -	
Labour Operations	Man Days	Rate	Cost $Jamaican	Cost related to Peas
* Preparing of land	8	$1.50 per day	$12.00	$6.00
* Forking	20	$6.00 per sq.	60.00	30.00
* Applying fertilizer	1	$1.50 per day	1.50	.75
Planting	2	" " "	3.00	-
* Weeding and moulding	8	" " "	12.00	6.00
Disease & pest control	8	" " "	12.00	-
Reaping	5	" " "	7.50	-
Sub Total	52		$65.25	
Materials				
8 qts. seeds @ 10¢ per qt.			.80	
6 lbs. Malathion @ 60¢ per lb.			3.60	
4 bags fertilizer @ $4.00 per cwt.			8.00	4.00
Sub Total			$ 7.40	
Total Production Cost			$72.65	

Estimated output - 25 bushels

Value of estimated output @ $2.40 per bushel = $60.00

Net loss per acre = $72.65 - $60.00 = $12.65

* N.B. Since corn is usually intercropped with Red Peas, certain costs are jointly shared, and consequently must be equally divided between both enterprises.

Corn not a profitable enterprise. To break even farm must produce about 59 bushels per acre.

Appendix I - continued

CROP - RED PEAS AREA - 1 ACRE

Labour Operations	Man Days	Rates	Cost $Jamaican	Cost related to corn
Preparing of land	8	$1.50 per day	$12.00	$6.00
Forking	20	$6.00 per sq.	60.00	30.00
Applying fertilizer	1	$1.50 per day	1.50	.75
Planting	3	" " "	4.50	
Weeding	8	" " "	12.00	6.00
Reaping & threshing	3	" " "	4.50	
Sub Total	43		$51.75	

Materials

20 qrt. peas @ 30¢ per qrt.	6.00	
4 cwt. fertilizer @ $4.00 per cwt.	8.00	4.00
Sub Total	$10.00	
Total cost of production	$61.75	

Estimated output - 20 bushels

Value of estimated output @ $21.10 per 100 lbs. = $154.89

Estimated margin per acre = $154.89 - $61.75 = $ 93.14

APPENDIX II

SOME PRELIMINARY RESULTS

Variable	Mean of Transformed Variable	Standard Deviation of Transformed Variable
Y	2.23240	.40065
X_1	.45606	.29411
X_2	1.91906	.32116
X_3	2.25632	.30091
X_4	.84153	.19208
X_5	.07739	.15927
X_6	.45605	.19121

CORRELATION MATRIX

Variable	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.000	.715	.910	.769	.084	-.003	.005
X_1		1.000	.689	.950	.293	.069	-.139
X_2			1.000	.689	-.052	-.097	.068
X_3				1.000	.340	.067	-.093
X_4					1.000	-.097	-.143
X_5						1.000	.280
X_6							1.000

Appendix II - cont'd

ANALYSIS OF VARIANCE TABLE

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F
Regression				
due to X_2	1	3.055	3.055	132.8260 ***
due to X_3/X_2	1	3.197	0.142	6.1397 **
due to $X_1/X_2, X_3$	1	3.259	0.067	2.6956 *
due to $X_5/X_2, X_3, X_1$	1	3.271	0.012	0.5217
due to $X_6/X_2, X_3, X_1, X_5$	1	3.288	0.017	0.7391
due to $X_4/X_2, X_3, X_1, X_5, X_6$	1	3.296	0.008	0.3478
Residual	17	.396	0.023	

*** Significant at the 1 percent level

** Significant at the 5 percent level

* Significant at the 20 percent level

APPENDIX III

SOME PRELIMINARY RESULTS

Model: $Y = AX^{b1}X_2^{b2}X_3^{b3}$

where Y = gross cash income

X_1 = cropland

X_2 = total cash expenses

X_3 = total labour input

ANOVA

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F
Regression				
due to (X_2)	1	7.949	7.494	139.456*
due to (X_3/X_2)	1	9.216	1.267	22.228*
due to ($X_1/X_2,X_3$)	1	9.267	0.051	.895
Residual	41	2.354	0.057	

* Indicate the regression coefficients are statistically significant at the 1 percent level.

Estimated Regression Coefficients

Constant	X_1	X_2	X_3	R	R^2
-.3360	.3276	.7743	.3884	.8930	.7974
	(.3461)	(.1430)	(.2819)		

The values which are placed in parenthesis below the regression coefficients are the standard errors of estimates.

N.B. The very large standard errors of estimates for the regression coefficients X_1 and X_2 stem from the very high degree of multicollinearity between the two variables. Because the very large standard errors of estimates precluded intelligent interpretation of the betas, X_1 had to be dropped from the analysis. When this was done, the standard errors of estimate for X_3 was reduced considerably.

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