CANE FARMERS'

SUGAR CANE SUPPLY IN JAMAICA

AN ANALYSIS OF THE SUPPLY CHARACTERISTICS
OF JAMAICAN SUGAR
CANE FARMERS

by

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This study analyses the significance of a number of selected supply variables, economic and physical, in explaining changes in supply among Jamaican sugar cane farmers over time. The study is considered an empirical application of much of the findings in the theory of agricultural supply.

The study is set within the overall theory of agricultural supply with a detailed discussion of the particular social and economic conditions of the study areas. As such, broad conclusions may be drawn from this study to be applied to other cases with similar characteristics.

Extensive use is made of a questionnaire to arrive at the particular characteristics of the farmers and their decisions regarding sugar cane supply. The study is, however, not exhaustive in scope nor are its conclusions incontrovertible.

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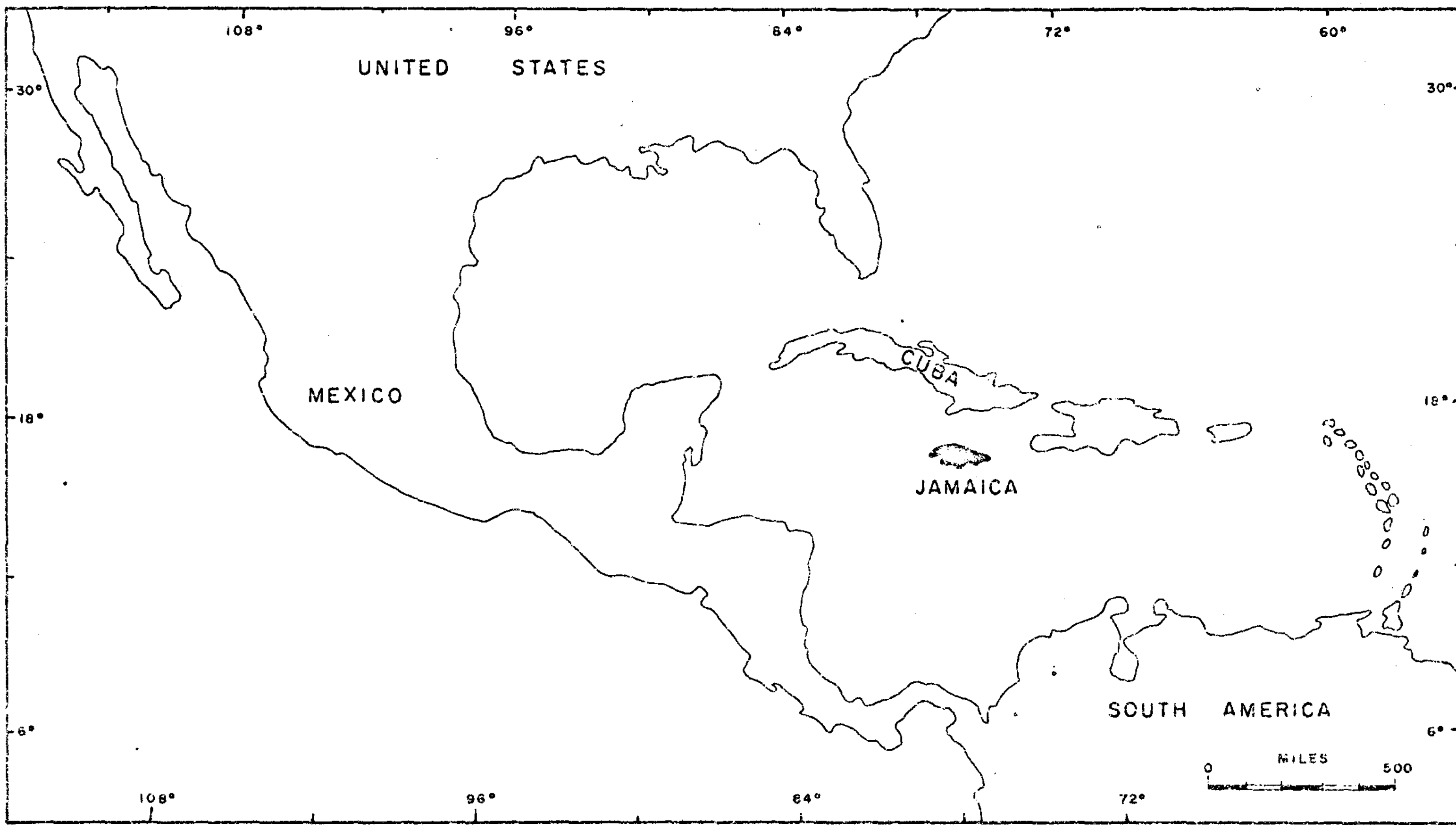

INTRODUCTION.

Most of the theories which have evolved in geography, to explain various human and physical relationships have been formulated on the basis of observations in the developed world. Very little attempt has been made to incorporate into these theories, material from the less developed countries which support over 66% of the world's population. When these 'general theories' are tested in the underdeveloped world and the 'regularities' do not hold, the theory is generally retained and the test case referred to as 'exceptional'. The economists have been more alert to the problem than geographers and have recently stated their desire to have theories relating to the developing world, formulated with the social and economic conditions of the developing world as their foundations.[1]

This study proposes to examine the trend in sugar cane supply among Jamaican cane farmers in the light of present theory. The author has formulated general hypotheses which state that changes in supply of sugar cane are a function of certain economic and physical variables which are selected in the light of the theoretical literature, and from the specific conditions in the sugar industry. The study is designed to identify the reasons for fluctuations in sugar cane supply among

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[1]See for example, (a) Martin, Kurt, and Knapp, John: The Teaching of Development Economics, Frank Cass and Co. Ltd., 1967. (b) Wharton Jr., Clifton R., Subsistence Agriculture and Economic Development. Aldine Publishing Co., (Chicago), 1969.

Jamaican sugar cane farmers and although the importance of theory and methodology are recognised, the author puts greater stress on substantive findings since they will help to clarify much of the ideas about farmers' behavior.

The sugar industry is the oldest agricultural industry in Jamaica and has been studied in various contexts. Most of the studies are, however, at the industry level. Some of these studies are concerned with sugar as a commodity in the economics of the nation's trade (Beckford, 1969). Others examine it at the West Indian regional level where attempts are made to explain past supply and to predict future supply (Abbott, 1964). The present analysis isolates the farmers, as a group in the Jamaican sugar industry, as opposed to the manufacturers, who also operate large 'estates or plantations' as farmers. The statistical method involves applying the multiple regression technique to time series observations. In addition, various social and historical patterns are offered as subjective reasons for changes in supply. Farmers' attitudes and opinions are obtained from the use of a questionnaire.

This study is a continuation of empirical works which attempt to formulate predictive response models in agriculture both at the individual and at the aggregate levels.[2] The need for such models is becoming increasingly urgent as national policy-makers are being forced to find quick answers to problems of national industries. Agricultural

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[2]See, for example, Behrman, J.H., "Supply Response and the modernization of Peasant Agriculture: A Study of Four Major Annual Crops in Thailand", Bateman, M.J.,"Developed Areas", in Wharton (ed.) 1969 op.cit. Also Peter Ady, (1949) "Trends in Cocoa Production", Oxford Univ. Inst. of Stats. Bull., Vol. 2, 1949.

industries are probably the most in need of these models, especially in the case of the developing world because of its great dependence on agriculture.

In Jamaica, the problem of maintaining production in the sugar industry has been of primary importance over the past decade. This stems from the economic importance of sugar in the national economy, as measured in two ways;

(i) As an earner of foreign exchange

(ii) In terms of the number of people employed in the industry.

Table 1 shows the value of sugar and associated products in their relative position as earners of foreign exchange.[3] This table shows that between 1964 and 1968 the contribution of sugar, as represented by the second row, has been between 29.9 and 21.0% of total foreign exchange earned through exports. The significance of foreign exchange to development financing is well known.

TABLE 1

VALUE OF DOMESTIC EXPORTS: 1964-1968 (£:MILLION)[4]

ITEMS	1964	1965	1966	1967	1968
Bauxite and alumina	33.8	35.3	37.7	39.9	44.4
Sugar, rum and molasses	21.8	17.7	18.6	17.6	19.2
Bananas	6.0	6.1	6.3	6.6	7.0
Citrus, coca, pimento ginger and their products	4.8	5.1	5.3	4.6	4.9
Manufactured goods	6.7	7.9	9.0	8.5	10.8
Others	2.5	2.9	3.2	3.2	5.1
TOTAL	75.6	75.0	80.1	80.4	91.4

[3] Economic Survey of Jamaica, (Central Planning Unit), Jamaica 1968, p. 32.

[4] £ 1 = U.S. $2.40 approximately.

Table 2 shows the number of people employed according to industry for March 1965.[5]

TABLE 2

DISTRIBUTION OF WORKERS BY INDUSTRY, MARCH, 1965

Industry	No. of Workers
Agriculture	43,080
Mining	4,047
Manufacturing	37,048
Construction	16,811
Public Utilities	3,735
Commerce	12,720
Transportation	13,356
Services	7,164
TOTAL	137,961

The figures by themselves do not clarify the whole situation since the agricultural workers are grouped together and represent employment only on farms of over 500 acres. It is important to note that, of the 43,080 workers listed in Table 2 as employed in agriculture, 22,981 represent workers employed by sugar estates and engaged in sugar cane growing (p. 39). In addition, there are over 20,000 cane farmers cultivating under 500 acres of land who, in turn, employ a large number of seasonal workers. Sugar production also contributes to the employment potentials of the manufacturing sector since the production of sugar, rum, and molasses is classified as manufacturing processes. Indirectly also, there are a number of ancillary activities, like transportation and shipping, which employ a significant number of people.

The methodology adapted to investigate the problem as outlined

[5]Employment and Earnings in Large Establishments, 1965, p. 22, Dept. of Statistics, Jamaica.

above involves a two stage analysis. One attempts to explain changes in supply of individual farmers over time with certain spatial variables. The other attempts to explain changes in aggregate supply with certain time series observations. The basic consideration being that the aggregate model will succeed in capturing certain dominant features of the industry which may be estimated at the regional scale, but which are impossible to quantify at the level of the individual farm. The aggregate level analysis follows more in line with the type of empirical investigations being carried out in much of the underdeveloped world and is more policy oriented, while the individual level analysis is more behavior oriented[6] and seeks to break new ground.

The question of the demand function does not explicitly enter the research since the real world situation makes it irrelevant. The condition under which sugar cane is produced in Jamaica is one guaranteeing the farmer a market for his total supply. The market structure is such that price does not reflect increase or decrease in demand because, at the national level there are artificial marketing structures and at the international level the Jamaican supply cannot influence the total market.[7]

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[6] Most of the information on farmers' behavior resulted from the questionnaire. The author wishes to express his gratitude to Dr. John Betak of the Department of Geography, for his patience in helping to construct a particularly useful questionnaire.

[7] The 1966 Commission of Enquiry into the Sugar Industry contains summaries of the market structure, pp. 145-150 and also the relationship between the Jamaican supply and the International market.

Chapter one summarizes the state of supply analysis to date. In chapter two, the problem is set within the relevant historical and institutional framework. Chapter three is a discussion of the time period, variables selected, and the study areas. Chapter four describes the formal analysis and attempts an interpretation. The final chapter summarizes the relevant findings in terms of theory and substance and points to lines of further research.

CHAPTER I

THE DEVELOPMENT OF SUPPLY ANALYSIS IN AGRICULTURE

The purpose of this chapter is to examine the development of the theory of supply in agriculture and to discuss the techniques of analysis which have evolved along with the theory. The expectation is that, work which has been undertaken in the field so far, should indicate the best possible approach to, and techniques for analysing farmers' sugar cane supply in Jamaica. In addition, the literature should provide an indication of some of the relevant variables, and the criteria for the selection of others to be used in the analysis. Where the statistical analysis is inadequate, the theory will be expanded to capture relevant factors for the specific situation.

The literature on supply analysis is as varied as it is voluminous. There is a lack of concensus as to the best theoretical base for the prediction of farm production, and indeed, aggregate output over time; a factor which might help to explain the frustration of some apparently sound policies. In addition, there is the observation that, supply models in agriculture have not been as functional as those existing in the industrial field - (Gittinger, 1969). The explanation is that, unlike agriculture, there are few decision makers in the industrial field, and a greater control of the input variables. Secondly, demand is regulated by advertising in industry more than in agriculture.

Any attempt to formulate general principles for the explanation of economic behavior, whether in agriculture or in any other field of economic activity, must first grasp the fundamental importance of all the factors at work and then proceed to isolate those which are considered of immediate relevance. It is only when the relevant variables have been isolated and others held constant that any serious attempt can be made to build meaningful and manageable models.

A. THE THEORIES

Most of the theories on agricultural production employ certain simplifying assumptions, primary among which is the assumed rationality of man's behavior. This rationality causes man to maximize his gains by constantly readjusting and reallocating his resources according to the influence of the market mechanism.

A second and concomitant assumption is that the agricultural industry operates under conditions of perfect competition. Some of these simplifying assumptions may be partly responsible for the low explanatory power of these theories. The theories have emphasized four major aspects of production analysis;

(1) The locational aspects of production, which emphasized the substitution between distance and other input factors.

(2) The technological efficiency of the production function, which became prominent in the neoclassical farm management literature.

(3) Agriculture, as a sector, in the total economy for the purpose of formulating development theory.

(4) Recently, the behavioral side of production has been

considered.

(1) Location Theory

The first attempt at formalizing agricultural production theory started with the location theorists. They were concerned with where various crops would be produced and the level of intensity of production. Von Thunen and Ricardo are the pioneers in this field and both authors attempted to explain variations in land use in terms of economic rent. Ricardo's analysis[1] tried to explain land use in terms of the variations in land quality. Von Thunen's model[2] (1826), is basically descriptive rather than normative, and tried to explain agricultural land use in terms of the variation in one input variable, transportation cost.

Von Thunen considered variations to the basic model such as crop combinations, the existence of multiple markets, differences in land fertility and transportation facilities. The normative basis of his model is the application of marginal economics to the substitution of costs over distance. The limitation to wide real-world applicability of his model is due to some 'built in' assumptions, foremost among which is the rational 'economic' behavior of individuals.

The model is a partial equilibrium one which is not concerned with the dynamic time factor. The proposition is made here that it is

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[1] Ricardo, D., The Principles of Political Economy and Taxation, London, 1917, Everyman (ed.): Dent & Sons Ltd., 1911. For a summary of Ricardo's contribution, see Chisholm, M., Rural Settlement and Land Use; Hutchinson University Library, London, 1962. He also provides a bibliography of references to Von Thunen in English.

[2] For a complete description of the Von Thunen model, see for example, Chisholm, M., Rural Settlement and Land Use, London, Hutchinson, 1962.

not conceivable that changes in transportation cost, prices, demand, and technology will lead to an automatic adjustment in the land use system.

Further development in agricultural location theory may be found in works by Brinkmann[3], Lösch[4], Dunn[5], Isard[6], Alonso[7]. Dunn's work has some relevance to the present research in that;

(a) He made some attempt to show the influence of the time factor.

(b) He showed the interrelationship among economic elements in the production system at the aggregate level.

(c) Both he and Isard deal with the underlying assumption, which is at the basis of the industry level analysis, i.e., that the production function is linear and homogeneous. As such, average costs and yields are constant over space. This particular distinction is important, as it forms the basis of aggregate analysis of any economic sector.

Although Dunn went much further than Von Thunen,he did not effect the transition to a dynamic model. Garrison (1959)[8] criticised Dunn's work in that it:

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[3]Brinkmann, T., Economics of Farm Business, (English translation), Berkley, 1935.

[4]Lösch, A., Economics of Location, Yale University Press, New Haven, C. Friedrich translation, 1954.

[5]Dunn, E., The Location of Agricultural Production, University of Florida Press, Gainesville, 1954.

[6]Isard, W., Location and the Space Economy, M.I.T. Press, Wiley & Sons, New York, 1956.

[7]Alonso, W., Location and Land Use, Cambridge Massachussetts, Harvard University Press, 1964.

[8]Garrison, W., "The Spatial Structure of the Economy", AAAG., Vol. 49, 1959.

> "...does not extend very far beyond an analysis of static equilibrium at the industry level. Discussions at the level of the firm and the discussion of dynamic factors are cursory although provocative in places".

The whole theory of location in agriculture serves to point to some of the general considerations in any supply analysis, no less so, to the study at hand. The theory makes specific reference to the fact that there are productive resources, producers, and consumers as depicted by a consuming centre. Some of the fixed resources which it suggests considering are land quality and climate.

(2) Farm Management Research

Farm management research is concerned with the efficiency of allocation of input for production either at the firm or at the industry (aggregate) level. The early studies were basically concerned with the biological inputs such as fertilizer, land and water.[9] Later the technological production function proved capable of extremely accurate predictions of yields obtained on experimental farm plots. Heady and his associates in Iowa are responsible for most of the refinements of the biological or technological production function over the past decade.[10] It often happens in the real world, however, that the purely technological function does not perform according to theory. The logical step in farm

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[9]Spillman, W.J., "Application of the law of diminishing returns to some fertilizer feed data", Jour. Farm Econ., 5, pp. 36-52.

[10]See for example the comprehensive work by Heady, Earl O. and Dillon, John L., Agricultural Production Functions, Iowa State University Press, Ames, Iowa, 1964.

management research was therefore, to incorporate certain non-physical inputs such as price of product, net profits, and availability of labour. As a result, additional theoretical approaches have been incorporated into the literature. These approaches have attempted to overcome the criticism made by Nerlove and Backman, (1960), that previous farm management research, employing the technological production function, concentrates upon what changes the producers should make instead of what changes they actually make in light of empirical testing and modifications of theories of producer behavior.

Mellor (1967),[11] emphasises the point that physical and environmental factors vary from place to place. There are varying reactions among producers to price and the use of resource inputs. In addition, the farmers' subjective view on acceptable levels of output is independent of theory. What the farmer sees before him is a set of utility surfaces and his reaction to various institutional policies on prices, technical change, exhortation, supply of consumer goods, land distribution, and so on, depends on how the farmer defines his subjective equilibrium, e.i., when he realizes the maximization of his utility subject to his income equation.[12] As a result, farmers may act differently although they face the same utility surface. Secondly, the utility surface may change with

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[11] Mellor, John W., "Toward a theory of Agricultural Development" in Southworth, H.M., and Johnston, Bruce (eds.), Agricultural Development and Economic Growth, Cornell University Press, 1967.

[12] Nakajima (1969) develops a full discussion of these concepts under various assumptions. See Nakajima, Chihiro, "Subsistence and Commercial Family Farms: Some Theoretical Models of Subjective equilibrium", in Wharton, Clifton Jr. (ed.) op.cit.

time, causing responses to prices and technological change which are much different from the postulated behavior.

One set of postulates which emerge from the foregoing discussion concerns the farmer operating near the subsistence level. If he is marginally endowed with land, he tends to apply labour to the point of zero marginal productivity to earn a subjectively defined equilibrium income. If the price of the product rises, labour may be withdrawn and more leisure consumed because it takes less product to enjoy the previously defined income. The result is that the "income effect" aborts the realization of the postulated elasticity of supply. On the other hand, a rise in price may increase the marginal value productivity of labour causing the farmer to increase the application of labour. This "substitution effect" would necessarily lead to a positive price elasticity of supply. The substitution effect may be frustrated if the farmer is well endowed with material resources to the extent that he values the marginal product of his labour above the returns possible from a small price increase. Finally, the relative prices of competing products affect the level of output of any single commodity since they act both on the farmer in his freedom to substitute profitable crops, and labour in its ability to move from the production of one crop to the other.

We cannot say, for sure, whether an increase in price will increase or decrease labour input and thus output. Even where land inputs increase, it is not certain that other inputs will increase sufficiently to maintain the intensity of use on the previously utilized land.

The case of part time farmers is very pertinent to this discussion. Professor Nakajima (1969), explains that when, as in Japan, a majority of farms are part-time farms, peasants may use labour-saving mechanization to increase their leisure even to the point of reducing farm income (presumably because non-farm income can be increased, with a part of the labour saved, by more than the decrease in farm income). It is clear then, that a thorough understanding of the farmers' decision-making process is essential to an understanding of supply over time.

(3) Decision-Making Models

The decision-making models evolved out of the discrepancy between the hypothetical output and actual output both in agriculture and industry. The decision-making models, therefore, assume that the farmer is making a 'rational'decision in the face of risk and uncertainty. He is uncertain about such factors as prices, yields, rainfall, and natural disasters.

Game theory has been applied to the solutions of problems involving risks and uncertainty. The literature on its application to problems is complete and will, therefore, not be discussed here.[13] The problem is to discover the best solution to a complex decisional calculus using a set of criteria such as the selection of an alternative which maximises the minimum profits.

Clearly, the theory is based on normative assumptions. For example, it assumes that the farmer has sufficient information to establish bounds for the criteria. This is at conflict with theories of behavior and information for decision-making.

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[13] von Neumann, J., and Morgenstern, O., Theory of Games and Economic Behavior, Princeton: Princeton University Press, 1944. With specific reference to geography, there are the works by Wolpert, J., "The Decision Process in Spatial Context", AAAG., Vol. 54, 1964, pp. 537-58 and Gould, P., "Man against His Environment: A Game Theoretical Framework", AAAG., 53, 1963.

(4) Behavior, information and decision

The concept of optimal production has been tossed about in the literature to define what actual production ought to be under certain conditions of rational economic behavior of the individual. Some authors[14] conclude that the departure from optimal behavior represents suboptimal behavior, since the decisional process requires a simplification of reality and, therefore, it shows that man seeks that solution which is only 'good enough'.[15] Simons has further indicated that the producer is really acting as a 'local optimizer' within 'bounded rationality' as a substitute for the supposedly omniscient rationality of 'economic man'.

Some of the assumptions involving risks and uncertainty have been examined theoretically in Hildreth (1957), Marshack (1950) and Von Newmann and Morgenstein (1953) and empirially in Farrar (1962) and Freund (1956).[16] They hypothesize that the farmer's choice is based

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[14]For example, Wolpert, J., op.cit.

[15]Simon, H.A., Models of Man, New York: Wiley 1957.

[16]Risk has been taken into account by Dasgupta (1966) and Freund (1956) who attempted a utility function after Markowitz (1952). Markowitz proposed that the utility function for income 'X' may be defined as:-

$$U(X) = X - 0^2_X A$$

where, X = mean

0^2_X = variance of X

A = a risk aversion coefficient.

The difficulty with the function is that it requires a quadratic programme which is not as handy as a linear programme and data are required which are not generally available at the farm level. See also McInerney (1967).

on the maximization of gains. Although the latter work is similar to some other theoretical work, which propose profit maximization as the basic economic motivation, there is the further proviso, that the choice is made only when the possibility of ruin is so small that it can be neglected. Their assumption implies the lexicographic order of preference.[17] Such a criterion means that people concentrate primarily on gains.

This concept of profit motivation is a key concept to the study which is being undertaken. In the empirical study carried out by Charnes, Cooper, and Thompson (1959), using the "focus of loss" constraint, there is a close approximation between actual crop pattern in Province (France) and that depicted by the model. One of their basic parameters is income, which is calculated using yields and prices. This method of calculating income or revenue is employed in determining profits in the present study. A further view of the concept of loss was made by Abbott, (1964), in the West Indies. He made the hypothesis that cane farmers will take land out of sugar cane only after a series of continual losses.

B. TECHNIQUES OF ANALYSIS

The basic techniques which are employed in the analysis of agricultural supply are linear programming, recursive programming, producer panels, and regression analysis. Closely related to these techniques are time series studies, which may be either included as a technique or as a method of observing economic behavior.

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[17]See e.g., Encarnacion, J., "On Independence Postulates Concerning Choices", paper presented at the First World Congress of the Econometric Society in Rome, September 1965.

Time series analysis is first discussed since it forms the basis of much of the later discussion. Most of the early studies, using time series data, attempted to predict aggregate output as a function of capital and labour. The Cobb-Douglas function, developed in 1928, was to become the most popular function for explaining time observations up to the middle of the twentieth century, and may be found in such works as Cobb and Douglas (1928), Menderhausen (1938), Bronfenbrenner (1944), Lomax (1949), and Tintner (1952).[18] The Cobb-Douglas function utilized 't' as an independent variable instead of the error term and is different from the pure time series technique which uses time units 1, 2, 3, ... for fitting a smooth function. The data are usually detrended to eliminate marked fluctuations. It is the residuals from this smooth function which are subsequently explained by means of observed independent variables. Bateman, (1969), objects to the use of a pure time series analysis, saying that it conveys very little information since most of the explanatory power of the equation is in the trend term.[19]

A more direct method of looking at time series observations has come out of the more recent literature. It involves collection of time series data and using one set of time series observations to explain the other. In such a case, the time unit becomes the sample point. The technique of analysis is usually some sort of programming or regression

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[18] See Bibliographic reference.

[19] Bateman, Merrill, "Supply Relations for Perennial Crops in Less Developed Areas", in Wharton, Clifton (ed.), op.cit., p. 246.

analysis. It must be made plain here, however, that these techniques are also used in cross-sectional analysis.

(1) Linear Programming

This technique defines a set of technical coefficients, which, in some cases, are the simple average resources in the area being studied. The model is then used to estimate total output under optimum conditions for the sample area. This means that there are resource constraints depending on the characteristics of the study area. However, the producers are expected to behave in an optimizing way. Wolpert (1964)[20] used this technique to estimate production among Swedish farmers. He noted that the actual production did not conform to the estimated production and concluded that Swedish farmers were not acting as 'optimizers'.

The main criticism against linear programming is that it is very sensitive to the choice of the basic technical coefficients and the bounds of constraint. As such it does not give a close approximation to reality.[21]

(2) Recursive Programming

The recursive programming technique is designed to set up a dynamic supply model. Recursive programming has been tested by Day (1962), Schaller (1968), Schaller and Dean (1965), and Sharples and Schaller (1968). This technique utilizes a combination of response data from individual farms and aggregates generated by time series. The usual linear programming

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[20]Wolpert, J., op.cit.

[21]Banssard and Petit (1967) referred to the problem they had estimating response among French vegetable producers to changes in the price of irrigation water using linear programming technique. They found that it was impossible to neglect the farmers' response to extreme price uncertainties.

restrictions are augmented by the addition of "flexibility constraints" and "maximum potential growth".

The 1968 study by Schaller was designed to provide "short term quantitative estimates of production and resource adjustments under alternative prices, costs, technologies, resource supplies, and government programes".[22] This model was to be complementary to existing models with two specific characteristics;

(1) The model should be aggregative in nature but should retain aspects of micro studies, within limits set by cost, time, and manageability.

(2) The model should incorporate technological attributes to give it more predictive powers than the usual linear programming models. The model adapted was the cobweb type,[23] as expressed by the equations;

1. $Q_t = f(P_{t-1})$

2. $P_t = f(Q_t)$

where, Q = quantity

P = price

t = present time

t-1 = one time unit ago.

The observation was made that the cobweb principle almost always involved the use of regression of aggregate time series data on prices

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[22] Schaller, W.N., "A National Model of Agricultural Production Response", Agricultural Econ. Res., Vol. 20, #2, 1968.

[23] On Cobweb Models, see, e.g., Waugh, Frederick, "Cobweb Models", Jour. Fm. Econ., Vol. 46, #4, 1964.

and production. The national model, however, involves the use of recursive programming to estimate production.

In the analysis, each year is treated by the farmer as a different decision problem since he formulates his expectations largely on the basis of recent experience. The recursive national model differs from the traditional optimizing models since it assumes that farmers want to make as much money as possible, within realistic limits.

The technique involves the addition of flexibility restraints on the year to year change in aggregate acreage of each production alternative specified in the model. The upper and lower bounds are given as:

(i) Upper bound: $X_{jt} \leq (1 + \bar{B}_j)\, X_{j,\, t-1}$

(ii) Lower bound: $X_{jt} \geq (1 - \underline{B}_j)\, X_{j,\, t-1}$

where, X_{jt} refers to the total solution acreage of crop j for year t; $X_{j,\, t-1}$ is the acutal acreage in year t-1. $\bar{B}_j$ and $\underline{B}_j$ are the maximum allowable increases and decreases respectively from acreages in the preceding year. These are estimated by regression on time series observations.

The use of the model is specified for three different time periods, viz; the short-run, the intermediate-run, and the longer-run analysis.

The results of the test of the model showed better estimates in the aggregate than for individual producing areas. Unlike regression, there are no statistical tests for measuring the reliability of the programming estimates. There are no real reasons for assuming that the base year acreage is an equilibrium acrease. In addition, the flexibility restraints for very profitable crops tend to be too flexible and, therefore, lead to over estimation of those crops.

The cobweb type model seems ideal for crop response analysis for the following reasons;

(i) It works in a situation of perfect competition.

(ii) There is usually a time lag in production response.

(iii) Any single part of the national aggregate may be analysed as an independent unit.

The study outlined above is described to show how those aspects, which are used in the current research, have been operationalized. These aspects include;

(a) The time factor.

(b) The cobweb principle.

(c) The physical resource situations.

(d) The advantages of aggregation.

(e) The utility and disutility of the analytical tool.

(3) The Regression Technique

The regression technique is used to estimate total output (in the context of farm supply). It may be used either in the case of cross-sectional analysis or in time series studies. Its relevance to the present study is best outlined by showing its advantages in a recent study employing linear programming, recursive programming and a regression model in estimating short-term (1-5 year) changes in an area's milk production.[24]

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[24] Zepp and McAlexander, "Predicting Aggregate Milk Production: An Empirical Study", Am. Jour. of Agr. Econ., Vol. 51, 1969.

Prices and technical coefficients were taken as simple averages in the area. Resources on sample farms during 1960 and prices and production technology representing 1965 were used in deriving linear programming estimates of 1965 milk production.

The resource restraints in the linear programming model were cropland, pastureland, silo capacity, family and regular hired labour, expansion capital, bedding materials and housing capacity for dairy, beef, hogs, and laying hens. Allowance was made in the model for adjustment in some "fixed resources".

In the recursive model, a series of 5 area-milk output estimates were developed for 1961 through 1965. Fixed resources for a particular year were defined as those resources employed during the previous year; the initial resource situation being the same as that used in the linear programming model. The 'flexibility constraints' were used to represent the forces causing lags in resource adjustments such as farmers' inertia to profitable changes due to risk and uncertainty or to personal preferences.

The regression estimates of milk production for 1961 through 1965 were based on time series data originating in 1950. The regression model used is of the order;

(1) $Y_o t = y_1, t \cdot y_2, t$

(2) $\Delta Y_{1,} t = a_1 + b_1 x_1, t + b_2 x_2, t + e_1, t$

(3) $\Delta Y_2, t = a_2 + b_3 \Delta Y_{1,} t + e_2 t$

where,

Y_o, t = area milk output in year 't'

y_1, t = no. of cows milked in area during year 't'

$\Delta y_1,t$ = $Y_1,t + 1 - Y_1,t$

y_2,t = average milk production per cow in study area during year 't'

$\Delta y_2,t$ = $y_2,t + 1 - y_2,t$

X_1,t = hourly return from farming to operator and family labour in year 't' divided by the industrial production workers' weekly payroll index for year 't'

X_2,t = Average milk price received by the farmer in the Philadelphia milk marketing area during the previous two year, $X_2,t = (P_t + P_{t-1})/2$

a_i = vertical axis intercept

b_i = slope coefficient

e_i,t = random error term.

The results

As with the Schaller-Dean[25] experience, it was found that the regression model tends to give better predictive results than the programming models. The recursive programmes seem to give the poorest results since they tend to underpredict low values and overpredict in the high ranges. The big drawback of the programming models is their normative nature based on the principle of optimization. It is well known that in the aggregate, farmers act nowhere near the optimum. It is also found that the regression model has added attraction because of its simplicity, whereby, no attempt is made to force a fit either through transformation or forced variables. This is particularly important insofar as the resultant model leads to a better fit to the aggregate data.

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[25] Schaller, W.N., and Dean, G.W., "Predicting Regional Crop Production, An application of Recursive Programming", U.S.D.A. Tech. Bull 1329, 1965.

The use of the regression technique, in the case above, and its performance as an empirical tool in analysing time series observations, are the main criteria for its adaption to the particular research at hand. Further justification for its use should be based on the result it achieves.[26]

(4) Producer Panels

This technique resulted from the failure of the technique above to perform adequately at the level of the individual producer. Producers are requested to make periodic reports on production, and the factors at work in their decision over time. It is essentially related to current decisions since the farmer is unlikely to remember factors which were instrumental in his decision-making after a long period of time. An attempt is made to incorporate this technique into the present analysis to explain individual decision-making. It is expected that the technique will contribute, even marginally, to the understanding of supply among cane farmers in Jamaica.

In summary, it is clear that agricultural supply theory and the techniuqes of analysis have progressed a long way. The theoretical basis of the present study has been outlined and, therefore, the results of the empirical analysis will have some implications for the theory.

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[26]Much of the work in the underdeveloped countries employs the regression technique on time series data. Examples of such studies are: (a) Bauer, P.T., West African Trade (Cambridge: Cambridge University Press, 1954). (b) Ady, Peter, "Trends in Cocoa Production", Oxford University Inst. of Stats. Bull., Vol. 2 (1949), pp. 389-404.

CHAPTER II

THE DEVELOPMENT AND ORGANIZATION OF THE JAMAICAN SUGAR INDUSTRY

This chapter is intended to provide a background or frame of reference for the reader to understand the development and structure of the industry in which the present analysis is being carried out. More specific references will be made to actual conditions in the various sample areas, which, being a part of the national whole, will, no doubt, contain some pardonable repetitions.

Since this chapter is concerned mostly with the historical development of the industry and a description of certain organizational features, it naturally will contain information, over and above what can adequately be incorporated into a statistical analysis. The reader will, no doubt, be able to draw some conclusions which the author himself might have overlooked. It is also hoped that the variables used in the analysis will have more relevance for the reader in the light of this background.

One of the major drawbacks to any study of this type is that it is impossible to isolate and study one aspect, and at the same time, be expected to provide answers for questions on all aspects. As such, some statements will naturally be made for which the author, in honesty, will have no ready interpretation.

The development of the integrated sugar industry in Jamaica, resulted from the foundations laid by European colonial occupation. This historical past may be a useful guide to the interpretation of some of the social and economic patterns and relationships existing, not only in the sugar industry, but also in other areas. Hall (1962), points out some of the relationships which have evolved from the historical process.

The beginning of the British sugar economy in the late 17th Century was based on Negro slave labour, and the 'trapiche' mille. In this phase, each family-owned farm had a mill because of the small primitive operations. There was no centralized system of production at that time. In the 19th Century, the characteristic feature was the 'ingenio'; a water and later a steam-powered mill found on large plantations.

Sugar assumed a state of prominence in the West Indies in the latter half of the 17th Century because of the following reasons.

(1) Cotton required more land per farm than cane for competitive production.

(2) Tobacco was, by then,out of the question since the whole Caribbean area had already been replaced by Virginia and Maryland as the tobacco-growing regions.

(3) Other possible cash crops, such as indigo and ginger, had very limited markets.

(4) Physical conditions, (some of which are described below), favoured sugar production.

(5) The expanding European market for sugar provided an added incentive.

1. The Physical Conditions

The description will be first of the ideal and then of the Jamaican situation. The two physical factors which favour sugar production are (a) favorable climate and

(b) good land.

The ideal climate for sugar cane production would consist of:[1]

(a) About 66 inches of rainfall per annum, distributed sinusoidally with time around a mean of 5½" per month, and amplitude of two inches, with a maximum in July and August.

(b) As little cloud cover as possible so that the crop directly intercepts the maximum of incoming radiation.

In addition to the growth factors, sucrose content would be greatly increased if there is cool dry weather when the cane is about ten months old.

The ideal land condition is terrain which is flat to undulating, with heavy water-retentive loams. In the Jamaican context, and in relationship to the analysis, it is found that there is some departure from the ideal situation. In the case of rainfall, the north and central valleys average over 60" annually but the southern areas and northwest coasts average between 30 and 40 inches. (Map 2). In these areas, irrigation has to be employed to supplement natural precipitation. In addition, the rainfall is distributed so that there are two marked wet and dry seasons. Because of the distribution of cultivation and harvesting

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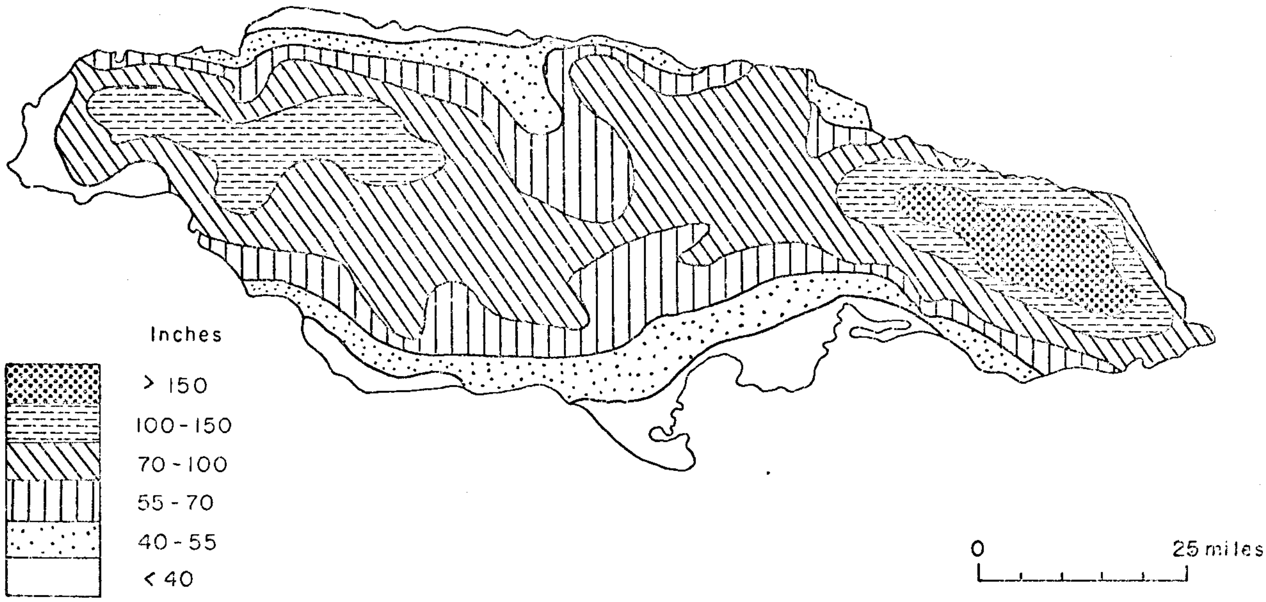
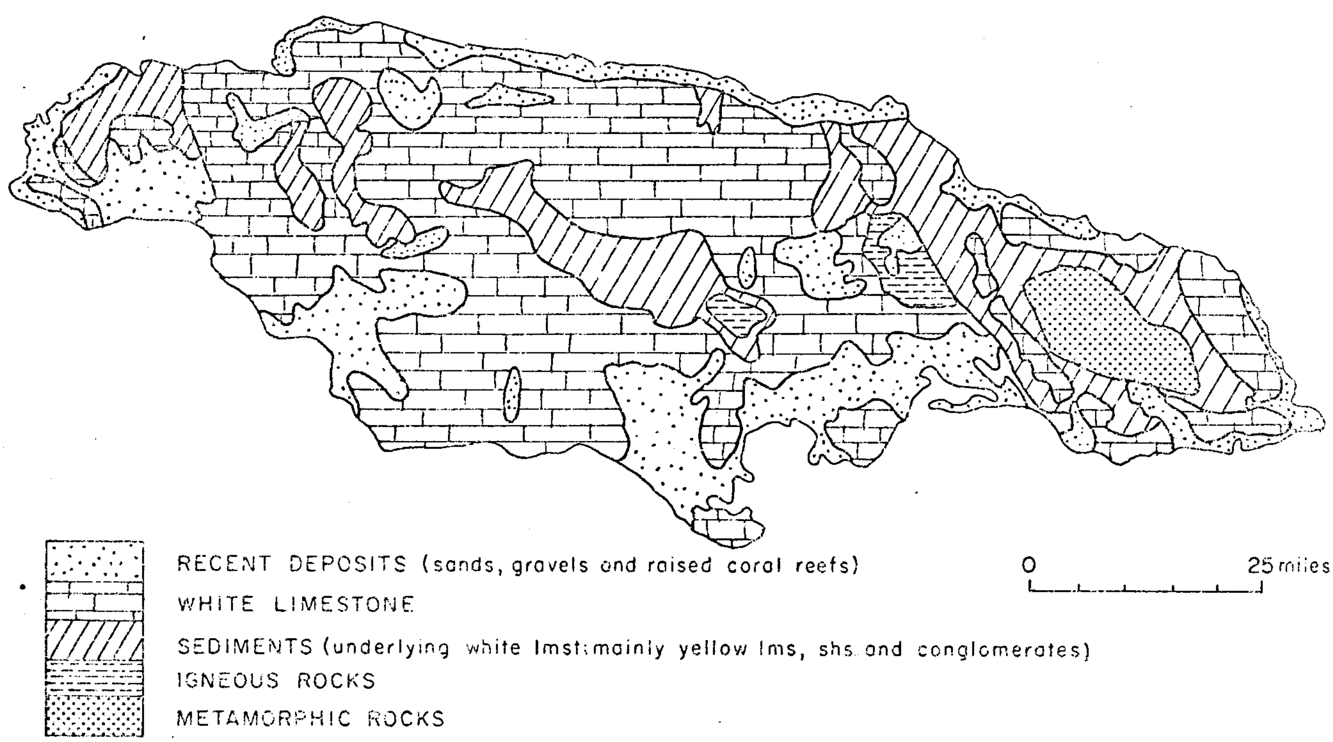
[1]This summary is contained in a personal communication from the Sugar Research Dept. of the Sugar Manufacturers Association, Jamaica, dated June 1, 1970.

JAMAICA : RAINFALL   Map 2



SOURCE: Modified from West, R.C. and Augelli, J.P., Middle America, Its Lands and Peoples, Prentice Hall, N.J., 1966, p. 167.

JAMAICA : GEOLOGY   Map 3



SOURCE: MacPherson, J., Caribbean Lands, Longmans, London, 1963, p. 34.

activities, it is difficult to determine the exact proportion of farmers who need rainfall at a certain time and those who need dry conditions at that time.

The cloud cover conditions have never been explicitly considered by Jamaican producers, and so there are no records of that item.

The land conditions described above, are present on the plains and interior valleys.[2] Many peasant farmers, however, produce on lands which do not meet these requirements. In the next chapter, it is pointed out that producers on inferior land make only a small contribution to total cane supply.

Because of the favourable physical and economic conditions described above, Jamaica became one of the leading sugar producing colonial territories, relying almost exclusively on slave labour.

A. The Colonial Period

The colonial plantations, as is the case with plantations today, were best operated on a large scale system. Therefore, throughout the 1700's small holdings steadily disappeared. The successful capitalistic grower, purchased his less favourably placed neighbours' estates. Such aggrandisements were particularly numerous in times of distress and war when increased expenses of production made the small owner's position untendable.[3] By the 1800's the average sugar planter in Jamaica, operated around 900 acres, while a few estates reached 5000 acres.

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[2]See Maps 3 and 4 for a representation of the geology and gross physical feature of the island.

[3]Ragatz; Joseph Lowell, The Fall of the Planter Class in the British Caribbean 1763-1833; A Study in Social and Economic History; Ox. Univ. Press 1963, p. 37.

The typical estate was, however, devoted to a wide variety of land uses, as shown by the example in Table 3 below.

TABLE 3

LAND USE ON TWO ESTATES,

PARISH OF ST. ANDREW, JAMAICA (1753).[4]

Total Acres	Cane	Coffee & Other Cash Crops	Food Crops	Animal Pens & Pastures	Woodland & Other
2000	190	0	200	500	1100
600	100	0	10	240	250

It is obvious that only a small portion of the land was actually used for sugar cane. Most of the land was used for food crops, pasture and woodlands, or actually wasted. The pasture was necessary because of the number of draft and riding animals. Food crops were grown by the slaves on individual plots, both for house consumption and for sale at the Sunday markets.

In 1791, Jamaica had 767 sugar plantations and 1047 grazing farms, which supplied most of the cattle and other animals needed by the sugar planters. The major cane producing areas are similar to those of today, being concentrated on the coastal fringes and a few accessible interior valleys, like those of the Rio Minho and St. Thomas in the Vale.

[4]Adapted from Pitman, F.W., The Settlement and Financing of British West Indian Plantations in the 18th Century. Essays in Colonial History, (New Haven, Yale Univ. Press 1931), p. 264.

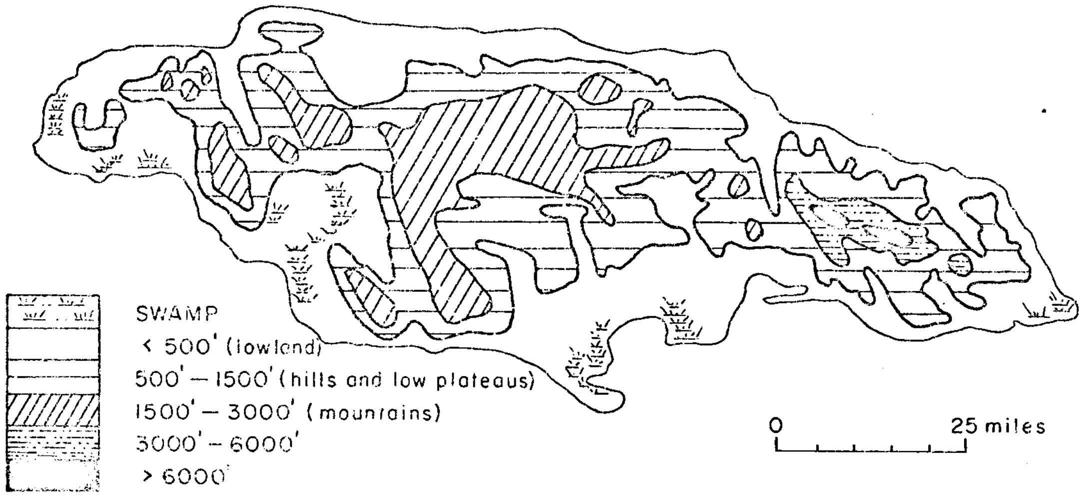
The tasks of land preparation, planting, weeding, thrashing, and harvesting were similar to those of today, although some of the tools were different. Parts of the economic structure of the colonial plantation system may be compared to certain aspects of the present structure. Internationally, mercantilism, which formed the basis of their economic behavior, provided the basis of the artifically created wealth of the planter class. By this trade arrangement, the imperial country monopolized the colony's trade in return for protecting the planter in the home market. The protection gave the planter no incentive to increase his efficiency in production. At times, both parties would agree to restrict output to maintain prices.

In the present trading agreements, most of the sugar is still sold on a protected market under the United Kingdom preference arrangement. However, unlike the old system there are now strong reasons for increased efficiency. The main reason is that costs have been rising to such an extent,that only efficient production can guarantee profit. In addition, there is the desire to take advantage of the United States quota, which is possible only after the U.K. quota has been filled.

The plantation was usually run on credit, which the planter obtained from a merchant agent, who was generally entitled to the plantation's production. Such easy credit worked as long as the home market remained protected and prices continued to be high.

The main source of the inefficiency of the sugar plantations was the management system. The planter, himself, was usually an absentee, visiting the plantation only occasionally. The whole business was left to a resident attorney, who only exercised scant supervision. Most of

JAMAICA : GROSS RELIEF — Map 4

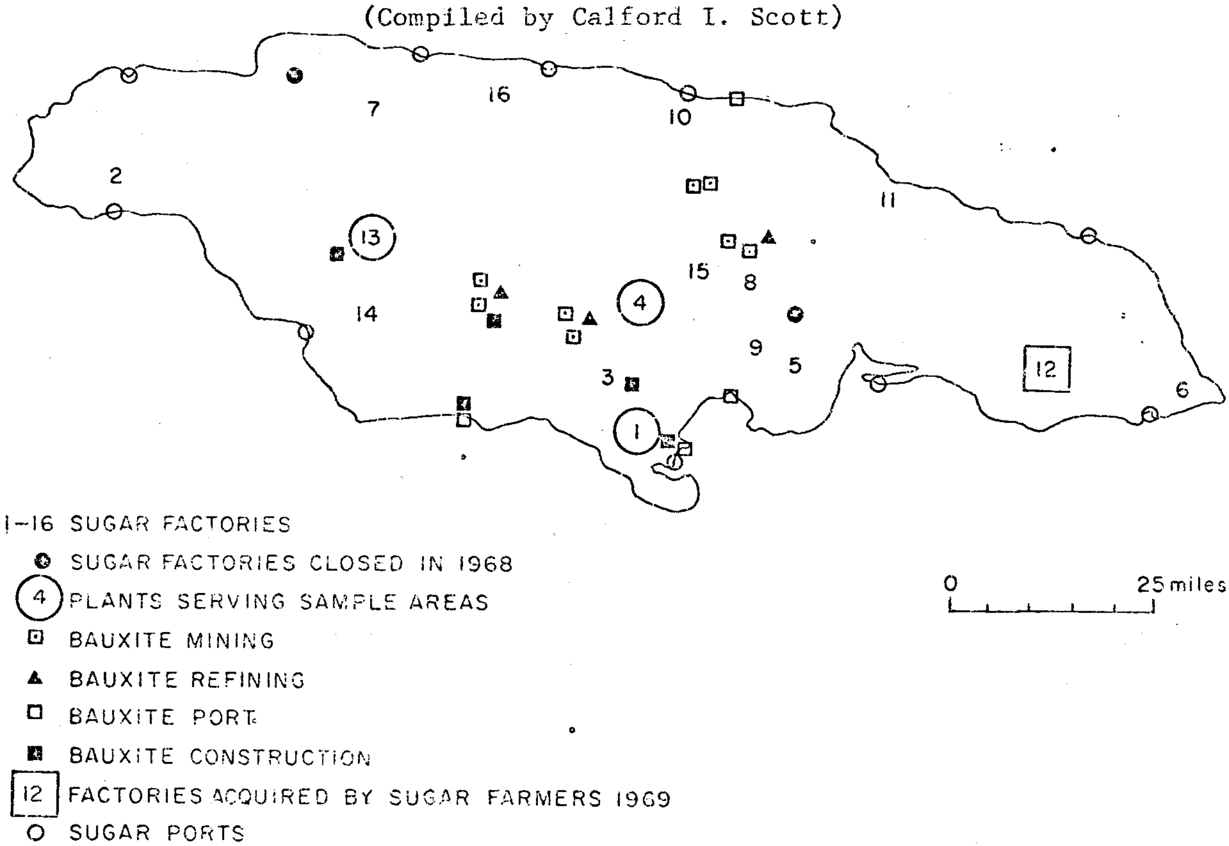


SOURCE: Modified from West and Augelli, op. cit., p. 166.

Map 5

DISTRIBUTION OF SUGAR FACTORIES AND SOME COMPETING ACTIVITIES (1969)

(Compiled by Calford I. Scott)



the work was done by a local overseer-bookkeeper who knew very little about sugar production.

In terms of trade, the West Indies plantation system monopolized the British maritime business throughout the eighteenth and early nineteenth centuries. Because of their lack of self-sufficiency, the planters were forced to import most of the basic requirements such as (a) slave labour, (b) food, (c) construction material, which was mainly lumber, and (d) manufactured goods, like clothing, tools, and luxury items. Jamaica is said to have imported about 800,000 slaves between 1690 and 1820. This was necessary because the slave population could not replenish itself, so importation had to be constant. One of the main staples imported for the slave population was codfish from New England and Newfoundland. This is still a staple in the Jamaican diet today.

B. The Decline of the Colonial Plantation System

The fall of the colonial plantation system in Jamaica was due to some external and some internal factors. Among the external ones are:

(a) The abolition of the slave trade in 1807 and the final emancipation in British territories in 1834.

(b) Growing competition from other sugar producing territories, like the Spanish colonies.

(c) The advent on the European market of beet sugar, which became established during the Napoleonic war.

(d) The loss of monopoly in the British market after 1846.

(e) The independence of the American colonies in 1783, with the consequent suspension of full trade, resulting in increasing cost of food and lumber to the British colonies.

(f) New industrial and marketing arrangements and techniques.

(g) Destruction caused by the numerous wars in the Caribbean.

Among the internal factors are:

(a) High rate of absenteeism and inefficient administration.

(b) Extensive indebtedness.

(c) The inefficient use of both good and marginal land.

(d) Numerous slave uprisings and disertions, which together with emancipation, caused an unusual labour shortage.

The fall of the plantation economy had severe respercussions on the Jamaican economy and also on the future relationship between people and sugar production; meaning that there was restructuring and abandonment of some large plantations, and a new method of obtaining and using labour on the land.

One of the effects of emancipation was a fervour of independence and assertion of the right to refuse work on the sugar estates. The freed slaves, therefore, abandoned the estates until there was such a shortage of labour, that importation of workers from the Orient was initiated. Jamaica imported 33,533 labourers from India between 1845 and 1917.[5] In addition, there were importations of Chinese, Germans, Scots, Irish, and Maltese. Some of the present labour shortages may be related to this historical situation. Jamaica became independent in 1962, and to some people this is analogous to emancipation. With the advance of the '60's, work in cane fields has been interpreted more and more as slave labour, to which the people are reacting. Unlike the

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[5]Deerr, N., The History of Sugar, (London, Chapman and Hall Ltd., 1949), p. 398.

nineteenth century one does not find Chinese, Germans, Scots, Irish, and Maltese in a Jamaican sugar cane field. In addition, it is not conceivable that labour could be imported, given the wage structure and the socio-political situation.

C. The Emergence of the Modern Sugar Industry

Many of the present day features of the sugar industry originated immediately after emancipation. The system of migratory negro labour and the residence of large numbers of Indian workers on, or in the vicinity of the plantation, are only two such examples.

The resurgence of the sugar industry was due to a reorganization and a rational commercial production of modern plantations, which took place in the late 19th Century and early 20th Century. Even so, the record 100,000 tons of sugar produced in the island in the early 19th Century was not surpassed until the 1930's,[6] showing the slow rate of recovery.

The modern estates[7] are organized as corporations, with large land holdings to guarantee adequate cane supply to the factories. As a results, the number of factories has declined with consequent increase in their capacity. (See Table 4 below).

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[6]West, R.C. and Augelli, J.P., Middle America, Its Lands and Peoples, Prentice-Hall, Inc., N.J. 1966.

[7]The term estate is used to mean the large sugar operations run by the owners of the sugar factories. These estates are really modern day plantations. A full discussion on their economic organization may be found in Beckford (1969). Any producer who does not own a factory is registered as a cane farmer.

TABLE 4

DECLINE IN NUMBER OF SUGAR FACTORIES (1832-1969)[8]

Year	1832	1852	1896	1966	1969
No. of Factories	670	427	134	18	16

The cane farmer, as a force in the sugar industry, was of little significance in the early twentieth century. It was stated earlier that the freed slaves migrated from the estates to the interior, where they cultivated food crops and reared domestic animals, mainly for house consumption, although there was usually a surplus to be taken to the local market.

The peasant farmer, however, soon began to cultivate some sugar cane which he sold to the plantation owners. Some of the plantations which had ceased manufacturing also became farmers as opposed to manufacturers. In addition, there was gradual land aquisition by some land owners, so that a system of large and small farmers exists in the sugar economy. Farmers' total cane supply reached 25% of total production in Jamaica in 1950.[9] This represented the advent of the cane farmers as a factor in the Jamaican sugar industry. Their percentage contribution

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[8]Figures up to 1966 taken from The Report of the Sugar Industry Enquiry Commission, Jamaica 1967. 1969 data found during field work. Map 5 shows the distribution of factories in operation now along with some competing economic activities.

[9]Abbott, G. C., "The West Indian Sugar Industry with some long term projections of Supply", Social and Economic Studies, Vol. 13, #1, 1964.

then grew to the extent that, in the sixties, their production has ranged from 45% - 53% of the total for the island. In fact, to a large extent, the fortunes of the total industry now depend on farmers' supply. This is borne out by the findings of the 1966 Commission of enquiry into the sugar industry. They found that the estate production was very stable, and concluded that, "...... major crop increases must be sought mainly from the cane farmers, which have the greatest scope for increased productivity".[10] In addition, the bottleneck situation stems from farmers' variability in supply to the manufacturer, who has to plan his manufacturing schedule with a fair estimate of crop intake. In fact, it is well known that the typical manufacturer cultivates, at least, the minimum amount of cane which will guarantee a "break even" factory throughput, otherwise he would be too vulnerable to fluctuations in the farmers' cane supply (Beckford 1969). But with increasing manufacturing cost, manufacturers wish to operate as near as possible to full capacity, a condition which is impossible without increased supply from the farmers.

D. The Present Organization of the Sugar Industry

The present sugar industry is organized as a complex relationship between several internal bodies (Chart 1) and between national and foreign markets.

The internal structure is the product of an evolutionary process, which has taken place over the past thirty years. The whole industry comes under the regulatory powers of the Ministry of Agriculture and Fisheries. This Ministry regulates the functions of the manufacturers

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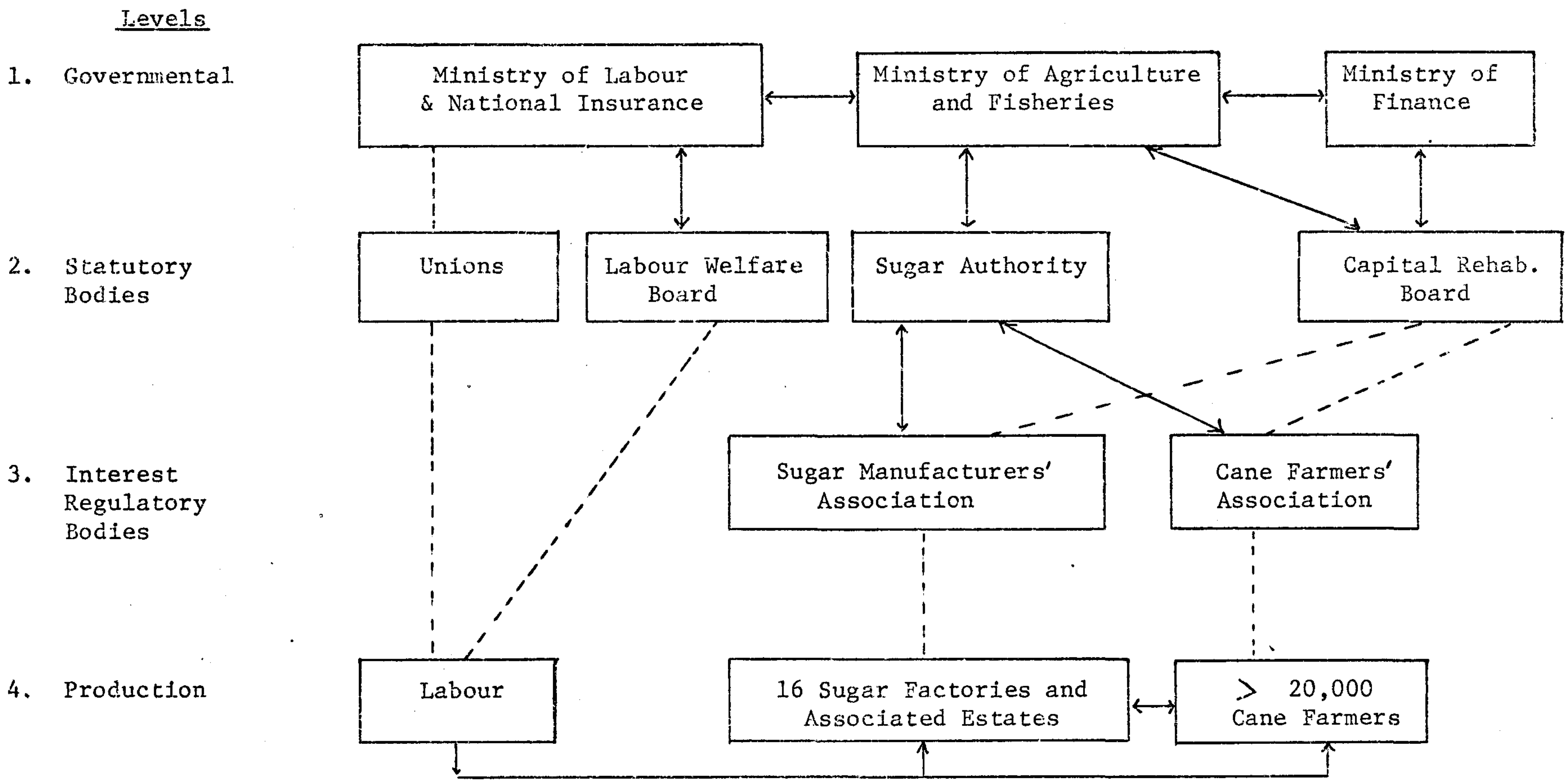
[10] Report of the Sugar Industry Enquiry Commission, op.cit., p. 88.

CHART 1

GRAPHICAL ILLUSTRATION OF THE ORGANIZATION

OF THE JAMAICAN SUGAR INDUSTRY



on the one hand and the farmers on the other hand. The Ministry of Labour and National Insurance influences the industry through its control of the labour unions, which represent workers in the industry, particularly those employed by the manufacturers either on their own farms or in the factories. The Ministry of Finance is responsible for capital rehabilitation funds which are used to rehabilitate depreciating capital established by farmers and manufacturers.

Within the industry, there are two main sections, viz., the manufacturers and the farmers. The manufacturers own and operate sixteen factories and nine distilleries. Through their Association, they are responsible for the marketing of all sugar, molasses, and distilled spirits, both locally and abroad. The manufacturers carry on virtually all research on improving varieties of cane in the industry.

The farmers also act through an incorporated Association, viz., the All Island Jamaica Cane Farmers Association (from now on the CFA), formed in 1941. Its function is to promote the cultivation of sugar cane and the welfare of the cane farmers in respect of the sale of cane; to arbitrate on behalf of farmers in disputes between farmers and manufacturers, and to make representation to the government on financial matters. Its membership comprises all farmers who supply canes to the factories. Chart 1 shows the relationship between farmers and the rest of the industry.

In 1969, the first sugar cane factory was acquired and run by farmers. As more and more manufacturers begin to abdicate the sugar industry, farmers might be called on to assume the full role in production. This supposition is posited on the basis of; (a) the large number of manufacturers who are making representation to government regarding their financial difficulties, (b) farmers' concern in some area to keep the industry as a going concern, because of the difficulty of switching to a new crop, (c) the government's interest in keeping the industry functioning because of its foreign exchange earnings and and the number of people it employs.

It would be of particular interest to compare the performance of farmers who are now involved in the enterprise owned and operated by farmers with the situation as it was previously. The problem is that the time span is inadequate for any useful comparison.

The next strong institution in the industry is the labour unions. It must be noted, however, that union activities are directed mainly at the manufacturers rather than at cane farmers, and where there are comarative union activities between estate and farmers, the wage structure is generally higher for estate workers than for workers employed by farmers. In addition, the estates are obliged to share premium prices with all workers, whereas, only those farmers who produce 200 tons or more, or who cultivate a minimum of ten acres are compelled to do so. In many instances, these conditions are not fulfilled on the farmers' side.

One would expect that this disparity in wages would mean a more reliable labour supply on the estates. However, indications are that this is not the case. The 1966 Commission of enquiry found that estates were experiencing difficulty in maintaining their field workers at full strength due to shortages of cutters and loaders. To alleviate the situation, however, most estates were introducing some measure of mechanical loading, In addition, pre-harvesting burning was introduced on some estates to increase the daily output of the manual reapers.[11]

The gross labour shortage is aggrevated by the increasing incidence of work stoppages due to poor labour relations. It is understood that the main "bone of contention" centres on the formula by which unions negotiate wages. Wage structures are negotiated annually, and the unions base their argument on the movement in the cost of living index rather than on a labour productivity index. In 1969, two factories alone accounted for fourteen weeks labour stoppage.

(a) Cultivation Practices

The production of sugar cane in Jamaica is characterised by a gamut of cultivation practices. These practices vary from those of the casual small producers to those of the large scale producers, as represented by the estates and the very large farmers. The following description of the various practices considers the stages of land preparation planting, upkeep, and cutting.

The large producers of over 500 tons invariably use the tractor for all stages of land preparation. The farmer then hires men to "drop the tops" and then the tractor goes through and does the covering. Below the 500 ton mark, practices vary between the producers who hire tractors to do the tasks, as done on the large farms, and the very small producer who will either hire an ox-drawn plough or will have the land forked. The cane tops would then be planted by hoe and hand.

Upkeep practices also vary. On level land, irrigation is widely

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[11] Ibid, p. 89

practiced where rainfall is deficient or markedly seasonal. Most of the irrigation is done by large farmers. In the hill areas, all watering is done by rainfall. Almost all farmers use fertilizer, but quantities range from six hundred-weight to one hundredweight per acre. Usually, the small farmers vary fertilizer application according to weather conditions and price expectancy.

Large farmers have a more consistent fertilizer application schedule. No research has been carried out as to the reasons for this, but it may be because the large farmers have a greater investment, which drives them to see that the fields are kept at top conditions at all time, and also because in the drier areas their fields are all irrigated so fertilizer application is less affected by drought.

Weeding is done twice in newly planted canes. In ratoons which are not burned, one weeding is sufficient. The large farmers weed mechanically or by hand. Mechanical weeding may either involve the use of a high clearance tractor or the use of spraying machines. Herbicides have been gaining in popularity with the increasing shortage of labour. The small farmer may or may not hire labour for weeding. Invariably, all his weeding is done manually, using the hoe or machete. The practice of thrashing[12] cane is dying out.

Burning of cane before it is cut, is a new practice. It was introduced by the sugar estates to prepare their fields for mechanical loading. The effects have not been incorporated in the analysis, but it

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[12]Thrashing refers to the periodic removal of dried leaves from the stalk of the cane.

should be pointed out here that great controversy surrounds its use. Some of the variables which this practice could affect are;

(i) total output per acre

(ii) labour availability

(iii) profits.

Although it does not directly affect the present analysis, because of the small number of farmers in the sample who were burning cane, the controversy will be briefly stated here so that the reader may have some idea of the implications for further research. In terms of output, it is said that burning is "likely to favour the depreciation of cane pests, notably the jumping borer. The value of the thrash blanket is lost which may be deleterious to soil structure, and increase the hazard of soil erosion on land slopes, as well as favouring rain water run off". (Comm. of Enquiry, p. 84). The labour situation would be substantially improved because the cane cutters could almost double their rate of output. The subsequent cultivation of ratoons is also facilitated, since, there is no thrash to 'turn' for the application of fertilizer. The cost factor and subsequent profitability would also be affected. Burnt cane requires at least two weedings. Secondly, the workers in burnt cane demand increased <u>pay</u> for tasks similar to work in green cane although their productivity in burnt cane is higher.

(b) <u>Transportation</u>

Transportation, and the changes in its availability through time, is one of the main controls of the sugar industry. Although a more specific description of transportation will be given in the next chapter, it may be said here that the system of transportation varies very little for the different areas. The types of carriers in common usage are:-

(i) Animal drawn carts taking up to four tons per trip. These are rapidly becoming obsolete.

(ii) Tractor drawn trailers used on level land; up to ten trailers are hauled in a train at about five tons per trailer.

(iii) Trucks which ply the longest routes, and the most varied terrain. The trend in transportation availability rests largely on the availability of trucks. They are the most versatile units and can change easily from one job to another.

The problem of availability of units depends on various interrelated factors. One factor is the total number of units in an area. Another is the speed with which they can 'turn around' at the factory. Finally, there is the problem of getting loaders and drivers for the units. Four of the six farmers who had abandoned sugar production and who were also truck owners complained that they could not get drivers. In addition, 26 of the 44 farmers who owned trucks said that they were experiencing increasing shortages of loaders for their units. This problem is a recent one. In the early part of the sixties the shortage of carriers was due to inefficiency of the unloading system at the factories. This was temporarily 'solved' between 1965 and 1966, but since then a new shortage has started. In certain cases, the farmer has to 'tip' the loaders an extra fifty cents each for loading his cane.

The recent major competitors for trucks and drivers are as follows:

(a) the bauxite industry

(b) building construction

(c) road construction

(d) citrus, coffee, and banana haulage

(e) water haulage in the dry season.

The outcome of all this is a grave problem of spoilt canes, resulting in frustration of both farmers and manufacturers. A strong, movement is underway to increase mechanical loaders in the industry and to supply more carriers to farmers.[13]

(c) Marketing

Once the sugar cane is transported to the facotry, the onus of marketing is with the manufacturer. The farmers' level of profit depends on market performance, to a large extent. (Appendix 2 shows the basic price formula on which farmers' cane is priced.) The point to be stressed here is that, the well known structure of the world commodity market for sugar does not put the producers in any bargaining position.

Jamaican sugar is sold on five different markets under different arrangements.[14]

(i) On the United Kingdom market under the Negotiated Price Quota.

(ii) The Canadian market under the Commonwelath Sugar Agreement. Canada pays the Free Quota Price plus a preferential incentive.

(iii) The United States market under the United States quota.

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[13]Appendix 1 shows the outline of application for the importation of Duty-free units following the transportation study.

[14]For a full discussion of marketing agreements see the Report of the Commission of Enquiry into the Prices to be Paid for Cane Farmers' Cane, 1962. (Jamaica, 1963), Chapt. IV.

(iv) The World market under the International Sugar Agreement. (Jamaica is now unable to supply this market because of low production).[15]

(v) The local market, under the local quota. In 1968, Jamaica had to import refined sugar due to shortfalls in production.

It has already been states that farmers may be moving towards more and more industry control. This situation, if it materializes, would provide a framework for comparing production trends on the basis, not of the traditional variables but in relationship to who controls the means of production.

Clearly, the industry as outlined above, is very complex. Most attempts to examine production of this industry have pitched the analysis at the industry level or at the level of primary commodity in the context of the world economy. The reader will, therefore, appreciate the difficulty of isolating measureable variables which can be used to analyse farmers supply, a task attempted in the next chapter.

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[15]The text of the new (1968) Agreement is contained in UNCTAD. TD/SUGAR. 7/10, United Nations 1968.

CHAPTER III

CHOICE AND DESCRIPTION OF TIME PERIOD, VARIABLES, AND STUDY AREAS

This chapter outlines the framework of the empirical investigation on which the study is based. The hypotheses for the formal analysis are stated at the outset followed by the description of the time period, variables, and study areas. The source of data for each variable, and the reliability of the source is discussed along with the description. Finally, there is a synopsis of the observations according to the various study areas.

On the basis of the development of theory in agricultural supply analysis, and from observations in the Jamaican sugar industry the following hypotheses are formulated for empirical testing.

1. The percentage change in individual supply over time is a function of certain spatial variables, viz:- type of land, distance from factory, price per ton of cane, and average annual rainfall in the production zones.

2. Aggregate production over time is a function of certain aggregate supply variables, viz:- use of fertilizer, average price of product, average rainfall, average annual profits per acre of land cultivated, availability of transportation, and availability of labour.

The basic assumptions of the two hypotheses above are that;

(a) The sugar industry behaves similarly to other agricultural industries discussed in the theoretical literature, and

(b) Demand changes are insignificant for farmer's supply in the Jamaican industry. The basis of this assumption is already stated viz:- that the West Indian Cane farmers sell all of their sugar cane in a guaranteed market.

In the realm of pure theory, the outcome of the empirical investigation of the hypothesesmay be a satisfactory statistical explanation. However, some latitude must be given to those scholars who would contend that, behind good statistical estimates, there are factors at work, which can only be explained through a thorough examination of the historical development of the socio-economic situation. Where the statistical explanation is insignificant, use is made of the farmers' opinion as discovered in the questionnaire.

A. THE CHOICE OF TIME PERIOD

The choice of the time period, 1961 to 1969, is conditioned by several factors which should guarantee a worthwhile and meaningful research. The primary consideration is the availability of reliable data. The period may be described as one of industry maturity and, therefore, one of structured economic organization.

The importance of the maturity of the agricultural industry was recognised by Schultz (1951) and Price (1953). They found that, as the industry matures, production becomes more a function of non-land input combinations such as fertilizer, labour, and water. This is important in the Jamaican sugar industry where total supply has only limited relationship to total land use over time. (The correlation coefficient (R) between total cane supply and acreage cultivated (Table 12) is .5877). In addition, as the industry matures, farmers exercise greater flexibility in choosing among various crops because they can recognise more clearly, their relative profitability. In the context of the Jamaican sugar industry, the growing availability of reliable data has already been mentioned. This is due to the extensive research work being carried out by the Cane Farmers' Association, the Sugar Manufactuers' Association, and economists at the University of the West Indies. In addition, over the period, there have been three Commissions of enquiry into the sugar industry covering all aspects from cane farmers' production to marketing.

The next major consideration is that technology is largely unchanged over the time period. In cases where there is constantly improving technology, as in the automobile industry, a variable 't' would have to be included in a regression model to explain that part of the growth in output attributable to technological change over time.

Heady and Dillon, for example, pointed out that changes in technology mean fitting a different production function for each technological period.[1] Evidence to support the proposition that technological change over the period is relatively insignificant is based on the fact of the 199 observations, only 3 had changed from manual weeding to the use herbicides. Most of the cultivation aspects of the production continued

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[1]Heady, E. and J.L. Dillon, Agricultural Production Functions, Iowa State University Press, Ames Iowa, 1961, p. 144

as manual operations. Land preparation, which had been carried out by tractors on the farms located in flat terrain, continued as such.

Harvesting has continued as a manual operation among cane farmers. This means that thousands of seasonal workers are required annually throughout the harvest, which lasts for seven to eight months. Burning of cane has not led to increased mechanization but rather to increased cost of production. The practice has caught on among farmers in some areas in the island, mainly due to pressure from workers who prefer to reap burnt cane because they work faster and also charge more to harvest each unit weight. There is no mechanical harvesting, although in 1968, the government gave the sugar manufacturers a permit to import five mechanical harvesters "for experimental purposes only" on the conditions that no workers would be displaced in the process of introduction.

B. THE CHOICE AND DEFINITION OF VARIABLES

The basic factor determining the choice of variables is the postulated relationship discussed in the theory of agricultural supply in Chapter I. Secondly, the specific characteristics of the Jamaican sugar industry point to important areas of investigation. Abbott (1964), for example, discussed most of the important factors influencing sugar cane supply in the West Indies. Such works provide invaluable ground work for the identification and definition of variables.

The variables used in the test of the first hypothesis are as follows;

The dependent variable is percentage change in output over the periods 1961 to 1966 and 1961 to 1969. The independent observations are classified as purely spatial variables. These are selected to test for their relationship with changes in production over time. These variables are as follows;

(1) Land Classes one to five, which define the quality of land on which sugar cane is grown. The classification follows that used by the Ministry of Agriculture and Fisheries, as follows;[2]

Class 1 land: level land with a deep fertile soil with no factors limiting its use for agriculture.

Class 2 land: land suitable for cultivation, but with moderate limitations such as (a) the risk of erosion, (b) wetness due to inhibited drainage (c) fertility or other limitations to its use.

Class 3 land: land suitable for cultivation, but with strong limitations of the order of 2 (a), (b), (c) above.

Class 4 land: land marginal for cultivation due to extreme danger of erosion and poor soil conditions.

Class 5 land: land not suitable for cultivation due to steep slopes, extreme danger of erosion, and very adverse soil factors.

Class 6 land: land not suitable for cultivation, which should never be cleared of natural vegetation. No cane farmers were found on this land class. The observations were recorded as '1' where they occurred on a certain type of land, '0' otherwise.

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[2]Soils and Technical Guide Sheets, Agricultural Chem. Division, Ministry of Agriculture and Lands, Jamaica, 1964.

Sample farms were allocated to various land classes by first locating them on a map then determining from the regional extension officer, the land class to which each belonged.

(2) Distance of the farmer from factory measured in terms of transportation cost (J$) per ton.

(3) Percentage change in price per ton of cane over the periods 1961-1966 and 1961-1969; the observations being lagged for two years to allow for structural adjustment within the industry.[3]

(4) Annual rainfall measured in inches. The rainfall associated with each farmers' production is that total which is obtained from the area in which the farmer is located and which is defined by the sugar estates for the taking of sample juice test and, ultimately, for calculating the price payment formula.

In the second model, the aggregate model, the year becomes the observation point and the sample values, and all observations are aggregated for that point. For this model, the following variables are defined:-

(1) The dependent variable is,total output, i.e., the total amount of sugar cane supplied by the farmer in tons per annum.

(2) The independent variables are, total fertilizer used, i.e., a measure of the total tonnage of fertilizer used by the farmers annually

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[3] In some industries, a one year lag is suggested since short term changes may easily be made. For example, in the wheat sector, annual adjustments are usually made to governments programmes and market expectancy. In sugar cane, it takes up to eighteen months for newly established canes to reach maturity, while ratoons mature within a year.

in each area.

(3) Price of product. This is defined as the average price of cane per ton received by the farmer annually. As in the previous case, there is a two year lag for price to allow for structural readjustment.

(4) Average annual profit. This variable measure the average profits received by farmers on each acre of land in the study areas. Abbott (1964),[4] recognised the importance of profits as a determinant of increases or decreases in supply among sugar cane farmers in the West Indies but suggested that total abandonment would only take place when the farmer has suffered many severe losses and the profitability per acre of cane relative to other crops moves against sugar cane (p. 34). Coincidentally, the Cane Farmers' Association has proposed movement in profits as the basis for pricing cane farmers' cane and has already carried out research on the average profits of cane production in the various producing areas. The method of research is to take those farmers with accounting books and examine the movement in costs of input over time. Most of the input costs are known throughout the industry; such as transportation cost, fertilizer, land preparation costs, cutting rates, watering and weeding expenses, and cost of tops. In the case of incentive payments, the farmers' records are open to doubt since there is a tendency to inflate these figures in years of good prices. However, it is better to use the farmers' data than to settle for 'transference' as practiced by the Commissions of enquiry. These commissions simply take the estate records 'since they are easier to come by' and subtract the

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[4]Abbott (1964), op.cit.

indicated overheads leaving the rest as farmers' costs.

Average receipts = average yield x average price/ton

Average profits = average receipts - average costs

(Appendix 3 shows the average costs of input items for the industry since 1959, while appendices 4A,B, and C, show a range of costs and profits attainable by different types of producers in various areas).

(5) Availability of transportation. This is an area function designed to measure the amount of transportation available to farmers in an area. The problem of transportation availability had already been studied by both manufacturers and farmers. This has resulted in recommendations which have been accepted by the government. The results have been outlined in this thesis. (See Appendix 1).

Several methods of measuring the proportion of required transportation, which is available to farmers in an area have been suggested. The two most appealing are as follows:-

(a) To take the number of vehicles registered annually to haul canes.

(b) To take the proportion of farmers' available tonnage per week, which was actually hauled by available vehicles.[5] The first method is rejected because the number of vehicles registered does not indicate whether they would be available for hauling canes.
The fact is that when the vehicle operators find more lucrative contracts for their vehicles, sugar haulage is neglected. In fact, vehicle re-

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[5]Thanks to Mr. Arthur Skyers of Sevens Estate Ltd., who pointed out these technicalities in transportation availability measurements.

gistration serves only to facilitate the manufacturer's accounting. The following table (5) shows the relationship between vehicles registered and the transport availability, as measured by the second method for study area number two.

TABLE 5

RELATIONSHIP BETWEEN NO. OF VEHICLES REGISTERED AND AVAILABILITY

Year	No. of Vehicles Registered	Total Farmers' Weekly Cutting (tons)	Farmers' Weekly Delivery (tons)
1961	189	5400	4410
1962	192	5700	4850
1963	221	5250	4620
1964	250	6000	5500
1965	208	6600	6600
1966	200	7000	7000
1967	186	5100	4200
1968	170	5700	4400
1969	120	5500	4000

This table shows that the maximum number of vehicles registered does not necessarily mean maximum availability. In 1965 and 1966, for example, farmers were able to deliver all their weekly cutting although there were fewer vehicles than in 1964.

(6) Rainfall measured in inches per annum.

(7) Availability of labour.[6] Like transportation, labour availability in an area function which indicates the proportion of required labour which was obtained. The general opinion was that up to 1965 there was no problem with labour supply. This made the problem of measurement easier than expected since full supply existed up to that time The procedure was to find out from the farmer how many workers were required on the farm and how many were obtained. This is possible only for those farmers who keep accounting books, since those without books could not recall this information for more than one or at most two years. It is for this reason that actual number of men employed is not used. Tests of the reliability of farmers' reports were corroborated by estates in the areas, which have extremely detailed records. The trend of workers supply on their farms is similar to the farmers' reports.

Yield was one of the variables originally considered worth including, but it is so highly multicollinear[7] with fertilizer used, that it is dropped from the analysis. Below are the comparative figures for yield and fertilizer. (Yield/tons/acre; Fertilizer/tons).

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[6] Heady and Dillon describes several ways of measuring labour availability and their use in agricultural production analysis. See Heady and Dillon, op.cit., pp. 554-584.

[7] Multicollinearity refers to a single equation relationship where there is such a high correlation between two or more variables that we may infer that one or more linear relationships exist between some or all of the independent variables. It may cause large variances in the estimation of the regression coefficients since the observations tend to play a dominant role in determining values of the parameters (Heady & Dillon, pp. 134-5.).

TABLE 6

COMPARATIVE YIELD AND FERTILIZER USAGE 1961-1969

Year	1961	1962	1963	1964	1965	1966	1967	1968	1969
Yield	24.0	25.5	26.3	29.8	30.5	31.5	28.0	26.5	25.0
Fertilizer	165.8	298.8	322.1	564.8	566.2	644.8	455.5	328.5	288.0

Multicollinearity value 0.99

C. THE DATA SOURCES

Apart from the availability of labour, all other data were obtained directly from institutional records of the Cane Farmers' Association and their affiliated bodies, and the Sugar Manufacturers' Association. The data which are used to calculate transportation availability were obtained from the farmers' liaison officers of the various sugar estates.

D. CHOICE AND DESCRIPTION OF STUDY AREAS

The choice of study areas was based on a desire to include, as wide as possible a cross section of conditions among cane farmers. One measure of the variability of producing areas is the cane payment formula by which sugar factories are grouped into three classes according to the percentage value of sugar which the manufacturer pays to the farmer. Appendix 2 outlines the basic cane payment formula and the grouping of factories according to the formula.

One factory was selected from each of the three groups, provided that cane farmers in the area supply at least 25% of the canes ground by that factory. In addition, the characteristics of the farmers in the area determined what factories were eligible for selection. To get at different types of farmers, according to quantity supplied and location, a system of stratified random sampling was used.[8] Four size categories were defined as follows:-

Producers of:

(1)	less than 20	tons of cane per annum in 1961
(2)	20 - 99	" " " " " " "
(3)	100 - 499	" " " " " " "
(4)	$\geq$ 500	" " " " " " "

Three distance categories were subjectively selected for each area, depending on the spatial distribution of farmers' groups with respect to the factory.[9]

The initial objective was to randomly select at least six farmers from each size group at each distance category. This meant that each factory should have a minimum of 18 farmers of each size category before it could be selected. Table 7 below, shows the distribution of farmers according to size categories at each factory. Due to these controls and because there was no response from one factory on the possibility of using

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[8]For a full description of sampling methods, see Croxton, Crowden and Bolch, Practical Business Statistics, Prentice Hall, Inc., N.J., 4th ed. 1969, or any standard statistical text.

[9]The liaison officers at the three factories were asked to group their producing zones according to what they regarded as near, intermediate, and far in terms of cost of transportation. From the results, three categories of distances were defined for each production area.

their records, only eight factories remained eligible for selection. The final number of observations is 199 after eliminations due to errors in recording and non-response.[10] The distribution according to size categories one to four is as follows: Class 1, 51; Class 2, 52; Class 3, 49; Class 4, 47. The areas finally selected, are those serving the Appleton factory located in the Nassau Valley, the Sevens factory located in the Rio Minho Valley, and the Monymusk factory located on the Vene plains. Map 5 shows the location of the factories serving the sample areas. A detailed account of the physical and economic attributes of the sample areas is provided below to present the reader with a frame of reference for understanding the conditions under which the study has been carried out.

E. THE SAMPLE AREAS

1. Area One

Area one is the supply region for the Appleton factory. Unlike the other two areas, this is a wet area, with rainfall above 70" except in dry years. There is no necessity, therefore, for any irrigation.

The physical features of the area are dominated by the Nassau valley, which is about ten square miles in area, and the largest single producing area in the region. There are a few solution basins used for sugar cane growing, but some depressions are extremely inaccessible due to the nature of the limestone weathering. Elevation increases northwards to just over 2000 feet on the border of St. James, Trelawney, and St. Elizabeth (Map 6a).

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[10] Problems of non-response were due to my inability to keep appointments and not because the respondents were unwilling to give requested information.

TABLE 7

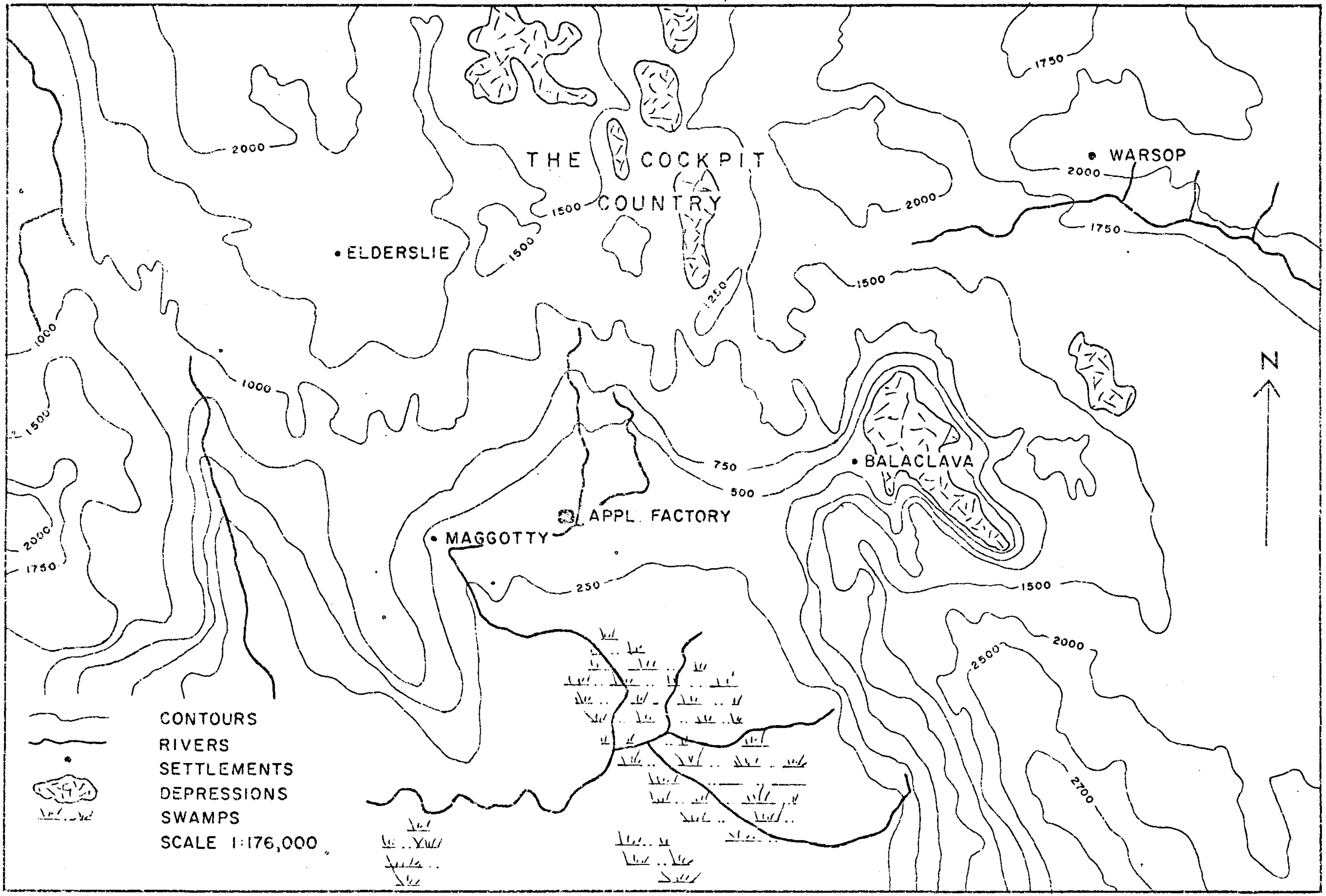
TOTAL NUMBER OF REGISTERED CANE FARMERS

ACCORDING TO SIZE GROUP AT EACH FACTORY. (1969)

	Factory	Size Categories (tons)			
		20	20 - 99	10 - 499	500 tons
1.	Monymusk	207	317	91	25
2.	Frome	1893	1923	407	109
3.	New Yarmouth	72	153	172	63
4.	Sevens	1945	1084	160	31
5.	Bernard Lodge	68	83	44	25
6.	Ja. Sugar Estates	82	147	46	14
7.	Hamden	425	824	114	31
8.	United Estates	726	314	60	20
9.	Innswood	371	173	52	16
10.	Trelawney Estates	1095	875	122	25
11.	Grays Inn	195	51	16	4
12.	Serge Island	363	289	32	10
13.	Appleton	1134	672	64	20
14.	Holland	211	78	13	4
15.	Worthy Park	1579	1128	73	2
16.	Richmond Llandovery	24	8	1	1

AREA I PHYSICAL FEATURES

Map 6a



(i) Land Classes

The soils in the Nassau Valley are formed over interior basin deposits, and range from loams, through clay loams, to clay. These soils, for the most part, fall on Class 1 land, although poor drainage in places gives rise to Class 2 land. On the periphery of the Nassau Valley, the limestone has weathered into pockets of deep fertile soils, giving rise to small areas of Classes 2 and 3 land around the districts of Balaclava, Aberdeen, Accompong, Elderslie, and Catadupa. Steep slopes in this region increase the possibility of erosion causing land classes to fall to 4 and 5. Most of the area outside the Nassau Valley is covered with Bonnygate stony loam. Except where small outcrops of Chudleigh clay loam, St. Ann loam, and Union Hill stony clay occur, giving rise to land classes two and three, the area is generally of land classes five and six. Soil shallowness and erodibility are the main limiting factors.

In this area, 63% of the sample occur on land classes one to three, with 37% on four and five.

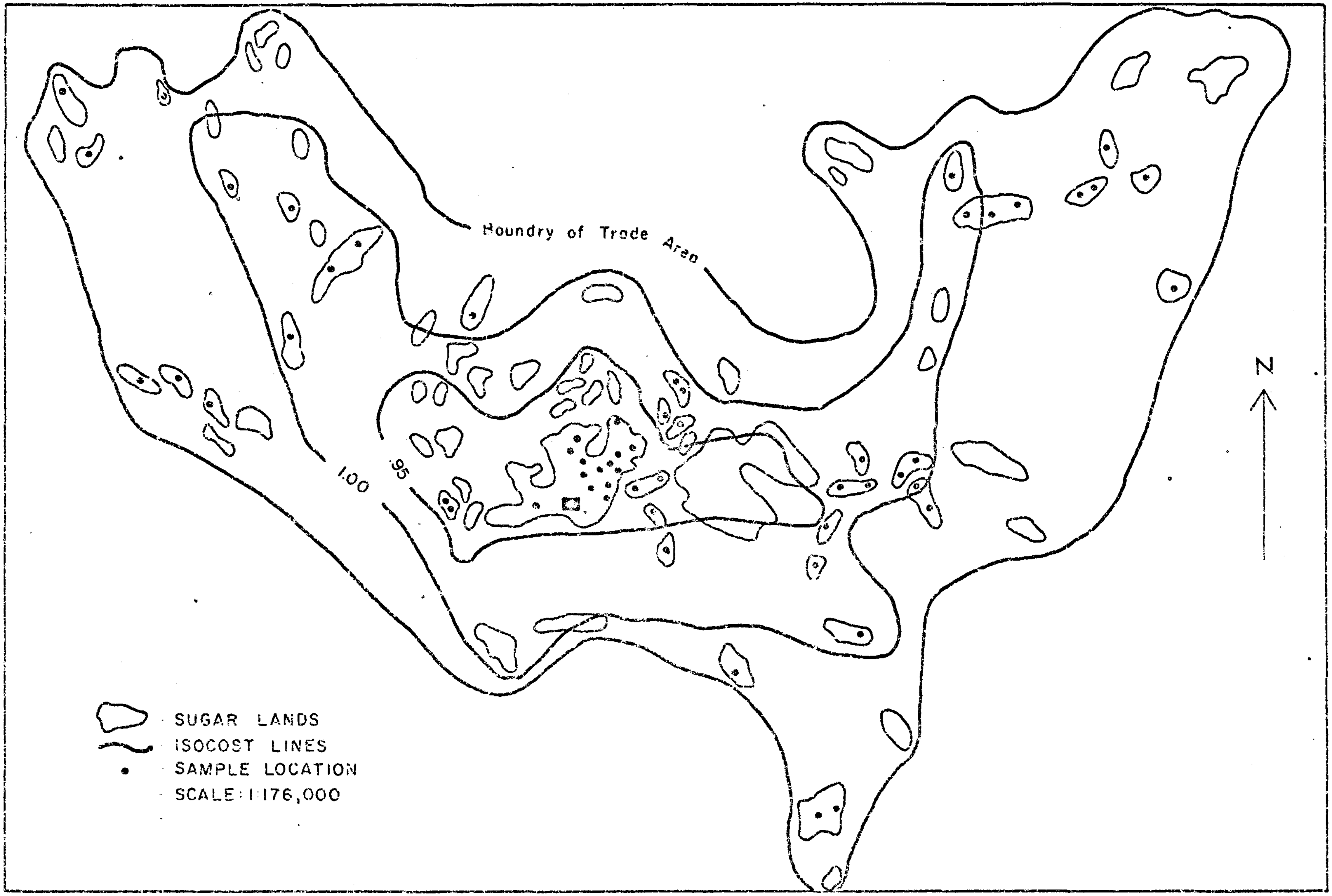
(ii) Land Use

Although the Nassau valley is used almost exclusively for sugar cane, (Map 6b), as are extensions to the north where soil factors are favourable, the study area as a whole is by no means dominated by sugar cane. The nature of the topography and the rainfall give rise to a variety of crops, the mix of which includes corn, citrus, ground provision and vegetables, pimento, coffee, and bananas. As in most other hill areas in Jamaica, soil erosion is the pressing physical problem.

The Summary Charts 2, 3 and 4, outline for each area, the

AREA I SAMPLE POINTS AND ZONES OF EQUAL TRANSPORTATION COST

Map 6b



major:

(a) Soil types.

(b) Limitations to their utilization.

(c) The land capability class into which they fall.

(d) Their suitability for sugar cane growing.

(e) The major land uses of the area.

(iii) Transportation

In the early part of the decade there were some difficulties with transportation but in 1965, the 'grab' was introduced so that carriers could "turn around" faster in the factory yard. This device solved the problem temporarily. By 1967, however, the shortage of carriers took a different turn. The problem since then, is not so much the scarcity of physical units for carrying cane, but rather, the unreliability of truckers, who blame labour shortages for their shortcomings. It became clear, also, that terrain, rather than actual distance, was responsible for much of the scarcity of transportation. Map 6c shows, by means of isocost lines, that roadways rather than linear distance, account for the variation in the cost of transportation. To add to the difficulties with transportation, the Revière bauxite company started construction works in 1968 thereby reducing the available numbers of trucks.

(iv) Labour

Many people blame the attitude of labour to the "sociology of sugar", for this growing shortage. Again, there is a 'bauxite' explanation. In 1965, Alpart started their construction works at Nain, 12 miles away. This started a trek of job-seeking workers from the areas around

AREA I TRANSPORTATION

Map 6c

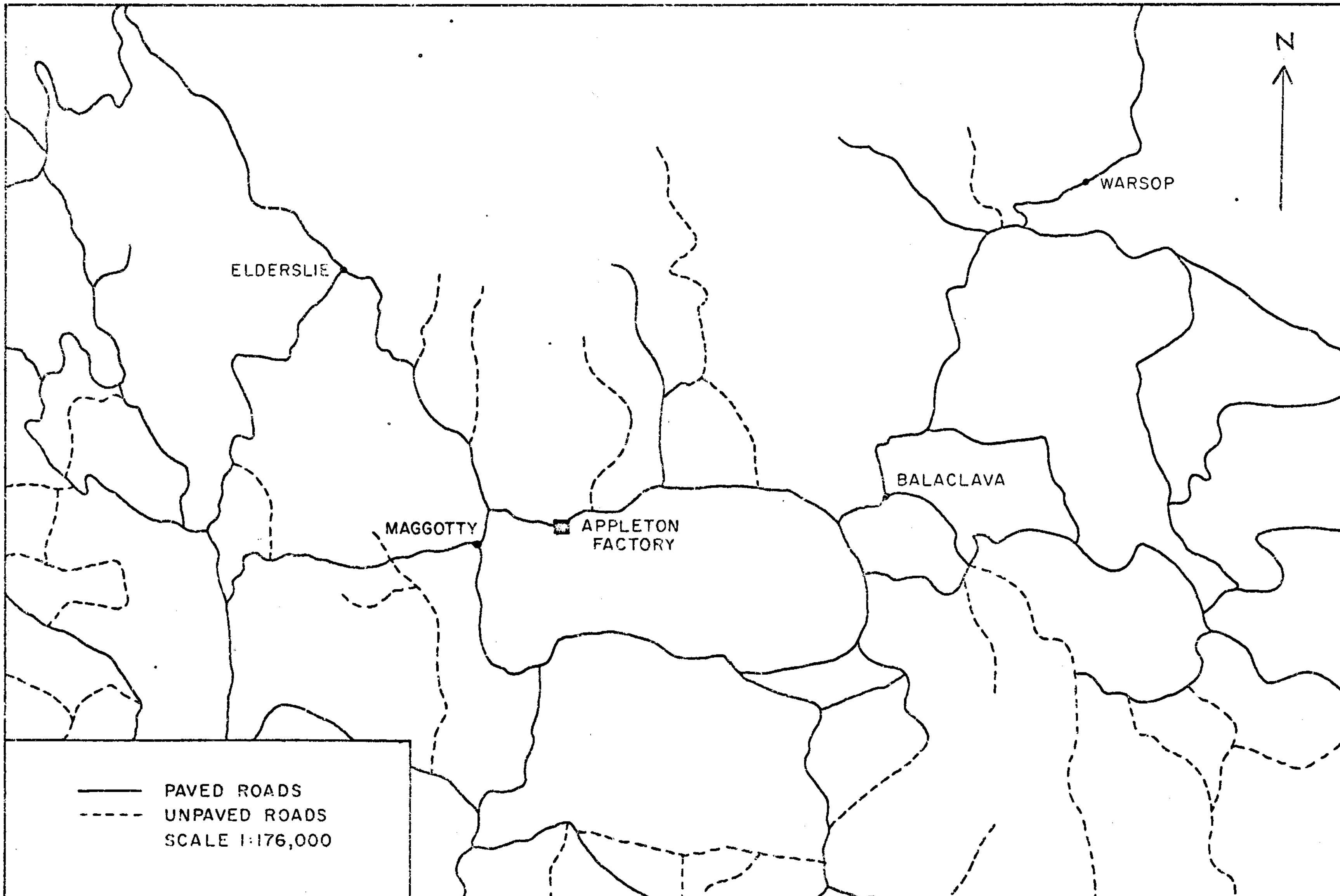


CHART 2

AREA 1: AREA SOIL CHARACTERISTICS AND GENERAL LAND USE

Soil Type	Limitations	Capability Class	Whether Suitable* for Sugar Cane	Major Land Use
1. Newell Loam	Slope 20^o	3.	YES	Sugar cane is dominant in the Nassau Valley but the area as a whole produces other important crops such as corn, citrus, ground provisions and vegetables, pimento, coffee and bananas.
2. Raheen Clay	Poor Internal Drainage	3.	YES	
3. Raheen Clay Loam	Internal drainage	2. (1. where soil occurs on elevated areas)	YES	
4. Vauxhall Clay Loam	Slope 10^o	2.	YES	
5. Boghole Clay	Internal Drainage	2.	YES	
6. Chudleigh Clay Loam	Slopes 10^o, Stoniness	2.	No	
7. Union Hill Stony Clay	Internal Drainage Stoniness	2.	Yes	
8. Donnington Gravelley Loam	Droughty, stoniness slope 20^o - 30^o	4.	Yes	
9. Same	As above but slope is over 30^o	5.	No	

*YES - highly recommended
Yes - recommended but not emphatically

so that the 1966 sugar crop began to feel the "pinch" of the labour shortage. In addition, the new Revière works, which started in 1968, augmented the difficulties. One should not get the impression that the bauxite companies are employing the sugar workers. In fact, I would say that there is no competition between sugar and bauxite for workers. But the 'demonstration effect' of industrial wages has led to a growing antipathy to farmwork and particularly to work in sugar cane.

2. Area two

The land rises from the southern plains at an elevation of about 500' to the mountains of northern Clarendon, southern St. Ann, and western St. Catherine (Map 7a).

The dominance of limestone in the geological structure accounts for the occurrence of numerous solution basins, which are widely used for sugar cane growing. Such basins include the Danks and Pindars Valleys.

Rainfall in the area ranges from about 40" in the south to about 70" in the north, in the Kellits - St. Ann area. The deficient rainfall on the southern plains is supplemented by irrigation from wells and re-appearing streams.

(i) Land Classes

Soils, in this area, are grouped into three main types;

(1) Soils over alluvium.

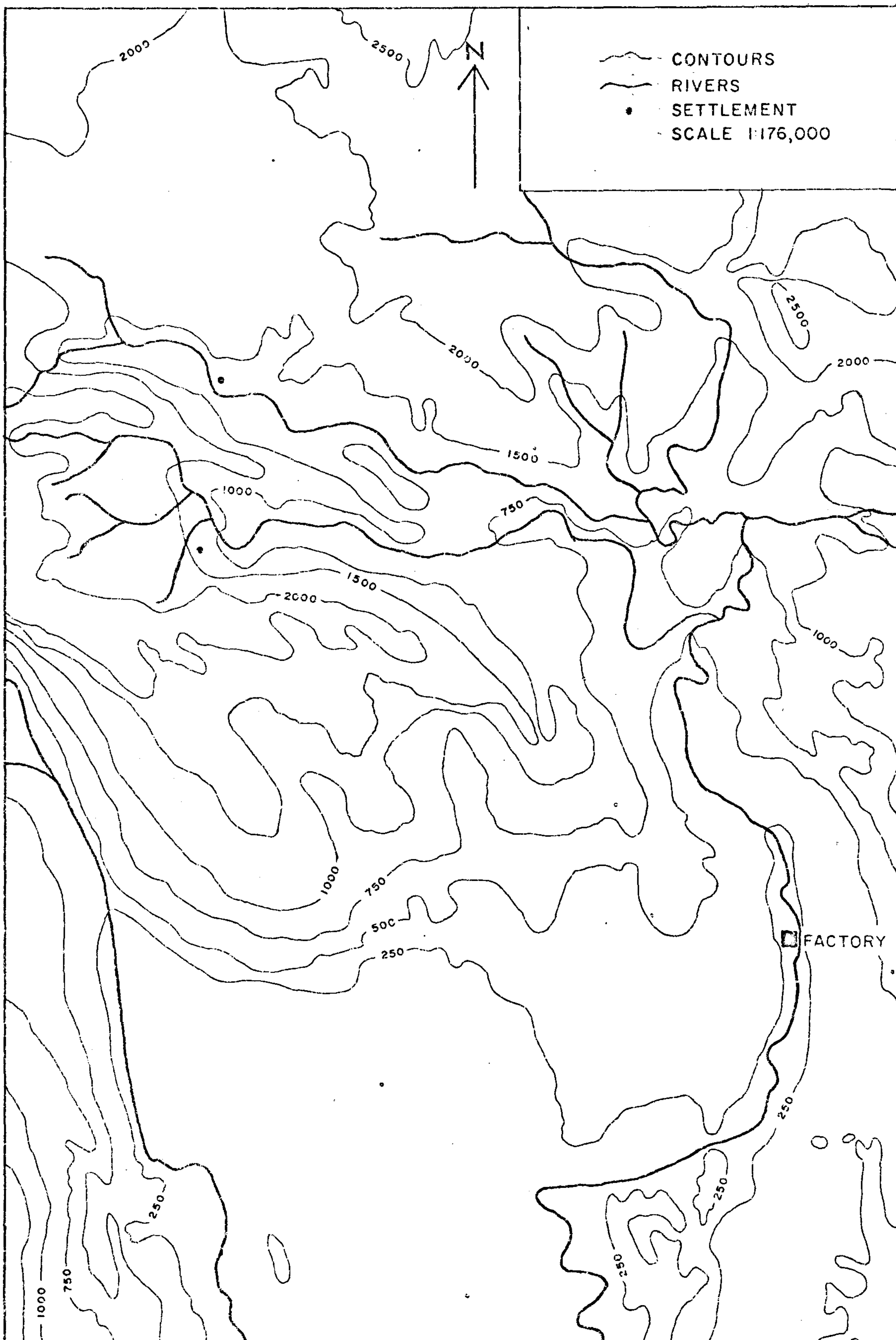
(2) Soils over conglomerates, tuffs, tuffaceous shales, and non-calcareous shales.

(3) Soils over limestone and limestone colluvia.

Soils in group 1 are found mostly on the plains to the south.

AREA 2 PHYSICAL FEATURES

Map 7a



For the most part, they fall in land classes two and three due to limitations set by drainage. They are, however, excellent lands for sugar cane production. The soils in group two are dominated by clays, clay loams, and sandy clay loams. The class into which they fall is determined mainly by the slope factor. Where these soils occur in interior basins and structural flatlands, they are usually in classes one to three, but with increasing steepness, the classes fall to four and five.

The soils in group 3 are found mostly on sloping terrain where susceptibility to erosion is the main limitation. In these areas, soils of classes five and six occur.

From the point of view of the present study, the greater variety of land classes have little effect on the location of the observations. 73% of the sample are on classes one to three because farmers tend to use their land in such a way that sugar cane occupies the flatter areas on any single farm. Twenty-seven percent of the occurrences are on land classes four and five.

(ii) Land Use

There is greater diversity of land uses in this area than in the first. In the extreme south, sugar cane assumes singular dominance. To the north-centre, where large areas of flatlands occur, sugar cane and citrus assume joint dominance, especially in the areas of Pennants and the Ballards Valley. In the north, food crops predominate, with sugar cane occurring on the flatter lands and lands close to the roadways. It is clear that, in this area, the variety of climate and topography is conducive to crop diversification. Map 7b shows the distribution of sugar growing areas and sample points in this area.

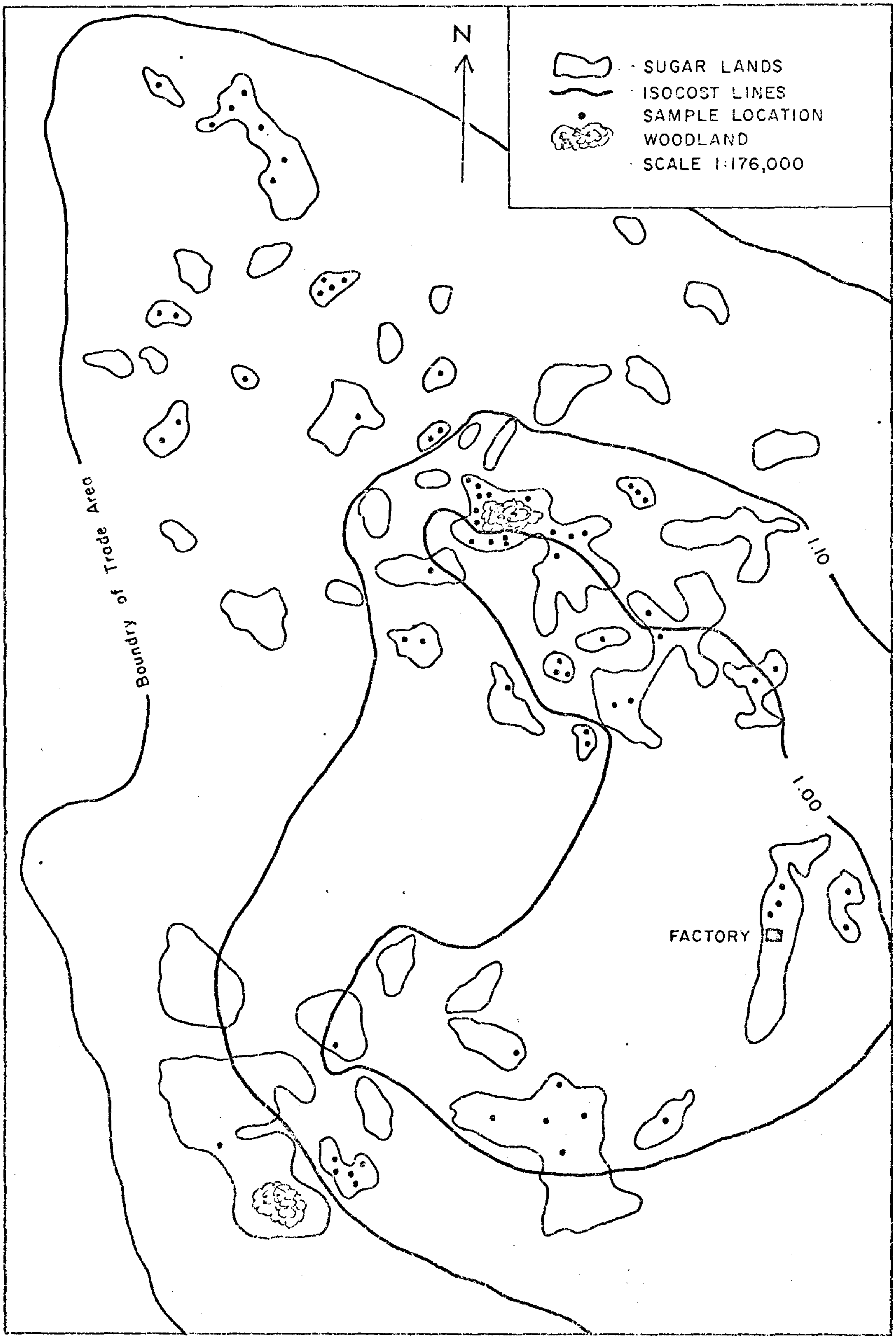
CHART 3

AREA 2: AREA SOIL CHARACTERISTICS AND GENERAL LAND USE

	Soil Types	Limitations	Capability Classes	Whether Suitable* for Sugar Cane	Major Land Uses
1.	Rhymesbury Clay	Poor Internal Drainage	3.	YES	Sugar cane in the south; sugar cane and citrus in the north-centre; mostly in solution basins.
2.	Four Paths Clay	Internal Drainage	2.	YES	
3.	Four Paths Loam	Poor Internal Drainage	3.	YES	
4.	Wirefence Clay Loam	Slope 20^{o}	1.	No	
4a.	Wirefence Clay Loam	Slopes 10^{o}	5.	No	Sugar cane minor in the north. Food crops become dominant.
5.	Diamonds Gravelly Clay Loam	Slopes 10^{o}	2.	Yes	
6.	Same	Slope 10^{o}	3.	Yes	
7.	Wait-A-Bit Clay	Internal Drainage	2.	YES	
8.	Same	Slope 5^{o} - 10^{o}	3.	YES	Tobacco is gaining prominence in the extreme north due to promotion by the Carreras Tobacco Co.
9.	Bog Hole Clay	Internal Drainage	2.	YES	
10.	Bonnygate Stony Loam	Shallowness, Stonyness Droughty	5.	No	
11.	Bundo Clay	Internal Drainage	2.	Yes	
12.	Non-such Clay	Internal Drainage	2.	YES	

*YES - highly recommended
Yes - recommended but not emphatically

AREA 2 SAMPLE POINTS AND ZONES OF EQUAL TRANSPORTATION COST

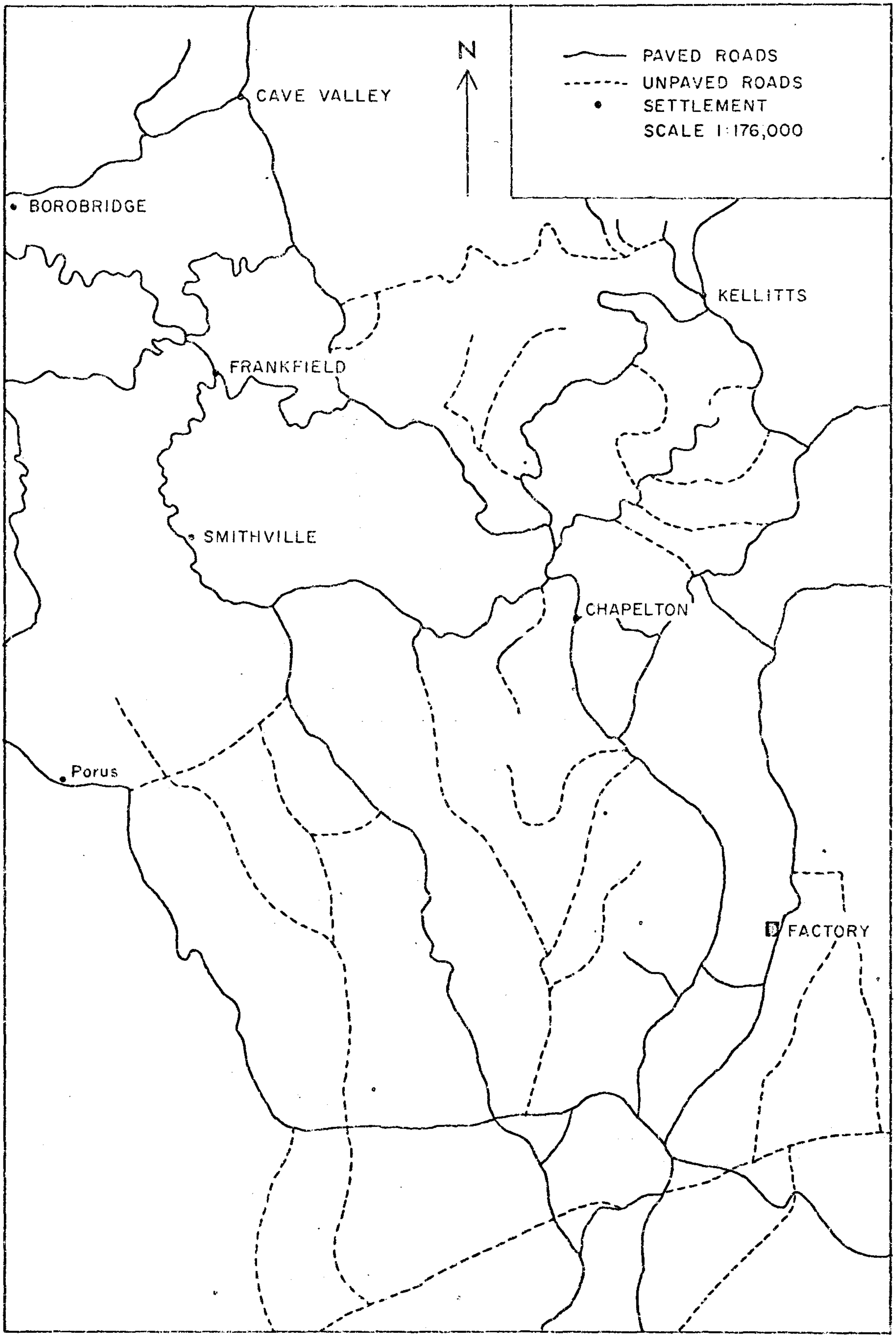


(iii) Transportation

Transportation to the factory tends to be dominated by trucks, although there are some mule-carts and tractor-trailers on the southern plains. The network of roadways shows a close alignment to the orientation of topographic features, which reduces the net accessibility of farming areas. As a result, a large proportion of farmers' cane in the north, is taken to roadways by donkeys before it is taken by trucks to the factories. In this area, transportation cost is strongly affected by terrain conditions. An examination of Map 7b and 7c shows that isocost lines are strongly oriented to the transportation axes and, therefore, to accessibility. The large exodus of carriers out of sugar haulage in recent years is due largely to labour shortages, but there is some relationship between conditions of roadways and the willingness of operators to haul canes from certain areas. In the extremely inaccessible areas, farmers are held to 'ransom' and, therefore, have to give the truckers 'an incentive' over and above the regular transportation rate before their cane is taken up.

(iv) Labour

Labour has recently been one of the main problems in this area. Like Area One, all aspects of cultivation and harvesting have been affected. A recent study in this area recommended the use of portable harvesters and the establishment of area machinery pools. The problem with this suggestion, however, is that in this area, there is not enough spatial concentration of farmers nor is the terrain suitable in most of the area for the introduction of the type of machinery which has been observed in operation in Puerto Rico and Australia. As in Area One, the opening up


N
PAVED ROADS
UNPAVED ROADS
SETTLEMENT
SCALE 1:176,000
CAVE VALLEY
BOROBRIDGE
KELLITTS
FRANKFIELD
SMITHVILLE
CHAPELTON
Porus
FACTORY

of the bauxite mining by Alcoa Minerals in 1965 has led, in part, to a gross shortage of labour in the sugar industry.

3. Area Three

Area Three, served by the Monymusk factory, is dominated by the Vere plains, which is composed largely of recent alluvium overlying yellow and white limestone. Topographically, the area is flat to undulating, with the highest point reaching about 500' (Map 8a). Most of the streams, which disappear in the limestone to the North of this area, are tapped just below the surface as a source of irrigation.

Rainfall in the area is usually below 40" per annum and in terms of the rainfall variable, there is a tendency towards extreme drought. However, the excellent irrigation system in this area tends to offset the effects of low rainfall, and to support one of the major sugar producing regions in the island.

(i) Land Classes

The soils in this area range from clay, through clay-loam, to loam, and are usually water-retentive. Due to the excellent combination of soil types, and topography, the land classes fall largely within the range one to three, all of which are highly recommended for sugar cane, except that the degree of land management required for their utilization increases from class one to class three land. The main limitation to land use on these soils is internal drainage.

(ii) Land Use[11]

The major portion of cultivated land on the Vere plains is under

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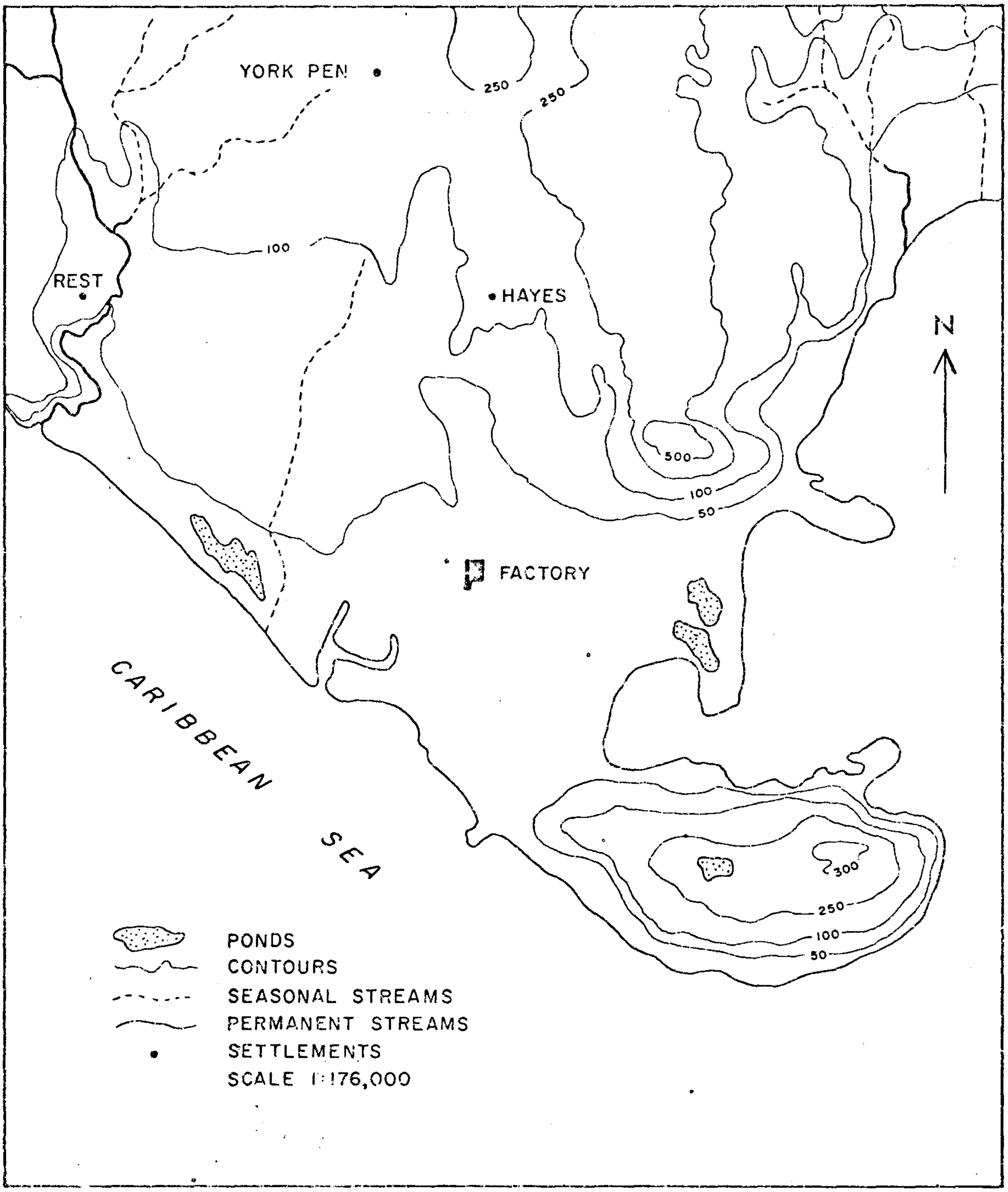
[11]Appendix 5A and B shows how particular farms may be used in dry and wet areas according to the size category of the farmer.

AREA 3 PHYSICAL FEATURES

Map 8a



sugar cane, with pasture lands as the second major use. (Map 8b shows the distribution of sugar cane lands and sample points). Most of the farmers interviewed in this area suggested that their main aim is to continue producing sugar cane because their land and their location in terms of climate, makes sugar cane the most feasible crop. Cattle is an important alternative but it requires heavy capitalization for establishing pastures and also large landroom. Most of the new cattle farms are being established by government's help and are being operated by graduates of the Jamaica School of Agriculture. Some of these cattle farms are on former sugar cane lands but the majority is on new land.

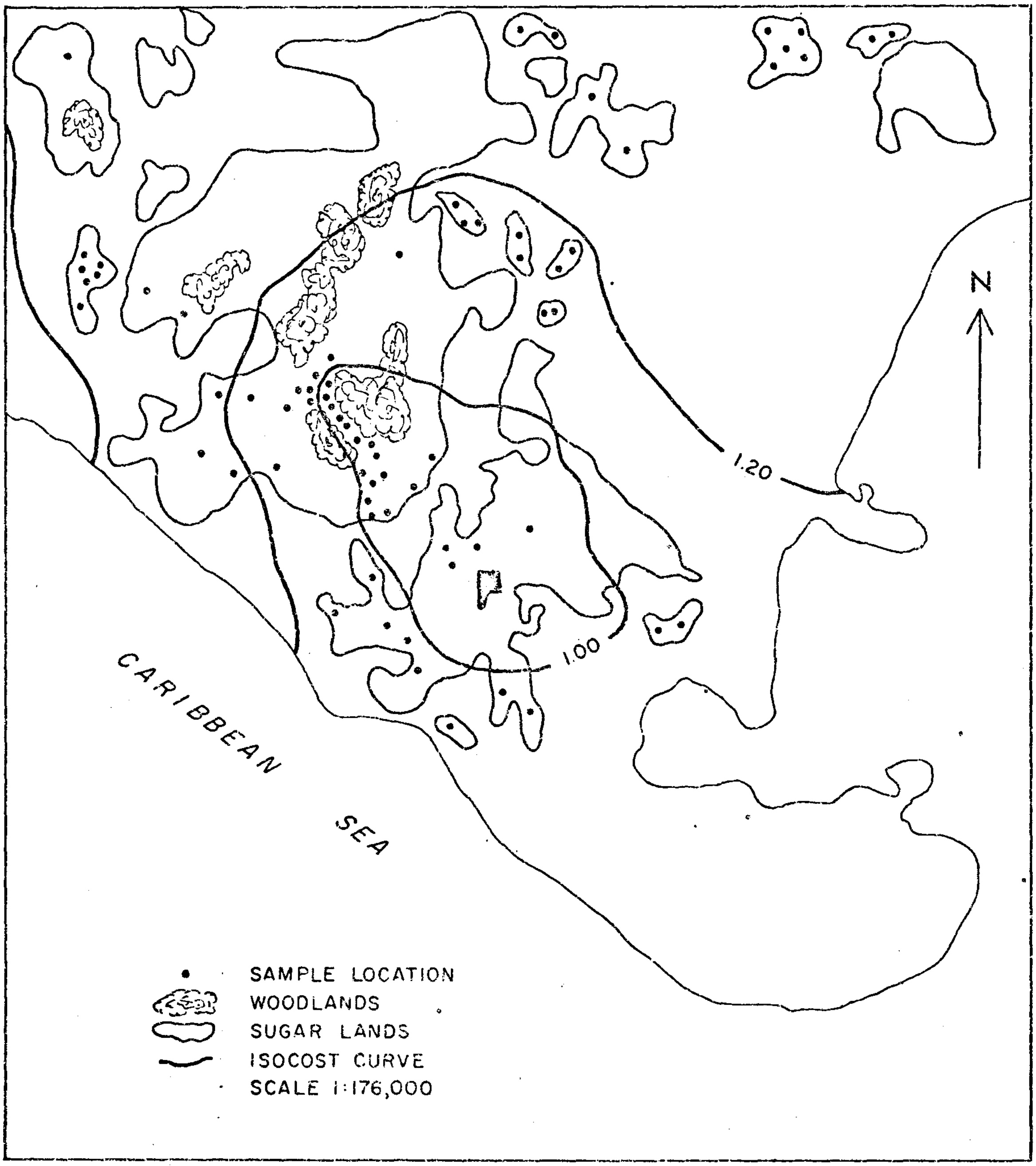
Although irrigation is adequate for supplementing natural rainfall, the large farmers are the ones who benefit most from the irrigation schemes, since the smaller farmers find it difficult to establish irrigation channel networks, and because the irrigation authorities prefer to serve the large farms. The result is that, in dry years, the very small farmers tend to suffer a greater fall off in production. All farmers are affected in some extremely dry years, by the incidence of salinity in overpumped wells.

(iii) Transportation

The area is served by an extensive system of roadways passable at most seasons of the year. It is one of the few areas in which transportation cost is closely related to distance (Map 8b). As a result, isocost lines are nearly circular around the factory. The mode of transportation include mule-carts, tractor-trailers, and trucks. In the early part of the decade, there was some transportation shortage due to congestion in the factory yards resulting in slow returns to fields. Since 1967, there

Map 8b

AREA 3 SAMPLE POINTS AND ZONES OF EQUAL TRANSPORTATION COST



AREA 3 TRANSPORTATION Map 8c

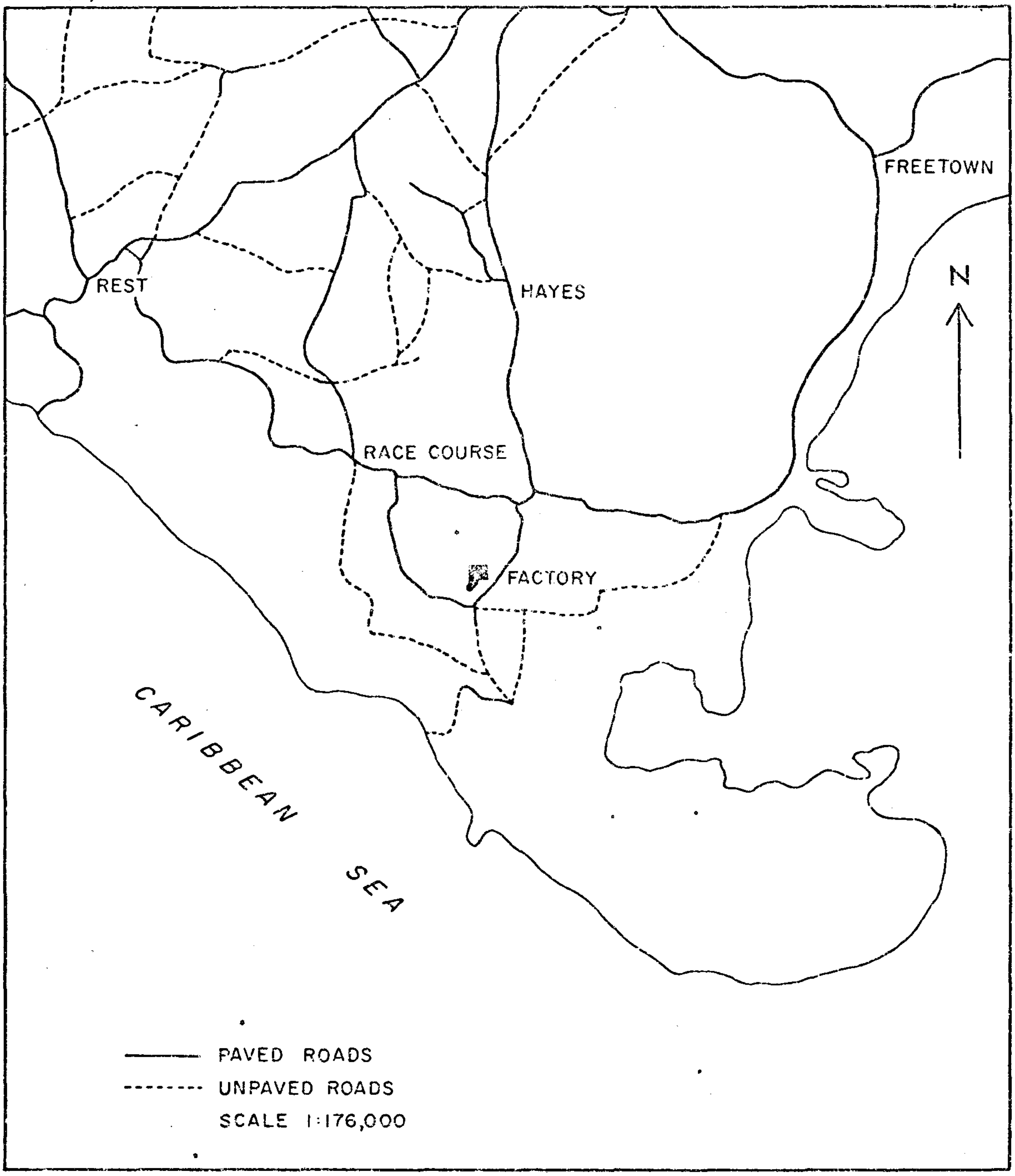


CHART 4

AREA 3: AREA SOIL CHARACTERISTICS AND GENERAL LAND USE

Soil Type	Limitations	Capability Class	Whether Suitable* for Sugar Cane	Major Land Use
1. Agualta Loam	none	1.	YES	Sugar cane with cattle grazing in second place. Both land uses are generally irrigated. Some coconuts are found along farm boundaries and river valleys.
Agualta Loam	slope 5° - 10°	2.	YES	
Agualta Loam	slope 10° - 20°	3.	YES	
2. Agualta Clay and clay loam	(a) Internal drainage	2.	YES	
	(b) Slope 10° - 20°	3. (4 where stones occur)	YES	
3. New Yarmouth Loam	None	1.	YES	
4. Halse Hall Clay	Poor Internal Drainage	3.	YES	

*YES - highly recommended
yes - recommended but notemphatically

has been a general movement of vehicles out of sugar cane haulage, mainly because of the shortage of loaders for the trucks.

(iv) Labour

The trend in labour supply in this area is characteristic of the trend in the island as a whole. The area is characterised by large pools of unskilled labour, but, at the same time, labour has become 'unavailable' for work in the sugar industry, and especially in the cultivation and harvesting phases. The respondents were emphatic on the point that the opening of the bauxite storage and shipping facilities in the area in 1966 and the mining operations some (12-14) miles away, accounted, among other things, for the dramatic fall-off in the supply of labourers in the sugar industry.

In summary, it may be said that there is a strong similarity in the organization of, and difficulties within the sugar industry among different regions. There are obvious physical differences depending on terrain and climate, but the human element and the conditioning of history results in a marked degree of homogeneity throughout the industry.

Tables 8 to 17 provide a summary of the relevant aggregate observations made in the various study areas. The graphs which follow, numbers 1 to 4, show the comparative trend of the observations on the supply of sugar cane for the three sample areas, distance categories, land and size classes.

TABLE 8

SUPPLY OF SUGAR CANE IN EACH AREA (1961-1969)
(TONS)

Year	Area 1	Area 2	Area 3
1961	33,334	67,111	73,441
1962	34,380	68,684	83,097
1963	36,610	83,420	84,121
1964	43,423	78,721	91,142
1965	48,412	83,360	105,423
1966	48,512	78,523	111,923
1967	44,104	66,110	96,801
1968	44,326	64,660	94,001
1969	32,210	67,511	81,911

TABLE 9

AVERAGE ANNUAL PRICE TON OF CANE ACCORDING TO AREA
(J$)

Year	Area 1	Area 2	Area 3	Ave
1959	5.48	5.23	4.90	5.20
1960	5.68	5.53	5.29	5.50
1961	6.04	5.70	5.27	5.67
1962	6.18	6.09	5.52	5.93
1963	8.62	7.98	7.87	8.16
1964	6.89	7.02	6.42	6.77
1965	5.83	5.86	5.50	5.73
1966	5.52	5.96	5.45	5.64
1967	6.33	6.10	5.96	6.13
1968	6.89	6.41	6.29	6.53
1969	6.80	5.86	5.92	6.19

TABLE 10

AVERAGE ANNUAL AMOUNT OF FERTILIZER USED ACCORDING TO AREA (TONS)

	Area 1	Area 2	Area 3
1961	33.1	67.2	65.5
1962	61.1	117.0	120.7
1963	67.2	124.8	130.1
1964	112.1	151.5	301.2
1965	113.2	149.0	304.0
1966	114.0	147.8	383.0
1967	90.3	75.2	290.0
1968	72.1	67.1	189.3
1969	37.5	72.3	178.2

TABLE 11

SUPPLY OF CANES (TONS) ACCORDING TO LAND CLASSES. (LAND CLASSES 1-5)

Year	1	2	3	4	5
1961	114,144	39,476	19,049	1,043	174
1962	120,410	42,418	20,837	1,943	553
1963	120,544	43,462	36,984	2,225	936
1964	136,106	45,443	38,057	2,124	656
1965	138,140	54,724	41,863	1,839	529
1966	137,086	52,261	47,075	1,935	611
1967	125,935	44,488	34,676	1,456	461
1968	119,066	46,233	35,984	1,335	369
1969	116,610	41,774	21,720	1,365	163

TABLE 12

TOTAL ACREAGE CULTIVATED 1961-1969

Year	Acreage
1961	7245.25
1962	7300.40
1963	7762.40
1964	7157.25
1965	7776.90
1966	7587.20
1967	7393.40
1968	7659.90
1969	7265.25

TABLE 13

AVERAGE PROFITS (J$/ACRE)

Year	Area 1	Area 2	Area 3	Overall Average
1959	43.4	41.87	39.98	44.75
1960	44.71	54.21	43.04	44.32
1961	57.52	56.87	55.29	56.56
1962	69.95	70.71	69.04	69.90
1963	110.75	109.65	104.75	108.35
1964	107.83	110.73	108.17	108.91
1965	78.29	78.03	76.21	77.51
1966	77.14	77.04	74.24	76.14
1967	70.39	66.85	69.37	68.82

TABLE 14

AVERAGE RAINFALL

Year	Area 1	Area 2	Area 3	Overall Average
1961	77.85	39.05	30.10	49.0
1962	86.08	39.58	31.30	52.32
1963	74.65	41.69	28.35	48.23
1964	93.10	56.22	35.30	61.54
1965	75.48	42.54	40.19	52.74
1966	75.60	31.66	29.41	45.54
1967	87.20	33.71	31.46	52.85
1968	99.45	39.90	22.21	50.20
1969	72.35	28.94	19.23	39.30

TABLE 15

SUPPLY OF CANES ACCORDING TO DISTANCE CATEGORIES 1-3
(TONS)

Year	1	2	3
1961	80,046	44,257	49,583
1962	85,148	47,177	53,836
1963	92,036	53,067	59,048
1964	98,045	55,653	59,588
1965	108,864	61,939	66,392
1966	103,386	64,446	71,136
1967	93,150	55,598	58,268
1968	89,221	56,367	57,399
1969	89,146	54,767	37,619

TABLE 16

TRANSPORTATION AVAILABILITY (AV)* IN TERMS OF FARMERS' AVERAGE WEEKLY CUTTING (W.C.) AS RELATED TO WEEKLY AVERAGE TRANSPORTED (A.T.)

Year	Area 1			Area 2			Area 3		
	W.C.	A.T.	A.V.	W.C.	A.T.	A.V.	W.C.	A.T.	A.V.
1961	2900	2050	70.7	5700	4000	70.2	5400	4410	81.7
1962	2400	2090	87.8	4890	4100	83.8	5700	4850	85.1
1963	2600	2320	89.2	5950	5470	91.8	5250	4620	88.0
1964	3300	3140	95.5	6090	5210	85.6	6000	5500	90.2
1965	3990	3985	99.6	6680	6680	100.0	6600	6600	100.0
1966	4280	4280	100.0	6970	6940	99.6	7000	7000	100.0
1967	3710	3320	89.5	5580	4730	84.9	5100	4200	82.3
1968	3930	2670	67.9	5750	3700	64.3	5700	4400	77.2
1969	2650	1870	69.8	5500	3025	55.0	5500	4000	72.7

TABLE 17

LABOUR AVAILABILITY (L.A.)[9] BY AREA IN TERMS OF NUMBER

OF WORKERS REQUIRED AND NUMBER OBTAINED*

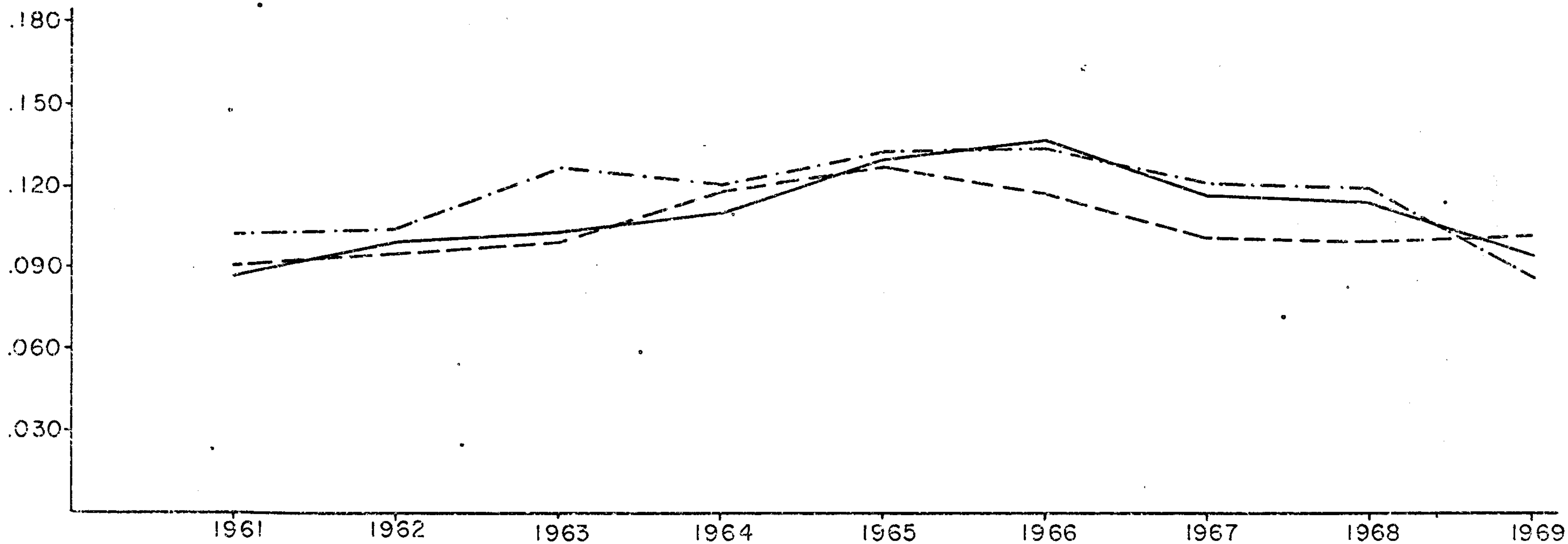
Year	Area 1			Area 2			Area 3		
	Reqd.	Obt.	L.A.	Reqd.	Obt.	L.A.	Reqd.	Obt.	L.A.
1961	326	326	100.	530	530	100.	403	403	100.
1962	340	340	100.	538	538	100.	412	412	100.
1963	355	355	100.	538	538	100.	412	412	100.
1964	378	378	100.	600	600	100.	433	433	100.
1965	378	378	100.	600	600	100.	433	431	99.6
1966	378	336	91.6	600	544	90.7	433	330	76.2
1967	378	324	85.8	600	492	82.0	433	345	79.7
1968	378	323	85.5	600	487	81.1	433	344	79.4
1969	378	272	71.9	600	414	69.0	433	309	71.4

[9] Note that labour availability L.A. = Reqd/Obt. x 100.

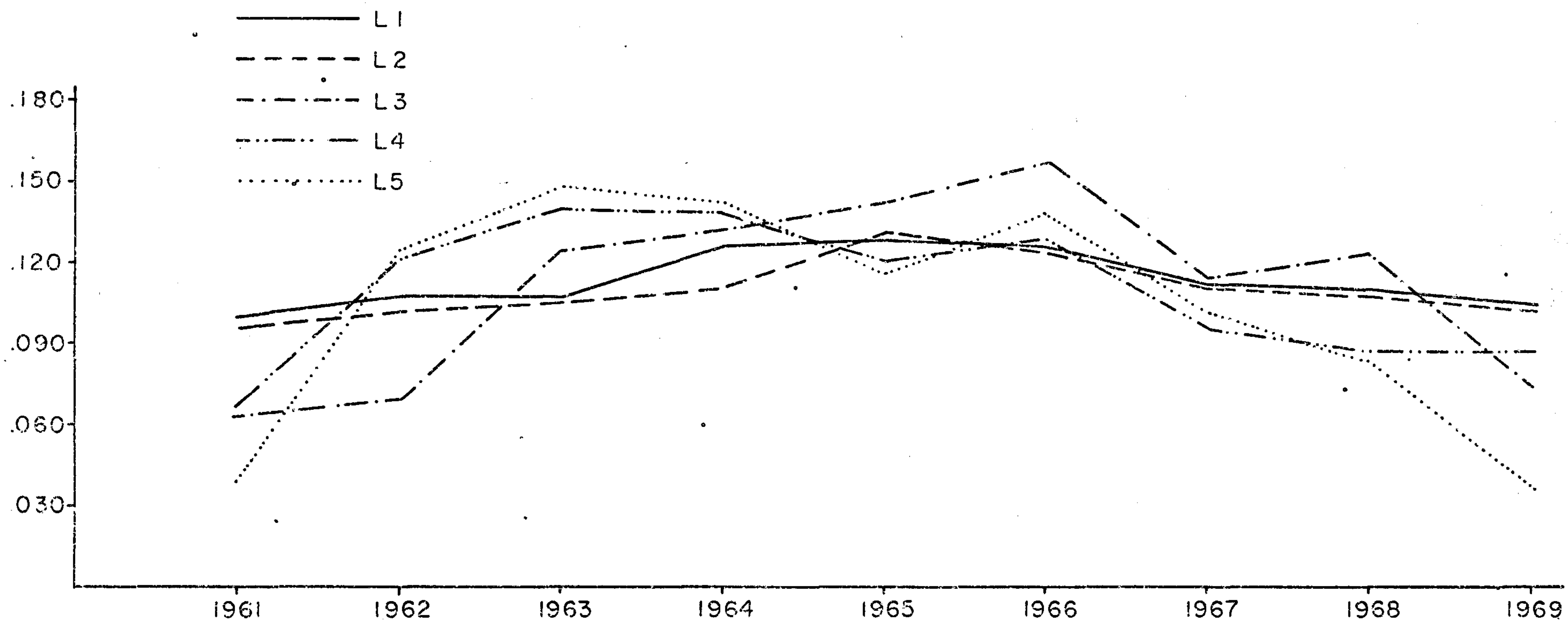
*In the cases where there was more labour available than required, the extra supply was not considered because of its uselessness in terms of diminishing returns and zero marginal productivity. This means that the average product per worker decreases and the marginal productivity of labour becomes zero when the labour supply curve is backward bending.

I: TREND IN PRODUCTION IN THE THREE AREAS SAMPLED

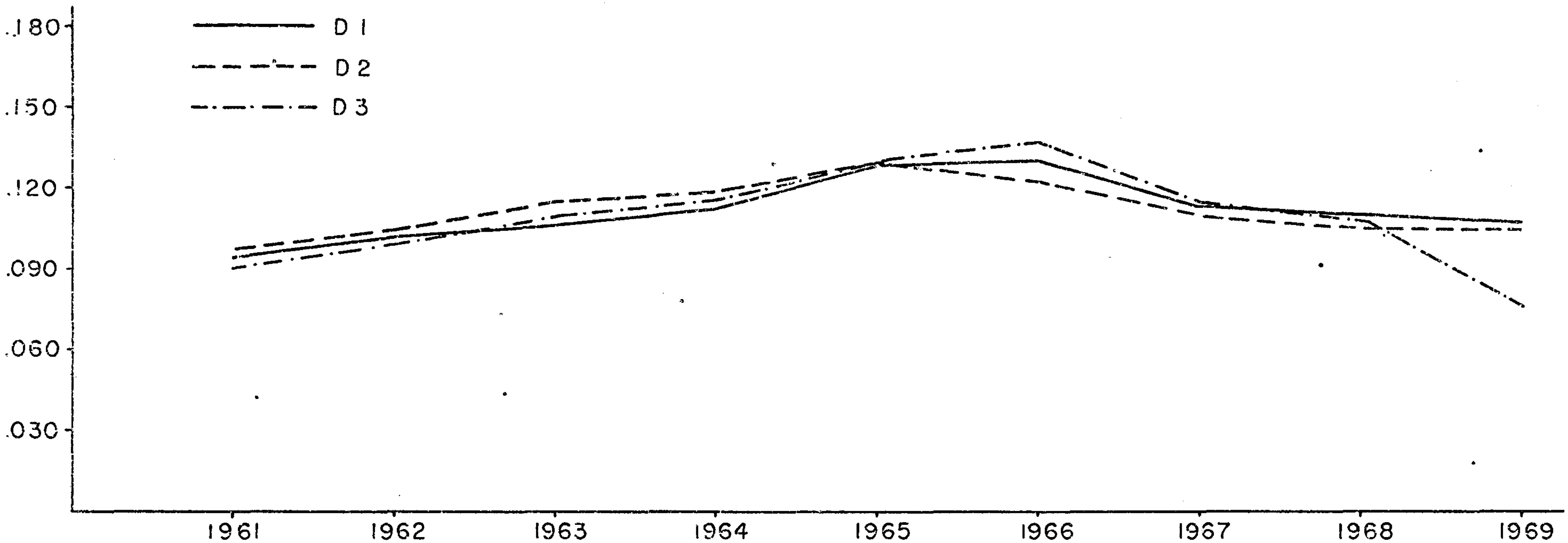
Y - AXIS IN ALL DIAGRAMS FACTORIZED FOR COMPARABILITY. TABLES 8, 11 -15 RELATE TO GRAPHS



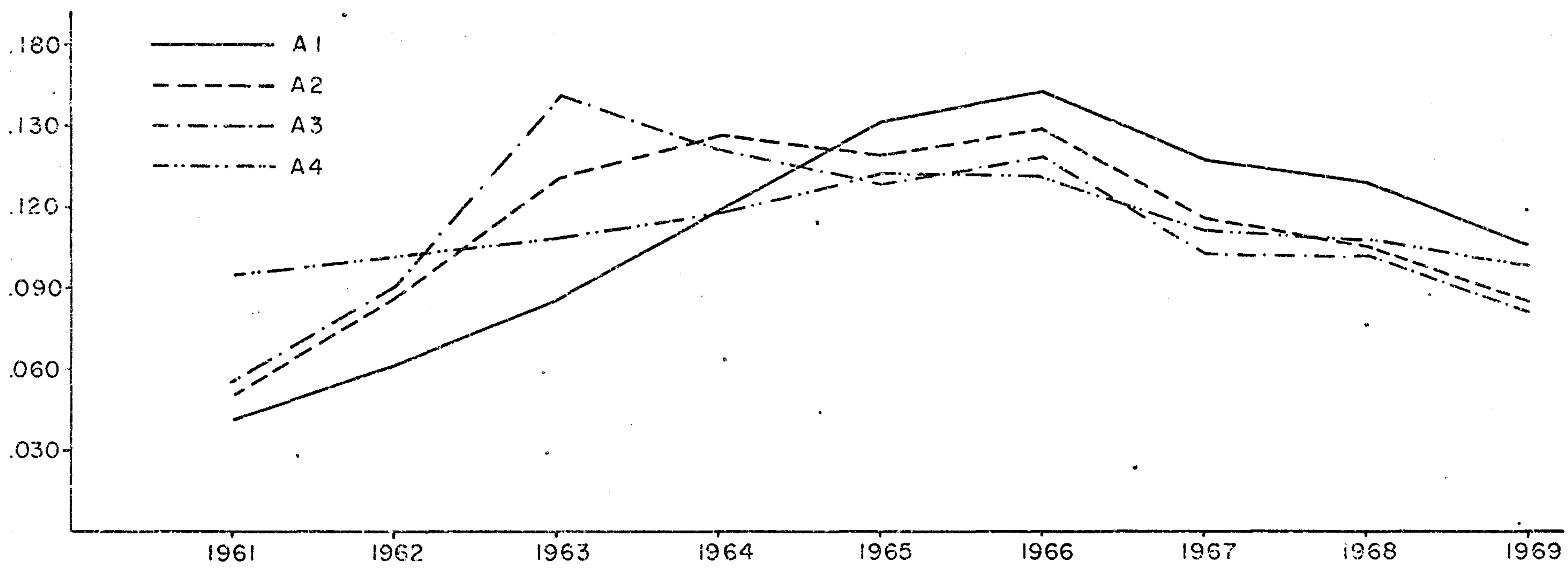
2: TREND IN PRODUCTION ACCORDING TO LAND CLASSES



3 : TREND IN PRODUCTION ACCORDING TO DISTANCE CATEGORIES



4: TREND IN PRODUCTION ACCORDING TO SIZE CATEGORIES



CHAPTER IV

FORMAL ANALYSIS AND INTERPRETATION

In this chapter, an attempt is made to operationalize the proposed statistical models. This involves testing the two hypotheses states in chapter three and repeated here for ease of reference. They are:

(1) The percentage change in individual sugar cane supply over time is a function of type of land, distance from factory, percentage change in price per ton of cane, and average annual rainfall in the production zones.

(2) Aggregate supply over time is a function of certain supply variables, viz:- use of fertilizer, average price of product, average rainfall, average annual profits per acre of land cultivated, availability of transportation, and availability of labour.

In addition, a thorough analysis is made of the personal interviews, to determine individual views of changes in levels of sugar-cane supply in Jamaica.

The basic assumptions of the analysis are similar to those usually made in other works involving the estimation of parameters from time series observations by the regression technique. These assumptions are that:

(1) There is a systematic association among the variables which hold through time.

(2) There is a linear relationship among these variables, and

(3) In the aggregate, average conditions have similar trend with respect to each observation.

A. THE DISAGGREGATE SPATIAL MODEL

For the first hypothesis, it is postulated that the relationship between percent change in individual output and the spatial variables may be approximated by the function:-

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_{7,t-2} + b_8x_8 + e_t$$

where, Y = percentage change in output

a = constant

b's = slope coefficient

x_1-x_5 = land classes 1 to 5

x_6 = distance from factory measured in terms of transportation cost

$x_{7,t-2}$ = percentage change in price with a two year lag

x_8 = rainfall in inches

e_t = random error term.

Table (18, a-e) below summarizes the distribution of the data used in the analysis of the change in sugar cane supply from 1961 to 1969. The results of the regression analysis[1] are summarized in the correlation

---

[1]Both the disaggregate and aggregate analyses were carried out using the BMDO2R stepwise multiple regression programme provided by the University of California computing facilities and available at the McMaster Computer centre. Thanks to Mr. McKenny of the McMaster Computer centre for guidance on the use of this programme.

SUMMARY OF DISAGGREGATE OBSERVATIONS

TABLE 18

(a)

Percentage change in Supply	-100	-100 to -50	-50 to 0	0 - 50	50 - 100	100
Percentage of observations 1961-1969	3.5	10.0	15.4	30.4	18.1	22.6
Percentage of observations 1961-1969	25.1	10.4	14.0	29.0	19.0	23.5

(b)

Land Class	1	2	3	4	5
Percentage of Total Observations	21.1	31.2	24.6	17.1	6.0

(c)

Rainfall Categories (inches)	0 - 29.5	29.6 - 50.5	50.6 - 70	70
Percentage of Observations (1966)	43.0	28.0	6.0	23.0
Percentage of Observations (1969)	43.2	27.6	7.0	22.2

(d)

Distance Categories ($)	.95	.96 - 1.05	1.06 - 1.20	1.20
Percentage of Observations	30.0	11.5	27.6	30.9

(e)

Percentage Change in Price 1961-1966	-12.0 to -10.1	-10.0 to -8.0	1.0 - 3.0	3.1-5.0	5.0
Percentage of Observations	18.1	6.6	17.0	54.8	3.5

Percentage Change in Price 1961-1969	0 - 2.9	3.0 - 5.0	11.0 - 11.9	12.0 - 13.9	14.0
Percentage of Observations	28.6	7.	16.1	42.2	1.1

TABLE 19

Variable No.	1	2	3	4	5	6	7	8	9
1	1.000	-.052	-.043	.156	-.041	-.049	-.049	.021	-.013
2		1.000	-.352	-.300	-.235	-.119	.056	.285	-.302
3			1.000	-.394	-.309	-.157	-.084	-.012	-.024
4				1.000	-.263	-.133	-.040	-.123	.074
5	SYMMETRICAL OPPOSITE				1.000	-.104	-.026	-.105	.165
6						1.000	-.199	-.080	.185
7							1.000	.271	-.197
8								1.000	-.900
9									1.000

The Relationship Between Percentage Change in Cane Supply (1961-1966) and the Spatial Variables.

Variables included 3, 4, 6, 7, 8, 9.

N = 199 R = .176 *F = 1.02

* significant at the 90% level

TABLE 20

Variable No.	1	2	3	4	5	6	7	8	9
1	1.000	-.045	-.055	.172	-.058	-.040	-.057	-.174	-.103
2		1.000	-.352	-.300	-.235	-.119	-.032	-.327	-.311
3			1.000	-.394	-.309	-.157	.032	.026	-.018
4				1.000	-.263	-.133	-.025	.008	.079
5					1.000	-.104	-.075	.210	.165
6						1.000	.169	.179	.178
7							1.000	-.030	-.187
8								1.000	.647
9									1.000

Correlation Matrix for Percentage Change in Cane Supply (1961-1969) and the Spatial Variables.

Variables included = 2, 4, 7, 8, 9.

N = 199 R = .261 *F = 2.343

*significant at the 95% level

TABLE 21

Correlation matrix showing the relationship between change in output between 1961 and 1969 for size category 1 and all independent spatial variables.

Variable No.	1	2	3	4	5	6	7	8	9
1	1.000	.157	-.099	.293	-.192	-.208	-.056	-.414	-.300
2		1.000	-.208	-.217	-.179	-.094	.002	-.319	-.298
3			1.000	-.424	-.349	-.184	-.125	-.023	-.059
4				1.000	-.365	-.192	.073	-.075	-.002
5					1.000	-.158	-.038	.199	.196
6						1.000	.144	.207	.122
7							1.000	.013	-.169
8								1.000	.722
9									1.000

N = 51

R. = .509

Variables included
2, 4, 6, 7, 8, 9
*F = 2.631

matrices of Tables 19 and 20. The most obvious observation, is the low correlation existing between the spatial variables and the percentage change in output.

A further breakdown of the data into the three sample areas made only limited improvements to the overall predictability of the model; the correlation coefficients for each area being .286 for area one, .434 for area two and .359 for area three. The best results were obtained when the regression was run for each size category as defined previously, viz; producers of:-

	$<$	20	tons
20	-	99	"
100	-	499	"
$\geq$ 500	-		"

The correlation matrix in table 21 shows the highest relationship among the variables. Even then, a combination of variables 2, 4, 6, 7, 8, and 9 explained only 26% of the variations in 1. The overall F ratio is only 2.631 which is significant at the 95% level.

One important observation which emerged from this analysis, however, is the consistently high association between percentage change in price (variable 8) and rainfall (variable 9). For the 1966 data, the correlation between these two variables is $R = -.90$. If it is borne in mind that the price paid to the farmer is based, among other things, on the sucrose content of the cane, in a normal year, it is expected that, areas with excessive rainfall would produce canes with relatively lower sucrose content and, therefore, receive relatively lower prices. In fact, the 1966 Sugar Manufacturers' Association's report corraborates this finding in stating that, 'the cane production for 1966 is three percent higher than in 1965, but sucrose content is eight percent less, except on the drier plains.[2]

(i) Failure of the Spatial Model

The failure of the disaggregate model to perform adequately may be due to any or a combination of the following reasons.

1. Inadequacy of the theory.
2. Inadequate specification of the model.
3. Lack of adequate data.

Starting with the third reason, it is doubtful whether the data could be substantially improved, seeing that they are obtained institutionally from one of the most developed industries in the island.

The second reason is more substantial. Firstly, absolute percentage change may not be the best measure of performance through time. The main reason is that farmers start at substantially different levels of production and, therefore, farmers who started with a low level of production will show a much higher percentage increase with only slight increase in actual output. The opposite is true for farmers with an initial high level of production. Therefore, a method of grouping farmers into categories by changes in production might seem to offset this weakness. This is done in further analysis as will be pointed out later. Secondly, the variables used in the analysis might not be affecting the farmers as assumed. In other words, the theory may be inadequate.

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[2]See Sugar Manufacturers Association's report for 1966, S.M.A. Research Department, Mandeville, Jamaica, 1966.

Most of the supply response models in agriculture are based primarily on assumed elasticity of supply with respect to changes in price of the product. Theoretically, the postulates of these supply models are internally logical but most of the assumptions on which they are based are too limiting; the result being that there is only scant evidence that these models hold in empirical works. For example, the theory does not consider whether there is extra land for the farmer to bring into production if prices increase substantially. Secondly, if increased non-land input is the important factor, it would be necessary to determine whether the farmer has enough liquid assets on which to subsist while he increases his productive investments.

Chapter one shows that the theory of agricultural supply is based largely on deductive reasoning, and even where there is empirical work, most of the models attain adequate predictability only at the aggregate level because the individual characteristics are subsumed at that level. In this particular study, the theory fails in light of empirical testing.

Since the model does not stand up to empirical testing, an attempt is made, by means of a new methodology and use of data from the questionnaire, to determine the factors which are related to the individual farmer's decision process.

The objective here is to examine, first, variables used in the disaggregate spatial model to explain their poor performance in that model and then to incorporate the questionnaire findings into the analysis.

The farmers are grouped into categories according to the percentage change in their sugar cane supply over the time period, and the categories are then cross-tabulated[3] with variables which could be associated with the individual producers.

The following categories are defined:- farmers whose change in supply over the time period is

1.	- 100 %		
2.	- 100	to	- 50 %
3.	- 50	"	0 %
4.	0	"	50 %
5.	50	"	100 %
6.	≥ 100		%

The first groups of data to be cross tabulated are those used in the regression model. The procedure involves detecting, by Chi-square statistics, whether or not two distributions are independent, viz; the farmers grouped according to percentage change in production, and the respective independent variables. If the distributions are not independent, then the next step is to determine where the association lies.

The distance variable is the first to be considered. It is grouped as follows;

GROUP	DISTANCE IN TERMS OF TRANSP. COST PER TON OF CANE (J$) (TON)
1	≤ .95
2	.96 - 1.00
3	1.01 - 1.20
4	> 1.20

The distribution of observations of this grouping is found to be

[3]The author wishes to thank Marianne Bayley of the Computer Centre at McMaster University for the many hours she spent adapting the Neucross programme to this problem.

independent of the distribution according to percentage change in the output at the 99% level (χ^2 tabled = 7.434, χ^2 calculated = 1.49). The data in the questionnaire provided a satisfactory explanation for the lack of significance of distance in the model. Transportation cost is used as the proxy for distance and question 10 (Appendix 6) provides the answer to the lack of signficance of the distance variable. Only 3.1% of the sample affirmed that increases in transportation cost caused an increase in production, apparently because they thought that there was need to maintain a certain net income by increasing total cane supply to offset the losses caused by the increases in transportation cost. 7.0% said it caused them to decrease production. However, 96.9% and 93.0% respectively answered that increases in transportation cost did not affect their level of production. The explanations given for the reaction to transportation costs are as follows:-

	EXPLANATORY RESPONSES	% OF OBSERVATIONS
1.	Once the cane is established there is <u>inertia</u>[4] to increases in transportation costs.	21.0
2.	Total profits affect us more than transportation cost alone.	16.0
3.	We own our own carriers.	13.0
4.	Transportation cost is only part of total cost.	36.0
5.	Transportation cost is definitely too high.	14.0

[4]Inertia. Underlining and wording are mine.

The answers given above, in addition to the fact that transportation cost increased only an average of 20 cents per ton over the 10 year period may explain the lack of significance of the distance factor.

The lack of significance of various soil types is more easily explained. Looking at charts 2-4 chapter 3, it is seen that land classes 1-3 are all recommended for sugar cane. Also most of the observations occur on these classes. The soils and technical guide sheets for Jamaica (1964), show that these soils are similar in their productive capacity for sugar cane but more costly land management practices are required to maintain productivity on the lower class land. There is no indication that the ratio of management costs for farms operated by farmers on different classes of land has been moving more rapidly against any particular set of farmers. Therefore, the land class variable shows up to be insignificant as a predictor of supply changes over time. The possibility exists however, that a different method of classifying soils would yield important results.

There is no denying that rainfall has a direct effect on sugar cane supply. However, a small percentage change in output by each individual farmer would not be easily related to small changes in rainfall. One would have to think in terms of the effect of rainfall in a rainfall 'zone'. This is particularly true in the case under investigation, where all of area three and part of area two are dependent on irrigation to supplement rainfall. As such, the full impact of rainfall cannot be evaluated unless some weighting is given to the irrigation component of total moisture intake.

The most controversial aspect of supply theory in the literature surrounds the effects on production caused by price changes. The major aspects of the controversy have been summarized in a recent work on subsistence agriculture in underdeveloped areas.[5] The concensus is that price is a major predictive variable under many special conditions. Firstly, there must be available land on which to expand production or the crop being cultivated should be responsive to ever increasing intensity of production. Secondly, farmers should be aware of the efficiency of factor inputs. Thirdly, there must be available information on alternative crops, and product and factor markets. Fourthly, the price factor works better for short-term crops.

Finally, the farmer's aversion to risk and uncertainty seems to be overcome only when the level of profits provided by price increases more than offset the certainty of a guaranteed price.

In the case of the Jamaican cane farmers, the reaction to price changes may be seen by the following summary of the responses to the question:- Whether the movement in price has caused an (a) increase or (b) decrease in their production. (See question 43, Appendix 6).

SUMMARY OF RESPONSES

	% OF RESPONDENTS	
	(a)	(b)
1. YES	0.0	1.5
2. NO	33.3	30.5
3. Have always regarded price as low but it does not affect farmer.	42.0	42.5

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[5]See Wharton, C. (ed.), Subsistence Agriculture and Economic Development, Aldine Pub. Co., (Chicago), 1969.

4.	Price certainty prevents deliberate fluctuation in production.	24.2	23.8
5.	Not certain.	0.5	1.0

This finding confirms the results of Gupta and Majid's work on sugar cane farmers in India. They concluded that farmers' cane supply was inelastic to price changes because of the annual security of income through guaranteed purchase.

The next step is to identify groups of farmers according to their cane supply characteristics and to attempt an association of related factors.

(ii) An explanation of individual supply

Age of farmer

The age structure is the first variable examined. It is found, however, that there is no relationship (phi sq. .228)[6] between the various categories of production changes and age. This is probably due to the predominance of old farmers in the industry. The age distribution is as follows:-

AGE	% OF OBSERVATIONS
0 - 49	8.0
50 - 59	31.0
60 - 69	56.0
≥ 70	5.0

In the 50 - 59 age group, only two percent are below 55 years old.

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[6]The phi sq. statistic is used to measure the relationship between two sets of non parametric distributions. For a summary of its use, see Hubert M. Blalock, Social Statistic, McGraw-Hill Book Co. Inc., 1960, pp. 229-34.

Size of farms

The first important positive finding is that percentage change in output is related to the size group of the farmer. (phi sq. .528). Probably the most important observations here concerns the percentage of the various size groups of farmers which had abandoned production. The percentages are as follows:-

SIZE GROUP	PERCENTAGE OF FARMERS ABANDONING
1	32.0
2	30.0
3	24.0
4	14.0

This shows the resistance of the larger farmers to abandonment. The general explanation is that their level of investment is so high that they tend to keep and maintain their fields as adequately as possible.

There are other characteristics of the larger farmers which contribute to their resistance to abandonment of sugar production. First, it was discovered through the questionnaire that although 25.1% of the sample had abandoned sugar production, only 12.5% of those with their own carriers had done so. Apart from the overall investment, those with carriers found transportation more available. A test of the relationship between ownership of carriers and the availability of transportation for all categories of production changes results in phi sq. values ranging from 0.550 to 0.799. The group with the highest <u>increase</u> in production shows the strongest relationship (phi sq. = 0.799), between ownership and availability of carriers.

Land class

The second valuable finding which is related to size categories is that land class and percentage change in output become significantly related when the analysis is controlled according to size of producers. The data are cross tabulated for each size category separately and the resulting phi sq. relationships are as follows:-

0.689	for	size	category	1
0.544	"	"	"	2
0.562	"	"	"	3
0.645	"	"	"	4

The existence of this important set of relationships is detected as a result of the distribution of the observations according to size and land classes. Only 4.5% of size classes 3 and 4 are on land classes 4 and 5, as compared to 17.5% of size classes 1 and 2. Furthermore, it has been pointed out previously that the larger producers (size classes 3 and 4) are more resistant to the abandonment of production. It follows then, that, the larger farmers who are located on the better land, are less susceptible to fluctuations in production.

Labour

The problem of labour has always been important to sugar cane farmers and the questionnaire brought out the fact that labour is generally in short supply. The following summary shows, for the total sample, the proportion of required labour available:-

PROP. OF REQUIRED LABOUR AVAILABLE	% OF SAMPLE
0 - 50 %	4.0
51 - 75 %	62.0
> 75 %	34.0

It should be pointed out, however, that a strong relationship (phi sq. .613) exists between the proportion of required labour available, and the proportion of family members who had continued working in sugar over the time period. In other words, those farmers with a high proportion of family members still on the farm found labour available; 25.6% of the total sample use family labour. However, the larger the farmer, the less likely it is that he would have members of his family working on his farm: The following summary shows the distribution of the use of family labour according to size category:-

SIZE CATEGORY	% OF SAMPLE USING FAMILY LABOUR
4	7.9
3	13.7
2	31.4
1	47.0

The implications are that sugar cane is no longer a viable family operation because it is the smaller farmers who cultivate sugar cane as a family concern, and, it is this group which is abandoning sugar cane growing most rapidly.

(iii) Inter-Activity Competition

One of the factors which is considered of vital importance in the analysis of supply changes in agriculture is the type of activities which compete for investments both in time and factor inputs with the crop under consideration.

It was found that occupation outside of agriculture was not very important for the farmers in the overall sample. In fact, only 21 of the 199 farmers had non-agricultural occupations which competed for time with sugar cane growing. Of these, 5 migrated, 7 obtained jobs with the bauxite company, 6 worked with the railway and 3 had become shopkeepers. Given the nature of sugar cane production, whereby it is easily possible to hold a steady job and carry on sugar cane production (and indeed many farmers do), it is reasonable to consider that migration is the only one of the four activities above which competes for time with sugar production.[7]

Alternative crops

More important is the type of agricultural activity which on some farms, has displaced sugar cane. The main such land uses are as follows:-

1. Bananas
2. Yams
3. 'Catch crops' like corn, peas, and pumpkins
4. Coffee
5. Plantains
6. Tobacco
7. Grass
8. Citrus
9. Limes

The important factor here is that in some cases, these crops are occupying land which was being used for sugar cane production. These substitute crops are directly related to rainfall zones and physiographic conditions. Crops 1-5 are substituted only in areas of higher rainfall and principally on hillsides, while crops 6-9 are substituted in the medium to low rainfall

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[7] Sugar cane cultivation is time consuming only during planting and harvesting. For those farmers who can hire workers and especially the very large farmers with overseers, their presence on the farm is rarely required.

zones of the interior basins and southern plains. In addition, the crops substituted on the low plains are, with the exception of limes, almost all cultivated by the larger farmers. The relationship between the variables, size group of farmer and type of substitute crop is phi sq. = 0.946.

The following table shows the percentage distribution of the substitute crops according to size groups of farmers. The crops are grouped as follows:- Crops 1-5, group 1; 6-8, group 2; and 9 (limes) group 3.

TABLE 22

PERCENTAGE DISTRIBUTION OF GROUPS OF SUBSTITUTE CROPS ACCORDING TO SIZE OF FARMER

Size of farmer	Crop Grouping		
	1	2	3
1	93.2	6.7	0.0
2	73.1	11.5	15.4
3	50.0	50.0	0.0
4	21.4	71.4	7.2

The table shows that crops in category one are more favoured by small farmers, while those in category two are favoured by the larger farmers. There is a tendency also, among the large farmers, to include poultry rearing as a secondary operation to their substitute crops. This activity, however, consumes very little land area and cannot be considered a major competitor for sugar cane land. Limes tend to be substituted with less regard for size. When the farmers were asked whether or not the crop they substituted was more profitable than sugar cane, 73% answered negatively while 27% answered in the affirmative. The majority of the 73% negative replies were from small farmers who further explained that they had substituted these crops because of lower labour requirements and because these crops provide a continuous source of income. On the other hand, the larger farmers explained that increased profits were their primary motive, followed by the lower labour requirements. The importance of this finding has strong implications for agriculture in most developing countries. The farmers are in need of financial resources. It is the larger farmer, in these countries, who has access to credit, and who also can plough back profits into his operations. He can, therefore, forego continuous (perennial) income unlike the small farmer; a fact which determines the type of crop which the farmer will plant given the physical possibilities.

This section would not be complete if the direct reasons for increases or decreases in supply were not given as the farmers stated them. The answers are combined to indicate whether the increases or decreases were planned by the farmer or resulted from forces beyond his control.

SUMMARY OF REASONS FOR INCREASE[8]

Planned		Unplanned
	% of Sample	
19.8		80.2

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[8] There is some amount of overlapping in the categories of planned and unplanned reasons. For example, poor maintainance may be due to neglect or due to shortages of labour, a problem over which the farmer has no control. Planned increases would refer to such things as increase in acreage, replanting or complete reaping, and fertilizer usage, while unplanned would refer to "weather conditions", "yields only" and "recovery of roots". Similar interpretations apply in the case of planned and unplanned decreases.

SUMMARY OF REASONS FOR DECREASE

Planned		Unplanned
	% of Sample	
29.2		70.8

The general attitude towards future production is one of pessimism. This is confirmed by the following summary replies which farmers gave to the question on their production plans.

PRODUCTION PLANS	% OF OBSERVATIONS
1. Will continue to produce.	27.7
2. Will continue to produce but will terminate production if labour difficulties increase.	18.5
3. Will definitely improve production.	7.5
4. Will improve only if labour and transportation improve.	9.1
5. Gradually abandoning cane growing.	7.5
6. Finished with canes but will return if solution is found to labour problems.	1.0
7. Definitely finished with cane production.	27.0
8. Uncertain.	1.0

When these answers are related to the various size groups of farmers, an interesting picture emerges. The smaller farmers are the most pessimistic. Of the 27.0% of the sample who indicated that they are definitely finished with canes, 70.5% are in size groups 1 and 2, while only 29.5% are in size groups 3 and 4. On the other hand, if the two replies, 'will definitely improve' and ' will improve if labour and transportation improve', are grouped as optimistic answers, we find that the distribution of optimists according to size groups is 30.3% for groups 1 and 2 and 69.7% for groups 3 and 4. It is also important to note that it is the larger farmers who are most positive about increasing production. The following summary shows the distribution of farmers who indicated that they would definitely increase production:-

SIZE GROUP	% OF FARMERS WHO WILL DEF. INCREASE PRODUCTION
1	13.3
2	20.0
3	33.3
4	33.4

A clear picture emerges then, that the larger farmers will have to be stimulated to increase their supply. There is every indication that the smaller farmers are not reliable producers and, therefore, any attempt to keep production viable must concentrate on the larger farmers.

Summary

An attempt has been made to differentiate among various types of farmers and to identify the forces affecting the supply among cane farmers in Jamaica. It is obvious that the farmers who have given their opinions consider the problem of supply somewhat differently from the assumptions made in the theoretical discussion. They also identified specific factors like transportation and availability of labour which were not given specific mention in the theory. In addition, the factors to which they attribute greatest importance are those which are, for all practical purposes, measurable over time only in the aggregate. It is, therefore, rational to apply these factors to an analysis at the aggregate level.

B. THE AGGREGATE MODEL

The aggregate model is designed to explain the variation in total supply through time. Such models are oriented to the type of policy which is formulated at the industry or national level and can successfully utilize variables which are measurable at these levels but related only with difficulty to the individual producer, especially when observations are to be made over time. The availability of transportation is a case in point. The format of supply analysis at the industry level presupposes aggregate response of the producers to certain variable processes. As indicated previously, the regression technique is particularly suited for this type of analysis, and as such, has been used with some amount of success.

The basic assumption here is that all producers face a similarly trending set of variables, and make similar responses. Unlike the case of cross-sectional observations, time series observations have the advantage that, it is not necessary to make any assumptions as to absolute levels of output or input, but only to note whether the directions of change of output among individuals are similar.

The model outlined here is a partial cobweb type, popular among the recursive programmers. This type of model assumes that the decision to produce is related to certain past observations on some independent variables, and in turn, present production affects certain factors in the future. It may be stated here that the assumption is relevant to the cane industry since consideration is being given only to that part of the model which looks at the effect of past observations on future output and not at the effect of present output on the future of the independent variables. In addition, the term 'partial' is associated with cobweb, to indicate that some independent variables are lagged, while others are associated in the same time period with the output. It has been pointed out previously that the two year lag on some variables is designed to take account of the time producers need to make effective structural changes on their farms.

Some of the factors selected for analysis at the aggregate level follow from the theoretical discussion. Price and profits are two such examples. However, it is the experience of scholars in the less developed countries and the responses of the Jamaican cane farmers which emphasize the importance of such additional factors as transportation and labour availability.

(i) The Industry Level

The function postulated to fit the model follows that used by Zepp and McAlexander[9] of the order;

$$Y_t = a + b_{1,t}x_{1,t} + b_{2,t-2}x_{2,t-2} + b_{3,t}x_{3,t} + b_{4,t-2}x_{4,t-2} + b_{5,t}x_{5,t} + b_{6,t}x_{6,t} + e_t$$

where, Y_t = total production

t = year t

$t-2$ = two years previous to year t

a = Y intercept

b's = slope coefficients

[9] Zepp, G.A. and R.H. McAlexander, "Predicting Aggregate Milk production: An Empirical Study", American Journal of Agricultural Economics, Vol. 51, 1969.

x_1 = total fertilizer used

x_2 = price of product

x_3 = rainfall in inches/annum

x_4 = annual profit/acre of land cultivated

x_5 = availability of transportation (% of required)

x_6 = availability of labour (% " ")

e = a random error term.

The variables used in the global model represent the values of the observations made in each of the sample areas. Tables 7-15 summarize the values of the variables found at the regional level.

It is usual, in time series literature, to include a variable "t" as a measure of technological change. This variable is, in fact, a measure of the rate of change when a pure trend function is fitted to time series observations. In this case, the assumption of constant technology rules out the inclusion of "t" and secondly, the use of the regression technique means that the rate of change associated with "t' is now indicated in the beta coefficients of the independent variables. For the computation, a stepwise multiple regression is adapted which brings the variables into the equation in the order of their contribution to the explanation of the variations in the data and terminates the programme when the F values becomes so low that further computation is impossible. The F-level chosen for inclusion or deletion is set at .05 for the purpose of the analysis. Table 23 below shows the observations used in the aggregate analysis.

TABLE 23

Year	Y	X_1	X_2	X_3	X_4	X_5	X_6
1961	173,886	165.8	5.20	49.0	41.75	80.5	100.0
1962	186,161	298.8	5.50	52.32	44.32	85.0	100.0
1963	204,151	322.1	5.67	48.23	56.56	89.9	100.0
1964	213,286	564.8	5.93	61.54	69.90	90.0	100.0
1965	237,195	566.2	8.16	52.74	108.35	100.0	100.0
1966	238,968	644.8	6.77	45.54	108.91	100.0	85.2
1967	207,016	455.5	5.73	52.85	77.51	85.2	80.0
1968	202,987	352.5	5.64	50.20	76.14	70.0	79.8
1969	181,632	288.0	6.13	39.30	68.87	65.2	70.0

In the first run, two variables, rainfall and transportation, are eliminated because the F values are too small for inclusion. The variables which are incorporated are fertilizer, profits, labour, and price. Together, these variables account for 97.8% of the variations and the overall significance of the regression is 44.4 (F). It is interesting to note that of the 97.8% explanation, fertilizer usage accounts for 86.4%. Further examination of the equation,

$$Y = a + 55X_1 - 607X_2 + 806X_4 + 642X_6$$

shows that price paid, (X_2) had the wrong sign and, that the beta value is not significant at the .05 level.[10] In addition, price is the fourth

[10]The constant a in this case being 103,717.

variable entered in the equation, adding only 1.1% to the overall explanation. Table 24 below shows the order of entry and the contribution of each variable to the total R^2.

TABLE 24

Variable Entered	R	R^2	Inc. in R^2	F to Enter or Remove
2 (fertilizer)	.9293	.8635	.8635	44.2845
5 (profits)	.9595	.9206	.0571	4.3122
7 (labour)	.9834	.9670	.0465	7.0467
3 (price)	.9889	.9780	.0109	1.9855

It is decided, therefore, that the inclusion of price does not add to the efficiency of the overall performance of the model. However, before this variable is dropped from the equation, it is observed that there is some degree of multicollinearity between X_2 (price) and X_4 (profit), and for this reason, the effects of each of these variables should be evaluated before a decision is to be made to delete one. This means the inclusion of variable X_2 in the equation before X_4. When this is done, the overall model deteriorates rather than improves, and at the same time, the transportation variable is forced in at a very low F value. The overall F value declines to 11.435, while none of partial F's is significant at the 90% level. It is obvious, therefore, that the most stable and significant relationship would result from the inclusion of the profit variable, and the exclusion of the price variable. (Note the findings of Gupta and Majid outlined previously).

The result of this step is a final acceptable model as follows:[11]

[11] The constant in this case being 96687.

$$Y = a + 62X_1 + 559X_4 + 476X_6$$

Table 26A, B, C, summarizes the mean and standard deviation of variables, correlation matrix, and the first preliminary summary table. Table 27A, B, C, summarizes the results of the final model. The overall F ratio of 48.897 means that the regression is significant at the 0.01 level. All the beta values are significant at the 0.05 level. The test of significance of each variable, using the partial F, showed that X_1 and X_6 are significant at the 0.05 level, but X_4 is not significant.

The final coefficient of determination, (R^2), is .967, which indicates a good fit for the data. The following table, (25), shows the relationship between the observed and predicted values of the dependent variable over the time period. All the residuals are within $\pm$ 2 standard deviations from the regression, and over 90% within one standard deviation.

TABLE 25

Y Observed	Y Predicted	Residuals	Normal Deviate
173,886	178,008	-4122	-.78938
186,161	187,854	-1694	-.32416
204,151	196,105	8045	1.54060
213,286	214,322	-61039	-.19834
237,195	240,418	-3217	-.61601
238,968	238,513	455	.08718
207,016	206,677	339	.06485
202,987	197,942	5045	.96608
181,632	185,449	-3817	-.73088

TABLE 26

VARIABLE	MEAN	STANDARD DEVIATION
Y	205,031.3333	22,740.0725
X_1	406.5000	160.57049
X_2	6.0811	0.8960
X_3	50.1911	6.0457
X_4	71.3677	24.4324
X_5	85.0000	11.9895
X_6	90.5555	11.8438

TABLE 26B

CORRELATION MATRIX

Variable	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.000	.929	.778	.251	.886	.771	.090
X_1		1.000	.688	.353	.799	.920	.023
X_2			1.000	-.011	.843	.567	.048
X_3				1.000	-.098	.412	.599
X_4					1.000	.496	-.279
X_5						1.000	.594
X_6							1.000

TABLE 26C

PRELIMINARY SUMMARY TABLE

	Beta Coefficient (STD error in brackets)			
Constant	X_2	X_3	X_5	X_7
103715	55.	-607.	806.	642.
	(19.)	(431.)	(219.)	(201.)

TABLE 27A

FINAL SUMMARY TABLES

Model $Y = a + b_{1,t} X_{1,t} + b_{4,t-2} X_{4,t-2} + b_{6,t} X_{6,t} + et$

	Beta Coefficients		
Constant	X_1	X_4	X_6
96607	62	559	476
	(21)	(144)	(179)

Figures in brackets indicate standard errors

TABLE 27B

ANALYSIS OF VARIANCE TABLE

	Degree of Freedom	Sum of Squares	Mean Sq.	F. Ratio
Regression	3	40005270	13335090	48.897*
Residual	5	1363602	272720	

*Significant at the 0.01% level

TABLE 27C

Step	Variable (X) Entered	Multiple R	R^2	Inc. in R^2	F to enter or remove	STD error of regression
1	1	.9293	.8635	.8635	44.2845	
2	4	.9595	.9206	.0571	4.3122	
3	6	.9884	.9670	.0465	7.0467	5222

In this work, an important step is taken to link analysis at the individual level with analysis at the aggregate level. This is done by analysing the result of the questionnaire given to all the producers in the sample. The outcome is an identification of the way in which farmers see themselves in the production process. There is no single overall theory which may describe the different modes of behavior of each individual. Rather they have to be sorted into various types for meaningful results.

The questionnaire also helps to identify broad factors which farmers consider as important, such as the availability of transportation. The incorporation of these factors in the aggregate analysis led to meaningful results. However, one must be aware that, in the aggregate, much information is lost and therefore, policies which emerge from the analysis of aggregate data must show cognizance of this fact.

Mo proposed that there should be a more rigorous test for the significance of a model from time series data than the usual high correlation of determination.[12] He proposed that the alternative test

[12] Mo, William, An Economic Analysis of the dynamics of the United States wheat Sector, U.S. Dept. of Agri. Econ. Research Service, 1968.

for the significance of a high R^2 be the measure called Theil's-U,[13] which is as follows:

$$U = \frac{\sqrt{\left(\frac{1}{n}\right) \sum_{t=1}^{n} \left(F_t^* - F_t{}^2\right)}}{\sqrt{\left(\frac{1}{n}\right) \sum_{t=1}^{n} F_t^{*2}} + \sqrt{\left(\frac{1}{n}\right) \sum_{t=1}^{n} F_t{}^2}}$$

where, F^* = predicted value at time t

F_t = observed value at time t.

The higher the predictive power of the model the closer is U to zero. In this case the Theil's-U result is .00947.

When the model is placed in the real world situation, some striking results are found. In the case of fertilizer usage, the beta value is 62 with a standard deviation of 21. The beta value measures the marginal change in Y associated with unit change in the X,s. In this case, we are interested in the increment to Y which will result from an increment of one unit of fertilizer. This involves taking the partial derivative of the whole expression keeping everything else constant. With respect to X_1, we get:

$$\frac{dY}{dX_1} = 62 \pm 21$$

meaning that, with the additional input of one ton of fertilizer, we expect a return of 62 $\pm$ 21 tons of sugar cane. We must remember that no cognizance is taken of the previous level of inputs. The above expression

[13] See eg., H. Theil, Economic Forecasts and Policy, North Holland Publishing Company, Amsterdam, 1961.

is reasonable since the average yield for farmers over the nine year period is 27.46 tons per acre, and the recommended fertilizer application is one ton to five acres. With this increase in the application of fertilizer, the farmers' output would be expected to be raised to between 35.66 and 42.06 tons per acre. These are very reasonable expectations, since they approximate the output on the estate farms, which are all fertilized. A qualifier should be brought in at this stage to show that the marginal value will not hold over the whole range of the function. At some stage, the returns to fertilizer will begin to fall. Therefore, these aggregate results should be combined with the results from response studies carried out on experimental plots so that the farmer can be given advice as to the exact changes that will take place in production at each level of fertilizer application.

The method of computing the marginal returns applies also to the other variables in the equation. Therefore, to find out the marginal output of sugar cane when there is an increase of one unit of labour, or a unit of profit, would involve partially differentiating the whole expression with respect to X_6 and X_4.

If we want to compare the percentage change in production with the percentage change in any of the input factors, the elasticity, associated with each of the X values, can be calculated using the following formula:-

$$\frac{dY}{dX_1} = bi \frac{Xi}{Y}$$

where, Xi = the input variable

bi = the slope coefficient

Y = the output

and the values of Xi and Y are taken at their arithmetic mean. In the case of the Cobb-Douglas function, the Xi and Y values are taken at their geometric mean, i.e., where the log of the Xi and Y values assume their respective means. Heady and Dillon found that the results, using either mean, are almost similar.

(ii) The Regional Level

At the overall aggregate level the model

$$Y = a + b_{1,t}x_{1,t} + b_{4,t-2}x_{4,t-2} + b_{6,t}x_{6,t} + e_t$$

provides a good estimate of the supply of sugar cane by Jamaican sugar cane farmers. It is hypothesized that the same model should perform adequately in the various regions. Tables 28A, B, and C show the correlation matrices for the total set of variables for each of regions one to three.

The model fits regions two and three where the coefficients of determination (R^2) are .7770 and .9678 respectively. In region one, however, the model does not work at the 0.05 F level. Only when other variables are introduced does a good fit emerge, and then it is rainfall, rather than labour, which is combined with fertilizer and the regional profits to produce the best fit resulting in a coefficient of determination (R^2) of .9529; the model being

$$Y = a + b_{1,t}x_{1,t} + b_{3,t}x_{3,t} + b_{4,t-2}x_{4,t-2} + e_t.$$

Tables 29, 30, and 31 summarizes the results of the application of the models in the three regions. One will observe that the models for regions one and three fit much better than that for region two. Here, we are dealing with two regions which are diametrically opposite as far as water supply is concerned. Region one depends solely on rainfall for its water supply. The fact that rainfall enters the model, confirms the hypothesis made in chapter three and earlier in this chapter that the effects of rainfall will not emerge fully when mixed with the irrigation components. It is only in region one that rainfall is the only source of 'direct' water input, whereas in region two there is some irrigation and region three is almost all irrigated. As such, the significance of rainfall would not become obvious in a statistical model unless some means were found to weight the irrigation component. In region three the model is applied to a particularly dry area and, therefore, there is less 'noise' in the observations. In region two, the model is fairly predictive accounting for a 77.7% explanation but a higher explanation was expected. The reader will, however, recall from chapter three that this region is divided into a southern portion, which relies on irrigation, and a northern portion, which has adequate natural precipitation. This is the area with the strongest hybridized observations and, therefore, the greatest amount of noise in the model. It may be concluded then, that the two models perform best in extreme cases and only adequately in mixed regions.

An examination of the beta coefficients for the variables in the model for each region points to possible informative conclusions. The reader is reminded that the author is attempting only an explanation of the variations in the betas, the results of which he does not consider incontrovertible. In the case of X_1 (fertilizer) the beta or response

TABLE 28A

CORRELATION MATRICES FOR AREAS ONE TO THREE

Variable No.	1	2	3	4	5	6	7
1	1.000	.905	.561	.261	.860	.619	.125
2		1.000	.515	.228	.727	.819	.213
3			1.000	-.454	.789	.607	.143
4				1.000	-.146	-.170	.033
5					1.000	.528	.170
6						1.000	.508
7							1.000

TABLE 28B

Variable No.	1	2	3	4	5	6	7
1	1.000	.877	.589	.416	.443	.773	.573
2		1.000	.597	.484	.480	.827	.607
3			1.000	-.014	.912	.547	.042
4				1.000	-.134	.269	.655
5					1.000	.517	-.144
6						1.000	.649
7							1.000

TABLE 28C

Variable No.	1	2	3	4	5	6	7
1	1.000	.922	.760	.229	.975	.602	-.462
2		1.000	.627	.373	.894	.625	-.350
3			1.000	.446	.830	.628	-.080
4				1.000	.249	.765	.676
5					1.000	.608	-.425
6						1.000	.355
7							1.000

SUMMARY TABLES (Region 1)

TABLE 29A

Model $Y = a + b_{1,t}x_{1,t} + b_{3,t}x_{3,t} + b_{4,t-2}x_{4,t-2} + e_t$

Constant	Beta Coefficients X_1	X_3	X_4
79208	79 (31)	173 (77)	162 (43)

Figures in brackets indicate std errors.

TABLE 29B

ANALYSIS OF VARIANCE TABLE

	Degree of Freedom	Sum of Squares	Mean Sq.	F. Ratio
Regression	3	319739	106580	33.7*
Residual	5	15813	3163	

*Significant at the 0.01% level

TABLE 29C

Step	Variable (X) entered	Multiple R	R^2	Inc. in R^2	F to enter or remove	Std error of regression
1	1	.9045	.8182	.8182	31.5	
2	4	.9513	.9049	.0867	5.5	
3	3	.9762	.9529	.0480	5.1	1778

TABLE 30A

SUMMARY TABLES (Region 2)

Model $Y = a + b_{1,t}x_{1,t} + b_{4,t-2}x_{4,t-2} + b_{6,t}x_{6,t}x_{6,t} + e_t$

	Beta Coefficients		
Constant	X_1	X_4	X_6
45666	53 (7.9)	333 (96)	92 (22)

TABLE 30B

ANALYSIS OF VARIANCE TABLE

	Degree of Freedom	Sum of Squares	Mean Sq.	F. Ratio
Regression	3	372536	124179	5.806*
Residual	5	106934	21387	

*Significant at the 0.05% level

TABLE 30C

Step	Variable (X) entered	Multiple R	R^2	Inc. in R^2	F to enter or remove	Std error of regression
1	1	.8770	.7691	.7691	13.3129	
2	6	.8785	.7717	.0026	.0691	
3	4	.8815	.7770	.0053	.1182	4624.6

TABLE 31A

SUMMARY TABLES (Region 3)

Model $Y = a + b_{1,t}x_{1,t} + b_{4,t-2}\, x_{4,t-2} + b_{6,t}x_{6,t} + e_t$

Constant	Beta Coefficients X_1	X_4	X_6
66648	28.7 (1.9)	350 (90)	62.7 (8.3)

TABLE 31B

ANALYSIS OF VARIANCE TABLE

Degree of Freedom	Sum of Squares	Mean Sq.	F. Ratio
3	1059414	353138	50.109*
5	35237	7047	

*Significant at the 0.01% level

TABLE 31C

Step	Variable (X) entered	Multiple R	R^2	Inc in R^2	F to enter or remove	Std error of regression
1	4	.9755	.9516	.9516	137.5128	
2	1	.9819	.9642	.0126	2.1087	
3	6	.9838	.9678	.0037	.5672	2654

coefficient becomes smaller from region one to region three. At the same time, however, the coefficient for X_4 (profit) increases in the same direction. An examination of table 10 shows that the quantity of fertilizer used increases from region one to region three. It is well known in agricultural science that the response to fertilizer usage is higher at low levels of application and gets progressively less as the maximum level of usage is approached.

In the case of profits, one would normally expect the response to profits to be highest in the high cost areas. In the hypothetical case calculated for various types of farmers (Appendix 4), it is shown that the technical farmer in the dry areas has the lowest profits. It is reasonable to conclude, therefore, that response to increasing profits is stronger, the drier the region and consequently the higher the cost of production.

Summary

The major implications of the foregoing discussion are that one will have to think, not in terms of one set of relationships to explain supply of sugar cane among Jamaican cane farmers, but rather, of two sets determined mainly by physical conditions.

The analysis of supply among sugar cane farmers in Jamaica has resulted in a series of important findings. Firstly, the relevance of the present theory of individual behavior, at the farm level, is open to question. There is no denying the fact that theory has suggested important variables and direction of investigation, but some of the basic assumptions on which a model of changes in individual supply may be formulated, do not hold in many social and economic environments.

In the aggregate, however, good estimates of supply are obtained because several factors which are operational at the global level cannot be easily related to individual supply.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. THEORY AND TECHNIQUE

The major purpose of this study was to identify and evaluate relevant features of supply among Jamaican sugar cane farmers. The study was set within the framework of current theory of agricultural supply. This chapter will first summarize the findings which have implications for the theory of supply and then look at the empirical results. The concluding remarks contain a brief set of recommendations for research priorities in the sugar industry followed by some subjective statements on national policies.

Most of the controversy surrounding the formulation of an adequate theory of agricultural supply centres around whether economic or non-economic forces dominate the rationale of the farmer. Those who argue that economic forces are dominant assume that farmers will be economically rational in the face of any positive economic stimuli.

Those who argue that non-economic forces are dominant indicate that traditional farmers are dominated by sociocultural and/or institutional and/or motivational factors which reduce the economic rationality of the farmer.

The test of economic rationality is usually confined to the supply responsiveness of farmers to price changes. In this respect, Schultz, Nerlove, and Mellor[1] support the theoretical basis of the argument that most farm production is based on economic rationality. Much of the empirical work which supports price responsiveness is confined to situations where there is a large amount of land to be brought into production, and therefore, does not relate directly to the cases where land is limited and responsiveness is related to increased intensity of production.[2] This latter case would, in fact, measure the degree to which farmers are willing to risk liquid capital investment in the hope of increasing future economic returns. This would extend the range of factors of production from land and labour to include other inputs.

In the study of the Jamaican cane farmers, supply proved to be highly unresponsive to price. Some reasons are put forward in Chapter four, where the farmers' opinions are also stated. From the theoretical viewpoint, there are certain notable implications.

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[1]a) Mellor, J.W., The Economics of Agricultural Development, Ithaca, N.Y., Cornell Univ. Press, 1966.

b) Nerlove, M., The Dynamics of Supply: Estimation of Farmers' Response to Price (Baltimore, Johns Hopkins Univ. Press, 1958.

c) Schultz, T. Transforming Traditional Agriculture, (London and New Haven, Conn.: Yale Univ. Press, 1964.

[2]a) Behrman, J.R., "Supply Response and the Modernization of Peasant Agriculture: A Study of Four Major Annual Crops in Thailand", in Wharton, C.R., (ed.) Subsistence Agriculture and Economic Development, Aldine Pub. Co., (Chicago), 1969.

b) Falcon, W.P., "Farmer Response to Price in Subsistence Economy: The Case of West Pakistan, Am. Econ. Rev., Papers and Proceedings, Vol. LIV, No. 2, 1964, pp. 580-91.

Bauer and Yamey (1959)[3] summarize the implications as follows:-

> "There are ...... serious difficulties in measuring the degree of responsiveness of producers to price changes. There are the familiar problems arising from the usual absence in the real world of anything resembling closely the ceteris paribus of the theoretical formulations of functional relationships in economics. There are further difficulties created by the time lags between changes in agricultural capacity and changes in output; and also by the effects of uncertainty about the permanence of absolute and relative price changes. The problems of testing a hypothesis or measuring the strength of a functional relationship make it difficult to reach objective assessments and rival hypotheses are likely to flourish side by side, often deriving from opposing policy preconceptions and sometimes giving rise to opposing policy prescriptions".

Some of the recent empirical works in Africa and South East Asia question the validity of elasticity measurements which give no importance to the magnitude of the price movement which is necessary to bring about a response in supply. In addition, negative price movement does not necessarily induce a farmer to take part of his crop out of production or to neglect it especially when these are short run phenomena.[4]

The peculiar institutional and economic matrix of the Jamaican sugar industry contributed to the failure of the theory of supply response to perform adequately in light of the empirical test at the disaggregate level. Farmers in the industry are certain of a given range of prices for their product, which reduces the risk factor. As such, for the near subsistence farmer, risk aversion may be so strong that the rewards for

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[3] Bauer, P.T. and Basil S. Yamey, "A case study of Response to Price in an Underdeveloped Country", The Econ. Jn., Vol. LXIX, #276, 1959, pp. 800-805.

[4] Bateman, Merrill J., "Supply relations for Perennial Crops in the Less Developed Areas", in Wharton, (ed.) op.cit., p. 248.

returns above the expected value may not offset the severe penalties for returns below these values.[5] This contributes to supply rigidites in the industry. In addition, in the case of the Jamaican cane farmers, some areas provide little opportunity for alternative economic enterprise. In such ases, the physical limitations of the productive unit are camouflaged by increasing effort to survive. Moreover, where the farmer might have reacted to a favourable market situation, credit facilities and other factors of production are not available to permit the necessary efficient reallocation to take place.

The supply conditions of the Jamaican sugar industry point to further limitations of existing theory. The ceteris paribus assumptions of the theory, of necessity, omit certain 'active' factors. These include available labour and transportation. As far as this study is concerned, they can be accomodated at the aggregate level.

The aggregate supply model performs more in accordance with the hypothesized principles than does the disaggregate model. This is because it has identified and incorported peculiar institutional factors at this level, a feature which is impossible to capture at the disaggregate level. The English economist, Marshall substantiates this finding by stating that relations can be found to be theoretically 'normal' only for aggregates of a reasonable size. The single individual's supply and demand curves may be abnormal and yet the market supply and demand curves may be normal. One must however, remember that aggregation

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[5]Compare the findings of Gupta and Majid in India referred to in Chapter IV. See also the cases mentioned in Hansen, A., Economic Issues of the 1960's, (New York, McGraw-Hill, 1960).

necessarily captures only the broad attributes of the phenomenon being studied and, therefore, the interpretation of such a model must take cognisanze of this fact. When one is concerned with the overall effect of certain variables, it is the aggregate data which are most useful. The models formulated at this scale are advantageous to government policy makers who usually design broad policy measures at an industry level.[6]

Closely linked to the theoretical formulation are the techniques of analysis. It has been pointed out that the regression technique performed inadequately at the individual level. The explanation given is that the variables suggested by theory are not appropriate. At the aggregate level, the technique proved very useful. This is mainly due to the fact that, at this level, it is possible to identify more factors, relevant to agricultural supply, as the social and institutional matrix indicates.

Where the farmers' subjective opinions are concerned, the cross-tabulution technique is invaluable in capturing and associating relevant variables.

B. SUBSTANTIVE FINDINGS

Changes in supply among individual Jamaican cane farmers depend on several characteristics of the farmer. It is found that the size of the farmer is strongly related to the fluctuations in cane supply. Large farmers prove to be more resistant to abandonment and therefore, more reliable producers. The smaller farmers are less stable and are more susceptible to abandonment. Closely related to the size factor is

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[6] For a summary of the uses of aggregate models, see, Grunfeld, Y., and Z. Griliches, "Is Aggregation Necessarily Bad?" The Review of Econ. and Stats., Vol. 42, Feb. 1960.

the profitability of substitute crops. Large farmers abandon sugar cane only when the alternative is more profitable. The smaller farmers give consideration to the continuity of income from alternative crops.

Some of the broader categories of difficulties, like labour and transportation, affect farmers regardless of size. However, the larger farmers are more likely to own carriers and, therefore, their transportation difficulties are reduced somewhat.

At the aggregate level, fertilizer proves to be the single most important factor causing short-term fluctuations in supply. Of course, the decision to use more fertilizer is dependent on several subsidiary factors such as previous prices and profits. The application of purchased fertilizer is also partly dependent on the weather. The aggregate results are spatially consistent at the regional level, where, in two out of three regions, fertilizer again proves to be of primary importance.

In one region, rainfall proves to be significantly related to output mainly because it is the only source of 'direct' water for agriculture in that region.

C. RECOMMENDATIONS

The future of the Jamaican sugar industry is questionable. It has been pointed out in Chapter 4 that most of the farmers are wavering between abandonment and continued production. The problems which they identify, such as, labour and transportation availability, are difficult to deal with at the governmental level, especially since the economic and political system advocates free enterprise.

(i) Research Priorities

Efforts to construct workable models for supply in the Jamaican sugar industry should concentrate research in the following areas:-

1. To determine precisely the framework of rationality within which the farmer operates. Economists, sociologists, and anthropologists tend to look at rationality from different angles. It is necessary, then, to find out what the cane farmer maximises; is his desire for 'gain' strictly economic or are there other motives like leisure, welfare, and prestige. When these have been determined, the next step is to trace the rationale by which farmers react to certain stimuli over time.

2. To carry out an investigation of the values, motives, attitudes, and aspirations of the farmer so that a better body of theory may be defined. Some work has been done by Doob in Jamaica to test for the presence of a subculture of peasantry, viz., mutual distrust, lack of innovativeness, fatalism, low aspirational levels, lack of deferred gratification, limited time perspective, dependency upon government authority, localiteness, and lack of empathy. The study was confined to the peasantry of the margin of commercial farming and, therefore, has only tenuous relevance to the cane industry. The groundwork for such studies has, however, been broken.

3. To analyse the efficiency of resource use. This involves measuring the degree of efficiency of resource allocation by different farmers and the process by which the efficiency has been arrived at. Secondly, of considerable relevance, is the degree to which variations in performance among farmers reflect the environmental characteristics.

These would encompass the whole range of physical, social, and institutional 'blockages' affecting the farmer.

4. To observe the movement in terms of trade between the sugar industry and other sectors of the economy. The fact is that a farmer may consider factors outside of the sugar industry of direct importance to his production decision. For example, he may face rising cost of clothing with no compensatory rising profits in sugar cane farming. The terms of trade have,therefore, turned against him, and he might regard this as reason enough for the abandonment of sugar cane farming.

5. To consider the effects of the presence of viable alternatives. An adequate explanation of the behavior of farmers in one sector is impossible without a knowledge of the alternative opportunities open to him. Alternatives may be in the form of crops or non-farm occupations which satisfy the aspirations of the farmer.

6. To incorporate the effects of the farmers outlook on the future of the sugar industry.

(i) Supply response in agriculture involving semi-permanent and permanent crops does not necessarily follow the same pattern as in the case of seasonal crops. Where there is a bright future for the particular crop, farmers may increase their investments. However, where the future is dull, the farmer may gradually 'phase out' of that particular crop. It follows, then, that research into the farmers' outlook on the future of the industry as a whole, will give the psychological framework for analysing supply among cane farmers.

(ii) Policy Implications

In the introduction to this work, the statement was made that it is government or national policy to keep the sugar industry viable. It has been demonstrated also that there are certain economic and institutional factors which directly affect the farmers' cane supply and which may serve as the basis of policy formulations.

Firstly, it seems that future output has to be concentrated in the hands of the larger farmers. These are the farmers who are more resistant to abandoning production and who are most responsive to profits. This is not to say that small farmers should be encouraged to leave the industry. Rather, it is not worthwhile to waste incentives in this direction. It may be argued that increasing farm size may contribute to increasing production. However, the author would not argue along lines which would affect the present system of land tenure among farmers. Large holdings of land have not been socially acceptable for a long time and any direct policy from the government in this direction may not meet with the best reception.

The second major policy implications centre on forces which work in the aggregate. In this respect efforts should be made to increase fertilizer usage, and to make more labour and transportation available to the farmer. The question of fertilizer usage goes hand in hand with the levels of profits which would be forthcoming from increased factor inputs. If the assumptions of economic rationality were to operate among the Jamaican cane farmers, one would expect them to increase fertilizer application substantially. It was pointed out earlier in this work that the return to fertilizer applied at about 1 ton to 5 acres would be between 35.66 and 42.06 tons of cane per acre, i.e.,between 8 and 15 tons (approx.) above the current average of 27.46 tons per acre. The cost of effecting this increased production and selling it would be as follows. (Cost data in Appendix 3). Assuming a simple average of the two figures (8 + 15) tons = 11.5

Purchasing fertilizer	J$/acre 8.08
Transporting "	.50
Application "	1.00
Cutting extra 11.5 tons	6.90
Loading " "	4.50
Transporting extra 11.5 tons	14.37
Cess " "	.80
	J$ 36.15

Assuming a revenue of $6/ton

Total income = $69
Total profits = (69 - 36.15) = $32.85/acre

Theoretically, this type of incentive should bring more investment in fertilizer but it has been shown that although fertilizer prices have been declining through government subsidy and builk handling by the CFA, there has not been a concomitant increase in usage. The author fears that it profits cannot be increased through reduction in cost and/or increasing prices (which are structurally rigid), then increasing fertilizer usage may be forthcoming only through further government subsidy on fertilizer prices. The whole problem of increasing subsidy to stimulate production needs thorough investigation.

Increasing the availability of labour and transportation is even more difficult under a free enterprise system. It is virtually impossible to force labourers to work. The alternative is the suggestion that mechanization be increased. The author sees mutual conflict between the objectives of the government to keep labour employed and any proposal to increase mechanization. However, when one remembers that labour has become unavailable, a policy of mechanization may be particularly attractive. The major problem is whether it is economically feasible to mechanize sugar production in the Jamaican context. More study would have to be done in this direction.

Attempts have already been made to increase the number of available cane carriers in the Jamaican sugar industry (Appendix 1). While the author was in the field in 1970, there were strong suggestions that the policy to increase transportation had not been effective over the first year, i.e., the 1969-70 crop.

So far the policy alternatives which have been suggested retain the basic objectives of maintaining certain levels of production and at the same time attaining maximum employment in sugar production. An interesting suggestion is that government give careful consideration to the possibility of further intensifying production by using labour saving devices. This is posited on the assumption that the increasing returns would bring about sufficient revenue from which some sort of transfer payment could be made to the workers who were displaced by the labour saving technique. This situation would result in the attainment of two objectives. The first is the maintainance of adequate cane supply. The second is the provision of an acceptable standard of living for those people who would normally have been directly employed in sugar.

In the final analysis, however, the national planners must continue to review the overall national policy with respect to revenue and employment. If suitable alternatives can be found for sugar cane, then the policy would be to gradually phase out without causing any serious economic disruptions.

(iii) Techniques of Investigation

In terms of methods of investigation, the interview technique is strongly recommended. While it is true that a wide range of data exist at the institutional level, such data lead to research only along traditional lines. It is the response of the individual farmer which will determine the outcome of the research priorities set out above.

The major difficulty to be overcome with the interview technique is to design it for application in an environment where the level of education is relatively low. The questionnaire used in this research has, at least, broken the ground for future work.

APPENDIX 1

APPLICATION FOR DUTY FREE VEHICLE AS A RESULT OF THE STUDY OF THE SHORTAGE OF TRANSPORTATION FACILITIES IN THE JAMAICAN SUGAR INDUSTRY

TO:- THE COLLECTOR GENERAL,
KINGSTON.

Date.............

I do hereby apply for the duty free purchase of a vehicle to be used exclusively in the haulage of sugar cane.

I further agree to the following:-

(i) The units will be used exclusively for the haulage of sugar cane during the harvesting of the crop.

(ii) When crop harvesting has been completed, the units will be laid up and the licence plates removed and handed to the Estate for return to the Collector of Taxes within the area. At that time a claim may be submitted for the refund of licence fees in respect of that portion of the year relating to the out-of-crop season.

(iii) The units will be clearly marked on both sides "Licenced For Cane Haulage Only", or at any other convenient spot where it can be easily observed.

(iv) In the event of my failure to observe any of the above conditions I understand that this will lead to the withdrawal of the duty free concession and that I will immediately become liable for the payment of the full duty on the unit/s.

....
Signature of applicant

APPLICATION APPROVED BY:-

....
Sugar Manufacturers' Association's
Harvesting Committee Representative

....
Cane Farmers' Association's
Harvesting Committee Representative

....
Sugar Manufacturers' Association's
Representative

....
Cane Farmers' Association's
Representative

APPENDIX 2

CANE PAYMENT FORMULA

1. GENERAL

Based on sucrose content in canes and average value of sugar from sales during the crop in question.

2. DETERMINATION OF SUCROSE CONTENT

(a) Analysis carried out at Factory from samples of suppliers' canes - samples to be not less than 10% of total supply.

(b) If farmer supplied 1,000 or more tons cane, the law entitles him/her to own sucrose test. Some factories extend this facility to farmers supplying 500 tons or over.

(c) If supply is under 500 tons cane, farmer is placed in a group and receives as his test the average sucrose test for that group.

(d) Average of the individual supplier's or Group's test is computed at end of crop and is applied in determining payment for the cane supplied.

3. DETERMINATION OF VALUE PER TON SUGAR

This is computed as an average from sales to:

United Kingdom (price negotiated)

U.S.A.

Canada

Local Consumption

4. Average value less certain cost is divided between Manufacturers and farmers on the following basis:

A. PERCENTAGES

i) That beginning with the 1965 crop all factories whose percentages of sugar value to cane farmers are now below 65.1% will be brought up to that level.

ii) That wherever factories were paying percentages that are higher than 65.1% they will continue to pay those percentages.

In accordance with the above the following will be the percentages of sugar value applicable for each factory:-

Frome Monymusk	67.125%
New Yarmouth Severns Bernard Lodge Jamaica Sugar Estates Hampden United Estates Innswood Long Pond Gray's Inn	65.875%
Serge Island Richmond Appleton Holland Worthy Park	65.1%

B. MOLASSES

The proceeds from molasses for division will be

i) The gross proceeds for sales of export and local molasses less transportation and insurance costs, and

ii) The national proceeds of molasses consumed in the production of spirits, computed at the gross export price less one-half of what the transportation cost of that molasses would have been to the most convenient buyer's storage installation.

iii) The value of molasses per ton of cane ground will be separately computed for each factory by dividing the molasses proceeds for division of the factory by the total tons of cane ground by that factory.

5. Portion of sugar value to farmers, less shipping expenses differential, is divided by the Individual Suppliers of Group Suppliers' crop average sucrose content.

6. To the result from (5) is added the farmers' percentage of the value of molasses per ton of cane for the factory in question (some percentage as in case of sugar).

7. Payment is made in three parts:

   i) First advance payment weekly during the crop (some factories \$4.00, some \$4.50 and some \$5.00). Sucrose test not applied at the same time.

   ii) Second advance payment one month after the end of crop, based on sucrose content and average, value of sugar up to that time. First and second advance constitutes 95% of total value per ton cane, except in the case of Frome where it constitutes $97^{1}/_{2}$% of the total value per ton cane.

   iii) A third or final payment in December of the year in question constituting the balance after the first and second payment are subtracted from the total value of canes based on the sucrose content and the average value of sugar and in molasses up to that time (all sugar for the crop in question should then have been sold).

8. If by then all sugar and molasses is not sold and there is to be an adjustment, it is brought into account in the following crop's payment.

A.I.J.C.F.Q.
11/5/70

APPENDIX 3

MOVEMENT IN AVERAGE COST OF PRODUCTION/ACRE (J$)

Year	1959	1960	1961	1962	1963	1964	1965	1966	1967
*Land Preparation	28.50	28.50	28.50	28.50	30.0	30.0	30.0	30.0	30.0
*Purchasing tops	5.0	5.0	5.0	7.50	7.50	7.5	7.5	5.0	5.00
*Transporting Tops	1.7	1.7	1.75	1.75	1.75	1.75	1.9	1.9	1.90
*Planting tops	6.5	6.5	6.5	6.5	9.0	9.0	9.0	9.0	9.00
Purchasing ert.	11.27	11.27	12.61	12.61	14.0	12.0	8.07	8.07	8.07
Transporting fert.	.45	.45	.45	.50	.50	.50	.50	.50	.50
Application of water	29.0	31.0	31.0	31.0	33.0	33.0	33.0	33.0	34.00
Weeding	7.5	7.5	7.5	9.0	9.0	9.0	9.0	10.0	10.00
Cutting	10.58	10.58	10.80	11.48	14.47	16.34	16.72	17.27	16.80
Loading	7.05	7.05	7.20	7.65	9.21	10.38	10.63	12.29	10.92
Transportation	21.80	22.00	25.00	26.88	33.14	38.20	39.14	40.59	35.60
Cess	.71	.71	.96	1.02	1.32	1.49	1.53	1.58	1.40
Donkey	10.58	10.58	10.80	11.48	14.47	16.34	16.72	17.27	16.80

*Items on which investment is assumed to occur once every seven years because of a seven year average ratoon.

APPENDIX 3 CONT'd....

Year	1959	1960	1961	1962	1963	1964	1965	1966	1967
Food	14.40	14.40	14.40	14.40	18.00	18.00	18.00	18.00	21.60
Incentive	-	-	-	.72	8.50	1.50	.88	.89	.86
App. of fert.	.80	.80	.80	.80	1.00	1.00	1.00	1.00	1.00

APPENDIX 3 CONT'D

Year	1968	1969
*Land Preparation	30.0	30.0
*Purchasing tops	5.00	5.00
*Transporting tops	2.00	2.00
*Planting tops	10.00	10.00
Purchasing fert.	8.07	8.07
Transporting fert.	.50	.50
Application of water	35.00	35.00
Weeding	10.00	10.00
Cutting	15.30	15.00
Loading	10.34	9.68
Transportation	33.53	31.25
Cess	1.33	1.67
Donkey	15.30	15.00
Food	21.60	21.60
Incentive	.80	.75
App. of fert.	1.00	1.00

APPENDIX 4A

COST DATA (1969) JAMAICAN DOLLARS

CASE 1: TECHNICAL FARMER IN DRY AREA

Assume Yield of 25 Tons per Acre in all 3 Cases.

	TASKS		UNIT COST	COST/ACRE
1.	Land Preparation	@	J$30.00/ac	J$30.00
2.	Purchasing Tops	"	0.75/1000	5.00
3.	Transporting Tops	"	2.00/ac	2.00
4.	Planting	"	10.00/ac	10.00
5.	Purchasing Fert.	"	2.02 cwt	8.07
6.	Transp. Fert.	"	1.50 ton	0.50
7.	Appl. of Fert.	"	0.25 cwt	1.00
8.	Eight Appl. of Water	"	4.38 app	35.00
9.	Weeding	"	10.00 ac	10.00
10.	Cutting	"	0.60 ton	15.00
11.	Loading	"	0.39 ton	9.68
12.	Transportation	"	1.25 ton	31.25
13.	Cess	"	0.07 .ton	1.67
14.	Fixed Cost	"	0.20 ton	5.00
	TOTAL			164.17
	LESS: Recurrent Cost Assuming 7 Years Ratoon			
	Land Prep.	"	4.29 yr	25.73
	Purchasing Tops	"	0.72 yr	4.29
	Transp. Tops	"	0.29 yr	1.72
	Planting	"	1.42 yr	8.02
	LESS:			40.26
	NET COST		164.17 - 40.26 =	$123.91/ac

APPENDIX 4B

CASE 2: TECHNICAL FARMER IN WET AREA WITH NO LOADING COST.

Total Cost as in Case 1. J$ 123.91/ac.

LESS:		J$/ac	
1.	Loading Cost	9.68	
2.	Water	35.00	
	TOTAL	44.68	
	NET COST		79.23

APPENDIX 4C

CASE 3: HILL FARMERS

	TASKS	UNIT COST	COST/ACRE
1.	Land Pre.	$30.00/ac	$30.00
2.	Purchasing Tops	0.75/100	5.00
3.	Transporting Tops	2.00/ac	2.00
4.	Planting Tops	10.00/ac	10.00
5.	Purchasing Fert.	2.02/cwt	8.07
6.	Transpt. Fert.	1.50/ton	0.50
7.	Appl. of Fert.	0.25/cwt	1.00
8.	Weeding	10.00/ac	10.00
9.	Cutting	0.60/ton	15.00
10.	Donkey	0.60/ton	15.00
11.	Transp.	1.45/ton	36.25
12.	Cess	0.07	1.67
13.	Food	8 men @ 0.15/day/ 18 days	21.60
	LESS: Recurrent Cost		156.09
	NET COST		40.26
			115.83

APPENDIX 4C CONT'D ......

Assuming Price of $6.00 per ton.

TOTAL NET REVENUE IN CASE	1	=	$J150 - 123.91	= 26.09
"	2	=	150 - 79.23	= 70.77
"	3	=	150 - 115.83	= 34.17

These hypothetical cases show that there are various types of farmers in the industry subject to different costs and profits in the production process. In the two extreme cases, viz., those of the technical farmers in the dry and in the wet area, the level of profits becomes extremely relevant in determining the changes in supply that may take place over time.

APPENDIX 5

RANGE OF LAND USES BY PARTICULAR CANE FARMER

ACCORDING TO SIZE CATEGORY IN DRY AND WET AREAS

A - IN THE DRY AREAS

Size Category	Sugar Cane Only on Single Farm	Mixed Sugar Cane and Food Crops	Sugar Cane & Coconuts	Sugar Cane & Grass in Separate Fields	Livestock Grazed on Non Farm Land
1	+	-	+	-	+
2	+	-	+	-	+
3	+	-	⊕	+	-
4	+	-	⊕	⊕	-

B - IN THE WET AREAS

Size Category	Sugar Cane Only	Mixed Sugar Cane and Food Crops	Sugar Cane with Food Crops in Diff. Fields	Sugar Cane & Large Prop. of Land Devoted to Other Major Comm. Crops	Livestock Grazed on N Farm Land
1	+	⊕	+		⊕
2	+	⊕	+	+	+
3	+	-	+	⊕	-
4	+	-	+	⊕	-

- Not found
+ Found
⊕ More Likely to be Found

APPENDIX 6

Questionnaire

GRADUATE SCHOOL
DEPT. OF GEOGRAPHY
McMASTER UNIVERSITY

PERSONAL INTERVIEW
CONFIDENTIAL

RESPONDENT'S NAME Mr. / Miss. / Mrs. ______________________________

AGE ______________

ADDRESS ________________________

SIZE CATEGORY ____________________

GROUP ________________ FACTORY SERVED ___________

DISTANCE CATEGORY ____________________

Not at home ______________________________
Date

Refused Interview ______________________________
Date

Interview Completed ______________________________
Date

INTRODUCTION

Good day, Mr. ...., I am Calford Scott of McMaster University and I am carrying out a survey to find out some of the important features of the Jamaican sugar industry. The replies which you give to my questions will be held confidential.

---

(1) In this interview, I am concerned mainly with the important

things farmers consider when they decide on their production. Mr. ...., what is the total area of land you operate?

....................Acres

---

(2) How many acres are there in sugar cane?

....................Acres

---

*(3) I see that your production increased in the years 196 , 196 , 196 , 196 , 196 , and decreased in the years 196 , 196 , 196 , 196 , could you explain first the reasons for the increases?

And the reasons for the decreases?

*(STRIKE OUT INCREASE OR DECREASE WHERE NOT APPLICABLE)

Inter-Activity Competition

Let us now look at some of those activities which affected your production:

(4) Have you planted any new areas in canes since 1961?

1. YES*
2. NO

---

*If YES? Ask how many acres......acres

When ....

*If YES, Ask 7. (Otherwise strike out 7).

---

(5) Have you taken any land out of sugar cane since 1961?

1. YES*
2. NO

*If YES, Ask how much land?.......acres

When............

*If YES, ask 6. (Otherwise strike out 6).

---

(6) Was any of the land you took out of sugar cane planted in any other crop by you ....

1. YES*
2. NO

by another farmers........... 1. YES*
2. NO

*If YES, Ask what crop(s)? Crops

*Ask 8, Otherwise cross out 8.

---

(7) Did you take any other crop out to get space to plant this new piece of sugar cane?

.............1. YES
2. NO

*If YES, ask what crop(s)? Crops

---

(8) Did you find it more profitable to cultivate this (these) other crops?.......................... 1. YES*
2. NO*

*Get Farmers to explain.

ALL FARMERS

(9) Have you ever taken any outside jobs which have caused you to neglect your cultivation or to give up parts of it?

.... 1. YES*
2. NO

*If YES, get farmer to explain.

1. What job?

2. What years?

3. Whether neglected or gave up sugar acreage.

Transportation Cost

Let us now consider transportation cost as it influences your production.

(10) Since 1961, the cost of transportation has risen from...... per ton, to .... per ton. Has this caused you to increase or decrease your production?

*INCREASE ....1. YES
2. No

*DECREASE .... 1. YES
2. NO

*EXPLAIN

Transportation Availability

Considering how available transportation has been;

(11) Do you own your own carrier? .... 1. YES*
2. NO**

*If YES, go to 12 and skip to 15.

**If NO, go to 13.

---

(12) How long have you been transporting your own cane?

.................Years.

(13) Have you ever transported your own cane? ....1. YES*
2. NO

*If YES, ask 14

(14) Why did you give up transporting your own cane?

Ask only those with own carriers

(15) How would you compare your transportation situation before you got your own carrier with conditions since then?

..............1. Better
2. Worse
3. No Difference

All farmers

(16) Would you say as far as your concerned, you regard transportation as ....1. Always Available.
2. Available most of the times.
3. Available only about 1/2 of the times.
4. Mostly unavailable.
5. Not available.

(17) Do you always hire cane carriers?

.... 1. YES*
2. NO

(18) *If YES, ask farmers who have own carriers.

a) Do you hire carriers every year......or only some years...........?

b) Why do you need to hire carriers?

(Questions 19 - 23 only for those who hire carriers)

(19) Do you arrange for transportation before or after getting a cutting order?

.... 1. Before
2. After

---

(20) Once the load is ready, does the carrier always come to pick it up? .... 1. YES
2. NO

---

(21) Have you ever found that you could not cut your cane because there was no carrier available? ...... 1. YES** (ASK 22)
2. NO* (GO TO 23)

---

(22) In which year did this happen?

---

(23) Have you ever cut your cane and have to leave it on the ground because there was no carriers available to pick it up?.... 1. YES*
2. NO

---

*If YES, (a) What years?

(b) How did this affect your production the following years?

---

(24) Would you describe to me what changes you have observed in the availability of tansportation since 1961?

---

(25) Would you tell me exactly how your production has been affected by the availability of transportation?

Labour

Let us now look at the labour situation.

(26) As I understand it, sugar cane production involves the following tasks, ...

1. Land Preparation
2. Planting
3. Weeding
4. Fettilizing
5. Thrashing
6. Cutting
7. Carrying

CIRCLE

Are there any of these tasks which you do not do on your farm?

---

(27) Do you use family members to help with any of these tasks?

1. YES*
2. NO (Go to 30)

CIRCLE

*If YES, ask what tasks? 1. 2. 3. 4. 5. 6. 7.

---

(28) Would you tell me exactly how many members used to help you in 1961 and how many help you now?

1961	1970
1	0
2	1
3	2
4	3
5	4

---

(29) Do you need to hire additional labour for any of these tasks?

CIRCLE 1. 2. 3. 4. 5. 6. 7.

1. YES
2. NO*

*If YES, go to 31.

---

(30) For the tasks in which you need to hire additional labour would you tell me how many you require and how many you obtain?

Tasks*	Reqd.	Obtained
1		
2		
3		
4		
5		
6		
7		

CIRCLE

---

*Get annual labour schedule

---

(31) Do you use any machinery? .... 1. YES*
2. NO

---

*If YES, (a) For what tasks? 1. 2. 3. 4. 5. 6. 7.

(b) Since when?

---

(32) You mention that the tasks you carry out on your farm are (NUMBER) ....,can you remember any year in which these tasks were not completed because there was labour shortage?

Tasks	Year
1	
2	
3	
4	
5	
6	
7	

CIRCLE

---

(33) Would you explain to me how the labour situation has changed between 1961 and now?

REQUEST ANNUAL COST SCHEDULE.

(34) Has this affected your production?

YIELD

Let us now look at the yields you are getting on your farm.

(35) We might have touched on this before, but have you noticed any changes in the amount of cane you produce per acre?

1. YES*
2. NO (Go to 38)

---

*If YES, are these increases ..... or decreases.

---

(36) Could you account for these changes?

---

(37) How long do you ratoon your cane? ....5 years
6 "
7 "
8 "

FERTILIZER

Looking now at fertilizer.

(38) Do you use fertilizer or manure? ....Fertilizer 1. YES
2. NO*

---

*If neither, go to 42.

(39) How much fertilizer (manure) do you apply per acre? .....cwt.

---

(40) How long have you been using fertilizer?

CIRCLE 20 - 18, 17 - 15, 14 - 12, 11 - 9, 8 - 6, 5 - 3, 2 - 0 ...years.

---

(41) Can you recall any years since 1961 when you did not use fertilizer (manure)?

---

(42) Have you ever used fertilizer (manure)?

Fertilizer ..... 1. YES*
2. NO

Manure ..... 1. YES*
2. NO

*If YES, ask what years?
Why did you stop?

PRICE OF SUGAR CANE

The price which farmers have obtained for their cane over the past nine years are as follows ....

SHOW SCHEDULE

Years	Price/ton
1961	
1962	
1963	
1964	
1965	
1966	
1967	
1978	
1969	

(43) What has been your reaction to these prices? Have you

INCREASED...... 1. YES
2. NO

DECREASED......1. YES
2. NO

***GET COST SCHEDULE

Physical Factors

I am now going to ask you about the quality of the land you cultivate and how this affects your production.

(44) Would you tell me whether any of the following factors affect your production.

(1)	Hilly land	YES*	NO
(2)	Swampy land	YES*	NO
(3)	Stony soil	YES*	NO
(4)	Soil drying out too quickly	YES*	NO

---

*. If PRODUCTION is affected, ask about what percentage of your farm is affected by each condition.

......Hilly %
......Swampy %
......Stony %
......Dry Soil %

---

(45) Could you describe to me exactly how you would like to see the weather conditions of any one year from the cane starts growing to reaping?

Activity	Weather Condt.	Reasons
Growing	Rain	Growth
________		
________		
________		
Harvesting	Dry	Reaping

---

(46) Have the weather conditions been much different from your description in any year since 1961?

.... 1. YES*
2. NO

*If YES, list year and type of variations

Years	Variations

*Ask 47.

(47) Would you say that these variations have affected your production?

.... 1. YES*
2. NO

*If YES, ask farmer to explain what aspects of production and years.

(48) What time of the year do you wish to reap most of your cane?

1.	Dec. - Jan.		5.	Apr. - May
2.	Jan. - Feb.		6.	May - Jun.
3.	Feb. - Mar.		7.	Jun. - Jly.
4.	Mar. - Apr.			

(49) Have you been able to do this?....... 1. YES
2. NO. (Ask 50)

(50) Has this caused you to make any changes in your production?

1. YES*
2. NO

*EXPLAIN

(51) How much cane do you keep back for other purposes?

---

(52) I will not list the nine factors we have discussed. I would like you to rank them according to how important they have been in your decision to increase or decrease production over the years.

(IF HE CAN READ, HAND HIM LIST. WHEN DIFFICULTY ARISES, EXPLAIN SYSTEM OF RANKING ITEMS OF RELATIVE IMPORTANCE).

FACTORS	RANK
1. Cost of transportation	
2. Availability of transportation	
3. Competition from other jobs or crops	
4. Changes in yield	
5. Use of fertilizer or manure	
6. The price you get for your cane	
7. Problems with labour	
8. The quality of your land	
9. Size of your farm	

---

(53) What are your production plans for the future?

Thank you Mr(s). ...., you have been very helpful.

Remarks

Interviewer's Signature

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