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This study has attempted to test an hypothesis that certain agricultural production enterprises in the Cauca valley were optimal with respect to their net enterprise incomes. Sufficient data were thought to be available to allow tests of corn, sugarcane, beef, and dairy production enterprises.

A quadratic equation in four independent variables was fitted by least squares procedures to available data on corn. The resulting coefficient of multiple correlation of $R^2 = .237$ was not significantly different from random results at or above the 10 percent confidence level.

A Cobb-Douglas function with seven independent variables was fitted to sugarcane production data. No acceptable results were achieved with any of the various combinations of variables.

An enterprise budget was computed for beef production from two-year-old grade Cebus in a field trial on intensive pasture. The net enterprise income of 3,134 pesos per hectare per year in this trial compared to the -134 pesos per hectare per year of the hypothesis, led to rejection of the hypothesis of optimality for typical beef production enterprises in the valley.

An enterprise budget for intensive dairy production was computed from the data of a commercial dairy herd in the Cauca valley. The resulting net enterprise income of 5,065 pesos per hectare per year led to rejection of the hypothetically optimum return of -12 pesos per hectare per year netted by typical commercial dairy producers in the Cauca valley.

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AGRICULTURAL RESOURCE ALLOCATION IN THE CAUCA VALLEY OF COLOMBIA

by

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A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Agricultural Economics

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June, 1968

ACKNOWLEDGMENTS

The author wishes to extend his thanks to Dr. Clarence Jensen, Dr. Dana Myrick, and Dr. Layton Thompson for their efforts in his behalf as a Thesis Committee. Thanks are also due to Dr. Edward Ward and Professor Maurice Taylor, who helped in the organization of the thesis research and gave valuable criticism of earlier drafts, and to other members of the faculty who taught, advised, and helped in many ways.

Special thanks are given to the author's students and colleagues at the Universidad del Valle, and to the many people of the Cauca valley who helped the author to learn something of an alien language, culture, and agriculture, and who provided much of the primary data upon which this thesis is based.

The author also wishes to express his gratitude to Warren Bailey and to others in the Economic Research Service of the U. S. Department of Agriculture for their long support, and for their help and encouragement through the final stages of this research. Finally, the author wishes to acknowledge his debt to his wife, Dorothea, who has patiently suffered through eighteen years of the author's continuing education.

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Chapter I: Description and Problem Setting

Guided development of the agricultural economy of the Cauca valley of Colombia may eventually be attempted. Such a development must rest on reasonable data of production techniques, of market structure, and of the social-political milieu. In 1962, these data were not yet available for rational planning, either in adequate quantity or quality.

The first purpose of this study is to explore and to bring together all of the available data of production processes for the agriculture of the Cauca valley. A second purpose is to analyze these data, to supplement them where possible, and to use them in the estimation of extant resource allocations and those that are possible in the future. The focus of the study is on the farm firm, as represented by theoretically constructed examples from aggregate production data.

Descriptive Information

The Cauca River flows generally south to north between the central and western ranges of the Andes mountains in Colombia, turning east around the end of the central range to join the Magdelena before that river empties into the Caribbean Sea. Midway of its south to north course, the Cauca flows through a large valley left when a glacial lake was drained some thousands of years ago. This is the Cauca valley, a rich agricultural area, and the locale of this study.

The valley lies at an average elevation of 1,000 meters (3280') above sea level, at a median latitude of three degrees north. The valley is about 200 kilometers long, and ranges from 10 to 30 kilometers wide (124 miles by 6.2 to 18.6 miles). The land area of the valley is about 350,000 hectares (865,000 acres). The area commonly referred to as the "valley" or "the flat part of the valley" is within the political department of Valle del Cauca, except for a small portion on the southern end lying in the political department of Cauca. But the entire department of Valle del Cauca includes considerable areas of mountainside and of jungle along the Pacific shores. This leads to certain difficulties over the separation of available statistical data into that of the valley area and of the remainder of the department.

The valley has been covered by a lake at least four times since the Pliocene, and about 15 percent of the valley floor is still covered by lacustrine sediments.1/ The top soil ranges up to 10 feet in depth and is underlain by gravel and sand. Alluvial fans extend from the mouths of canyons and overlie this lacustrine deposit along the margins of the mountains on both sides. The constantly changing meanders of the Cauca river have produced a pattern of old dikes, flood plains, flat benches, and bog areas. The valley floor slopes less than one degree to the north, and only a little more steeply from the sides toward the river. In historical times the Cauca has been located along the western margin of the valley over about the northern two-thirds of the area.

According to Reese and Goosen 2/, the soils of the valley are distributed as follows: 12.6 percent terrace soils, 68.1 percent alluvial fans and plains, 9.6 percent levee soils, 1.2 percent slackwater soils, and 8.5 percent stony, mixed alluvial, and marshland soils. The terrace

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1/ William F. Reese, and Doeko Goosen. Reconnaissance Soil Survey of the Flat Part of the Cauca valley. CVC and FAO of the UN, Cali, Colombia: 1957, p. 6.

2/ Ibid., p. 32.

soils range from clayey to loamy; the alluvial soils from sandy loams to clays; levees are predominantly silty clay loams and clay loams; and the slackwater areas have soils that are fine textured silty clays and clays. Thirty percent of the valley soils have good permeability, 25 percent have permeability between good and poor, and the remaining 45 percent have soil permeability of poor or very poor.3/

A table of mean monthly temperatures for selected towns in the Cauca valley is included as Table A-1 of the Appendix. The average for the valley would be a little above 24 degrees centigrade (75 degrees Fahrenheit). The city of Cali, in the southwestern part of the valley, has an average mean monthly temperature of 24.3 degrees centigrade, with a minimum monthly temperature of 23.6 degrees centigrade in November, and a maximum mean monthly temperature of 24.8 degrees centigrade in February and March.4/ Appendix Table A-2 gives the average relative humidity for three stations in the valley. Cali has an average mean relative humidity of 63 percent with a minimum monthly mean of 68 percent in November, and a minimum monthly mean of 57 percent in July.

Rainfall in the Cauca valley is partly a function of the season and partly of the location where the recording is taken. Rain-bearing clouds come generally from the West. The higher peaks of the western range of the Andes force these clouds to drop their moisture on the Pacific slope, creating rain-shadows that may stretch nearly across the valley opposite

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3/ Loc. cit.

4/ Ibid., p. 17.

the highest mountains, and may never reach the valley floor opposite the lower passes.

Generally speaking, there is a major dry period in the summer months of June-August, and a minor one in the winter months of December-January. The major wet period comes in the spring months, with the minor one in the fall. But this is only a generalization, and and does not necessarily hold for any given locality of the valley. Cali receives about 1200 millimeters (47.2 inches) of rain during the year, and is representative of those parts of the valley that are not affected by rain-shadows. Appendix Table A-3 gives average monthly rainfall data for selected locations in the valley. The ground water table in most parts of the valley lies less than three meters (9.8 feet) below the surface, and in some areas is much closer than that.5/

Because of the location close to the equator, there is only a small difference in the daylight hours between the shortest and longest days of the year. The sun rises a few minutes before or after 6 a.m., and sets a few minutes before or after 6 p.m. throughout the year. Thus, the Cauca valley enjoys a year-round growing season for tropical and semi-tropical crops. There are few days during which there is not some degree of cloud cover, from scattered cumulus to solid overcast, so that the value of solar insolation received by plants is relatively low for three degrees of latitude. Crops such as corn, beans, soybeans, rice, sugarcane, cotton, tobacco, plantain, pineapple, manioc, avocado, cocoa,

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5/ Ibid., p. 20.

coffee, grapes, citrus, and most vegetables are produced in the valley with varying degrees of success. The elevation of the valley is too high for coconut and banana, near the upper limit for cocoa, and below the lower limit for the best quality of coffee. Temperate zone crops such as wheat, barley, oats, rye, apples, potatoes, peaches, and plums are not produced in commercial quantities.

The population census of 1951 shows a total of 422,000 people in the six largest towns of the Cauca valley, and a total urban population of just over half a million. The total population of the valley in 1961 was 1,106,000, about evenly divided between rural dwellers and those living in towns of 5,000 or more inhabitants.6/ Estimates made by the Corporacion Autonoma Regional Del Cauca (CVC) in 1964, gave the city of Cali just over 700,000 inhabitants, and the valley about two million people in total. Therefore, one may conclude that the total population of the Cauca valley doubled between 1961 and 1964, while the population of Cali increased at an even more rapid rate. This excessive rate of migration was caused primarily by two factors. Cali, as a rapidly expanding industrial and business center, has been exerting a pull on landless and submarginally employed rural dwellers. This tendency has been seen to operate in similar situations in numerous times and places, and is unremarkable. The more important factor was the push of civil violence and banditry in the outlying areas of the valley, and in the mountain areas surrounding it. The violence was endemic in some areas for ten years or more, and

6/ 1951 Censo del Poblacion, Departamento del Valle del Cauca. Bogota, Colombia: 1964. p. 15.

encouraged many rural dwellers to migrate to Cali and other population centers where life was more certain.

One paved road, a part of the Pan American Highway, transects the Cauca valley, and connects Cali with other towns north and south. A branch of this road, also paved, traverses the central range of the Andes to Bogota, and a new paved road is under construction over the western range to the main seaport of Buenaventura. A reasonably complete system of graveled and graded secondary roads connects small towns and the countryside with the population centers, though some of these present "tactical" problems during rainy periods.

There is a narrow-gauge railroad through the valley that connects Cali with its satellite towns in the valley, and with Medellin and Popoyan in neighboring departments. There is also a narrow-gauge line connecting Buenaventura with Cali, and one that connects to Bogota (with a gap at the top of the divide, so that freight must be transshipped by truck between the two lines). Cali has an airport with limited international flights, and a regular schedule of domestic flights to the other major cities in the country. Two other towns in the valley, Cartago and Tulua, have airports, but these are used largely by aerial spray services and have limited use as commercial stops.

A highly developed and competitive truck and bus service connects rural and urban centers of the valley with the rest of the country. Telephone and telegraph communications are available in all towns, though service is limited in the rural areas.

Table I summarizes the land use pattern in the flat part of the Cauca valley in 1957, as estimated by Reese and Goosen.7/

There are also data available on land use from the 1959 Census of Agriculture. They include land that is outside of the flat part of the valley, and exclude land that is in the valley but outside the political department of Valle del Cauca (Table 2). The last column in Table II shows a calculated average area per farm, for the various land uses. Rice, cotton, and soybeans are unique among the cultivated crops in having an average area per farm that is large enough to utilize machinery.

Table III shows the tenure patterns of farms in the Department of Valle del Cauca by size groups. The proportions of owner-operators and of hired managers change rather drastically between the smallest and largest groups. Although there are no very precise data available, a large proportion of the farms in the two largest size groups tend to be livestock farms and sugarcane plantations. Both of these types of farms tend to be operated by hired majordomos, and they account for about 58 percent of the land area farmed in the department, although they represent only about 4.3 percent of the farms. At the other end of the size distribution, 3.9 percent of the land area is farmed by about 52.2 percent of the farmers in the department. Similar data for the flat part of the valley are not available, but knowledgeable observers in the CVC estimate that the farms in the valley are distributed between small owner-operator and large majordomo-operated farms in much the same fashion as for the department.

7/ Ibid., p. 26.

Table I: Land Use in the Flat Part of the Cauca Valley, 1957

Type of Use	Hectares	Acres
Sugarcane	45,000	111,150
Corn	25,000	61,750
Rice	15,000	37,050
Cocoa, coffee, plantain	10,800	26,676
Beans	9,000	22,230
Tomatoes	900	2,230
Fruits	800	1,976
Tobacco	600	1,482
Cotton	200	494
Grapes	100	247
Manioc	100	247
All cultivated crops	107,500	265,532
Pasture	222,500	549,575
Swamps and lakes	12,000	29,640
Urban areas	58,000	143,260
Total land area	400,000	988,000

Table II: Land Use in the Department of Vallé del Cauca, 1958 & 1959

Land Use	1958		1959		Average Area per Farm (Ha's)	
	No. Farms	Ha's	No. Farms	Ha's	1958	1959
Maiz	16,968	57,669	19,427	40,269	3.40	2.07
Manioc	7,872	6,128	10,302	8,778	0.78	0.85
Beans	6,099	22,157	6,653	14,452	3.63	2.17
Vegetables	2,953	2,420	4,224	3,401	0.82	0.81
Tobacco	611	829	956	927	1.36	0.97
Cut Grass	530	2,697	659	3,440	5.09	5.22
Rice	264	14,240	272	10,051	53.94	36.95
Potatoes	143	777	235	957	5.43	4.07
Soybeans	160	5,806	118	2,638	36.29	22.36
Cotton	122	6,293	435	18,740	51.58	43.08
Wheat	92	976	123	748	10.61	6.08
Barley	58	239	77	250	4.12	3.25
Sesame	9	36	5	26	4.00	5.20
Coffee	--	--	35,014	110,444	---	3.15
Plantain	--	--	31,666	28,189	---	0.89
Citrus	--	--	21,185	596	---	0.03
Sugar Cane	--	--	8,511	67,837	---	7.97
Coco	--	--	5,177	4,875	---	0.94
Banana	--	--	2,995	2,183	---	0.73
Total Cultivated	35,881	120,267	43,486	104,677	3.35	2.41
Total Permanent	--	--	104,548	214,824	---	2.05
Total	35,881	120,267	148,034	318,801	3.35	2.15

Source: 1959 Census of Agriculture, Universidad del Vallé, Cali, Colombia: September, 1963, p. 26.

Table III: Tenure and Population Distribution by Size of Farm

Size of Hectares	Farms operated by				Hectares in Group	
	Owners		Managers			
	Number	%	Number	%	Number	%
≤ 5	25,320	56.4	1,179	19.8	45,920	3.9
> 5 ≤ 20	13,675	30.5	1,796	30.1	157,456	13.5
> 20 ≤ 50	3,664	8.2	934	15.7	144,520	12.4
> 50 ≤ 100	1,320	2.9	749	12.6	142,257	12.2
> 100 ≤ 500	789	1.8	1,094	18.4	390,166	33.4
> 500	90	0.2	203	3.4	287,630	24.6
Total	44,858	100.0	5,955	100.0	1,167,949	100.0

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Table III: Tenure and Population Distribution by Size of Farm -Continued

Size in Hectares	Farm Population Engaged Primarily in: Agriculture Number	Agriculture %	Nonagriculture Number	Nonagriculture %	Total Farms	Ave. Ha's per Farm	Ave. Acres per farm
≤ 5	23,205	51.1	3,142	64.7	26,499	1.73	3.81
> 5 ≤ 20	14,565	32.1	795	16.4	15,471	10.18	22.40
> 20 ≤ 50	4,216	9.3	338	6.9	4,598	31.43	69.15
> 50 ≤ 100	1,763	3.9	249	5.1	2,069	68.76	151.27
> 100 ≤ 500	1,481	3.2	292	6.0	1,883	207.20	455.84
> 500	207	0.4	43	0.9	293	981.67	2159.67
Total	45,437	100.0	4,859	100.0	50,813	22.99	50.58

Source: 1959 Census of Agriculture. Universidad del Valle, Cali, Colombia: September, 1963, p. 11 & 14.

Table IV shows the amount of land in the flat part of the valley that is estimated to fall into the five basic land use productivity classes.8/

Problem Setting

This thesis is addressed to the problem of rationalizing the farm production in the flat part of the Cauca valley. The problem is much more vast and complicated as a planning problem than any one individual can hope to grasp, let alone to solve. There is no doubt that the required data of production techniques, as one of several necessary subject matter areas, are less than adequate for a meaningful planning effort. The objectives of this thesis are limited to an exploration of such production data as were available up to the summer of 1965, and to an attempt to organize these data in terms of the individual farm firms of the area. Rationalizing of the aggregate agricultural production of the Cauca valley, in terms of a planning model, must remain for other studies.

Agricultural production by farm firms does not take place apart from the broader milieu of the economy. The following paragraphs discuss some of the factors that affect the current organization of production on farms, and that would affect any adjustments an individual operator might make in his own farming system.

Firm Costs and Prices

There is no general cost and price index available for the agricultural sector of the Colombian economy, and none of both precision and of

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8/ Reese and Goosen, op. cit., p. 117.

Table IV: Extent and Percent of Land by Land Classes, Cauca Valley of Colombia

Class	Hectares	Percent of total	Description
I	141,055	33.3	good to excellent cropland
II	179,285	42.2	fair to good cropland, good pasture
III	13,845	3.4	poor to fair cropland, fair to good pasture
IV	42,095	10.0	poor to good pasture, not suitable for crops
V	46,935	11.1	poorly suited to agriculture
Totals	423,215	100.0	

Source: Reese and Goosen, op. cit., p. 117.

long-term coverage for any sector.9/ The data of costs and prices used in this thesis are those that were recorded in the process of collecting farm production data, and do not all rest on a well-developed statistical base, but they are thought to be reasonably representative of the production periods 1962-1964. It is necessary to assume that costs and prices for individual farms, and the supply and demand schedules in the aggregate, are constant at early-to-mid-1963 levels. This might be quite a heroic assumption for any applications of farm production data subsequent to 1963.

There was a devaluation of the Colombian peso late in 1964, and this changed the cost-price relationships in subsequent months. The peso dropped from its previously stable level of 10 Pesos/U.S. dollar, to levels fluctuating around 18 Pesos/U.S. dollar, over a period of only a few months. The important effects of this devaluation on the agricultural sector of the economy in the Cauca valley, and elsewhere, might be summarized as follows:

(a) The peso cost of production inputs that were imported from hard-currency areas went up in proportion to the devaluated purchasing power of the Colombian peso. This affected all agricultural machinery and parts, some agricultural chemicals, semen, feed additives, and component prices for agricultural equipment assembled in Colombia.

9/ For a first attempt at developing production indices for agriculture in the Department of Valle del Cauca, see: Jesus H. Colmenares. Analisis de la Produccion Agricola en el Departamento del Valle--Numero Indices de Produccion Agropecuaria 1955-1962. Univ. del Valle, Facultad de Ciencias Economicas, Cali, Colombia: 1964 (unpublished bachelors thesis).

(b) The peso cost of production inputs that were domestically produced was not visibly affected. This included seed, nitrogen components of fertilizers, gasoline, and replacement livestock.

(c) The prices received by producers for a list of "basic" foodstuffs did not increase. The consumer price of these items is fixed by the government, and this puts a ceiling on the price that may be received by the producer, outside of the black market.

(d) The net result over the short-run, for such basic commodities as refined sugar and corn, was that some of the input costs to the producer rose, while the price of his product did not. A classic cost-price squeeze was produced in these commodities.

(e) The short-run result for such nonbasic commodities as soybeans was that the increased cost of the imported components was soon reflected in higher product prices, and this was passed on to the consumer.

(f) The net result of the devaluation of 1964 was a consistent upward pressure on consumer prices, for all agricultural products.

If one assumes a standard set of production functions for the various products, the expectation would have been for some changes in the input mix for certain commodities, to reflect the changes in relative input costs. One would also have expected some changes in the supply of the "squeezed" commodities, reflecting a lessened profit margin in relation to the "non-squeezed" ones. The extent to which either or both of these sets of expectations were realized is unknown.

Aggregate Supply, Demand, and Prices

An important segment of the effective milieu for individual farm operators is the overriding systems of aggregate supply, demand, and price relationships. The evidence of observation suggests that these relationships were not those of the classical model in which equilibrium is achieved by adjustments in price and/or in quantity supply, in response to a given demand.

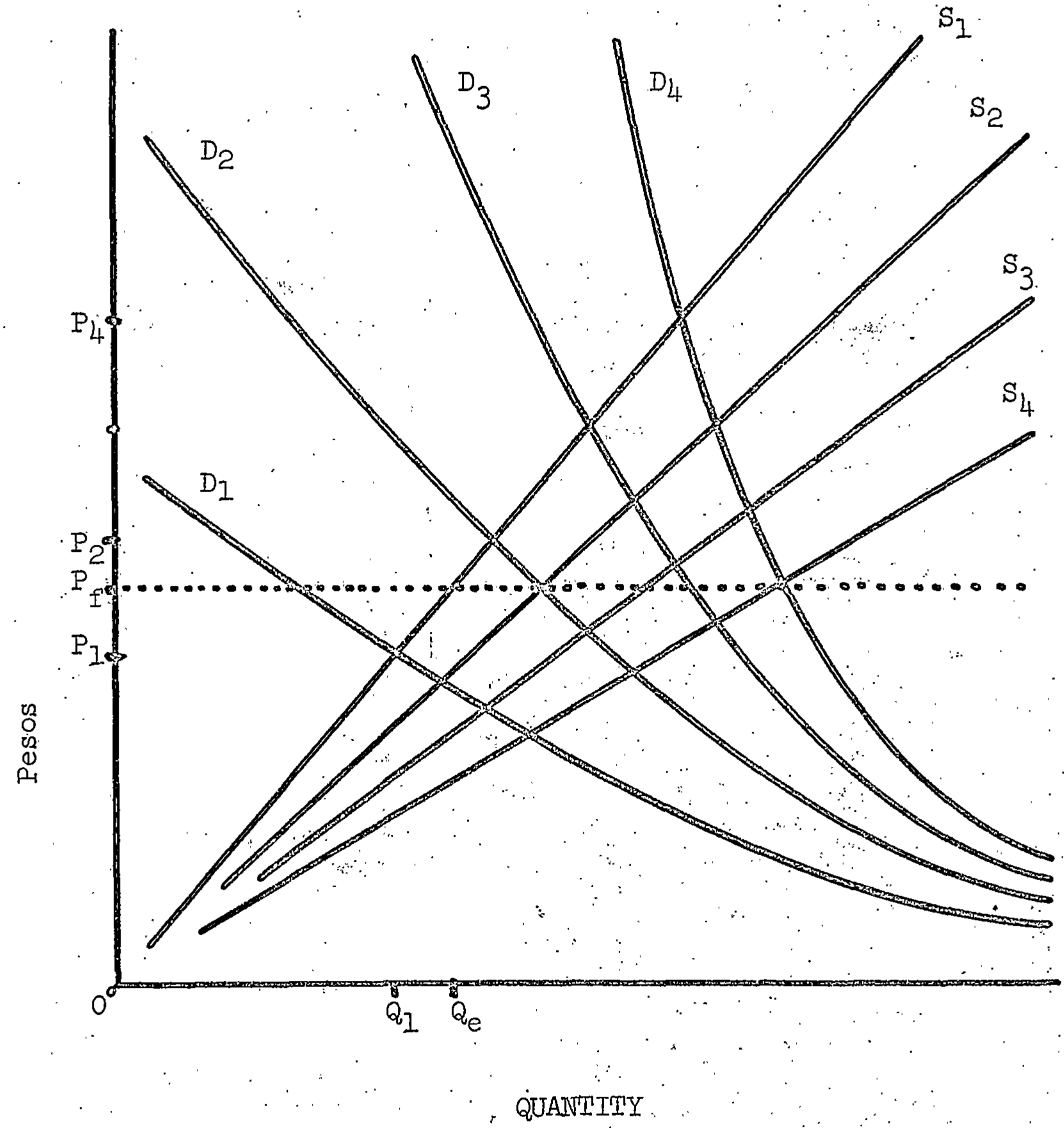
The demand for food in Colombia may be partitioned into two categories. One of these might be called the "basic" and the other the "luxury" category of food items. The basic category includes such items of the diet as potatoes, rice, manioc, refined sugar, and wheat flour. The luxury category includes such food items as meat, eggs, cheese, and milk. The policy of the Colombian government is that the basic items of food consumption be available as cheaply as possible. An extensive chain of government warehouses and retail outlets are maintained in which the basic food items are sold at retail, at published maximum prices. This system is intended to fix a price ceiling on the basic foods, and does so for all persons who desire to buy these items from government stores. This price maximum at retail sets an effective maximum price to the producer of basic food commodities, although not a minimum one. The prices of the nonbasic luxury items in the food diet are left to free-market determination.

A significant part of the population exists on an income so low as to leave the family food budget at or below basic subsistence levels. These people are faced with the unfortunate choice of buying the basic foods up to their income limits, in an attempt at least to fulfill the volume demands of their stomachs, or of buying substantially smaller quantities of the luxury foods and going perpetually unsatisfied in quantity terms. It so happens that the traditional and governmentally defined basic food items are also high in starch and low in proteins, the uncontrolled luxury food items are relatively high in proteins, and much more expensive than the basic foods. The aggregate demand function for basic foods would appear to be price-inelastic over most of its range.

Colombia is not entirely populated by families with extremely low annual cash incomes. There is a modest market for the luxury foods, even at the relatively high prices that obtain for milk and other high-protein foods under free-market conditions. The aggregate demand function for luxury foods would appear to be the opposite of that for basic foods; it should be price-elastic over most of its range. Supply would tend to equilibrate with the demand at a price high in relation to average expenditure for food of the average Colombian consumer.

Figure 1 posits a hypothetical model of the shifts in the demand function for basic foods, as incomes and tastes change with a development program. The curve D_1 represents aggregate demand in a relatively underdeveloped stage, perhaps the present period. The supply function for these foods is given as curve S_1, and the governmentally fixed price is shown by the line P_f. This effective price to the consumer is fixed at a

Figure 1: Shifts in Demand For a Basic Food in a Developing Economy, With an Administered Price Policy



level above what would be an equilibrium level (P_1) in order to encourage production of these foods. The equilibrium quantity that would be supplied at price P_f is Q_e, which is greater than the equilibrium quantity Q_1. The result of this dis-equilibrium between demand and supply at price P_f will depend on the relative bargaining strengths of producers and of the handlers in the marketing channels, since there is no reason to market the surplus product at prices less than that maximum fixed by the government.

As economic development progresses, and disposable incomes rise, the demand function might shift toward that represented by curve D_2, where demand for the basic foods is less price-elastic than in period 1. But given the same supply function and price P_f, the quantity supplied will not exceed Q_e, and there is a dis-equilibrium problem again. Assuming that the government stands fast with its previous price ceiling of P_f, the only recourse is a subsidy to producers of P_f-P_2. The other alternative for an equilibrium of supply with the new demand would be a change in the supply function from S_1 to S_2.

As the economy progresses through periods 2, 3, and 4, the hypothetical demand function for basic foods shifts toward the higher price-inelasticity of curve D_4. Assuming the same administered price maximum, there must be a producer subsidy of P_f-P_4, or a further shift in the supply function to that represented by S_4, in order for equilibrium to obtain between supply and price. But the equilibrium of supply and demand under the shifts in both, represented by the intersection of D_4 and S_4, for instance, can only come about if there are increasing efficiencies in the production and marketing of the basic foods. A government anticipating economic development, part of whose benefit will be in income increases to the lower-income segments of the population, must be prepared either to subsidize producer prices of the supported foods, or to increase the efficiency of production and/or distribution of these products. The government of Colombia has been interested and active in the area of increasing the efficiency of production and in trimming the marketing margins of the products it places on the basic foodstuffs list.

The other part of the food production-consumption picture is that concerning luxury food products. Figure 2 is a hypothetical model of this subsector. Curve D_1 is the demand function for the luxury high-protein foods at period 1 of the development process. This function is price-elastic over much of its range, under the assumption that only a small segment of the population has income in excess of its survival needs, that might be spent on the relatively high-priced luxury foods.

As the economy progresses and incomes rise in the aggregate, the demand function for luxury foods is presumed to shift toward the situation represented in curve D_4, where the aggregate demand is highly price-elastic. In this model, the quantities demanded and the prices received both increase somewhat in proportion. If there are production and/or market channel efficiencies realized at higher levels of supply, the supply function might shift toward curve S_3. In this case, the quantities demanded would exceed those at equilibrium points on the original supply curve, and prices would be somewhat lower than they otherwise would be.

Figure 3 combines the supply curves S_1 and S_4, with the equivalent demand curves from both figures 1 and 2, giving a hypothetical model for

Figure 2: Shifts in Demand for a Luxury Food in a Developing Economy, With Free Market Price Policy

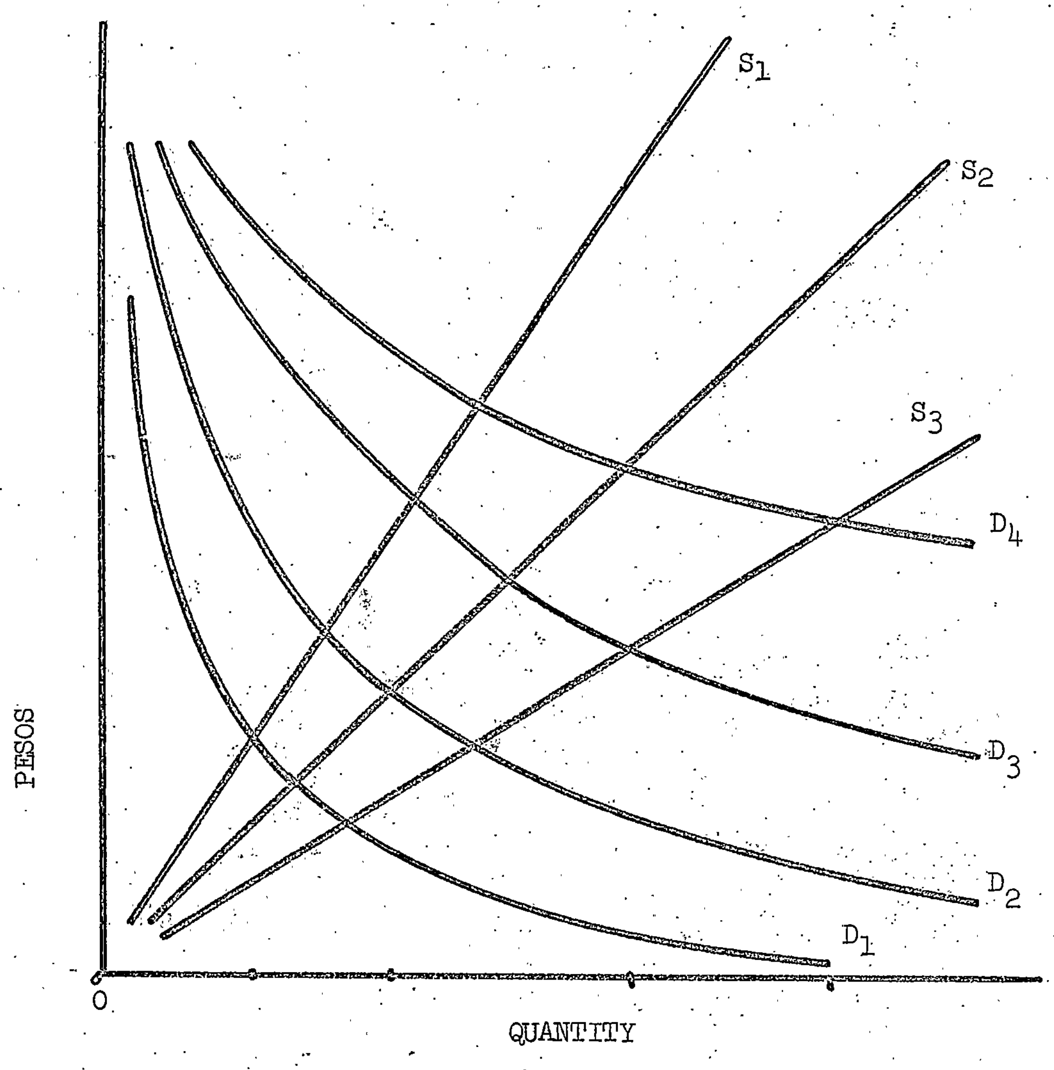
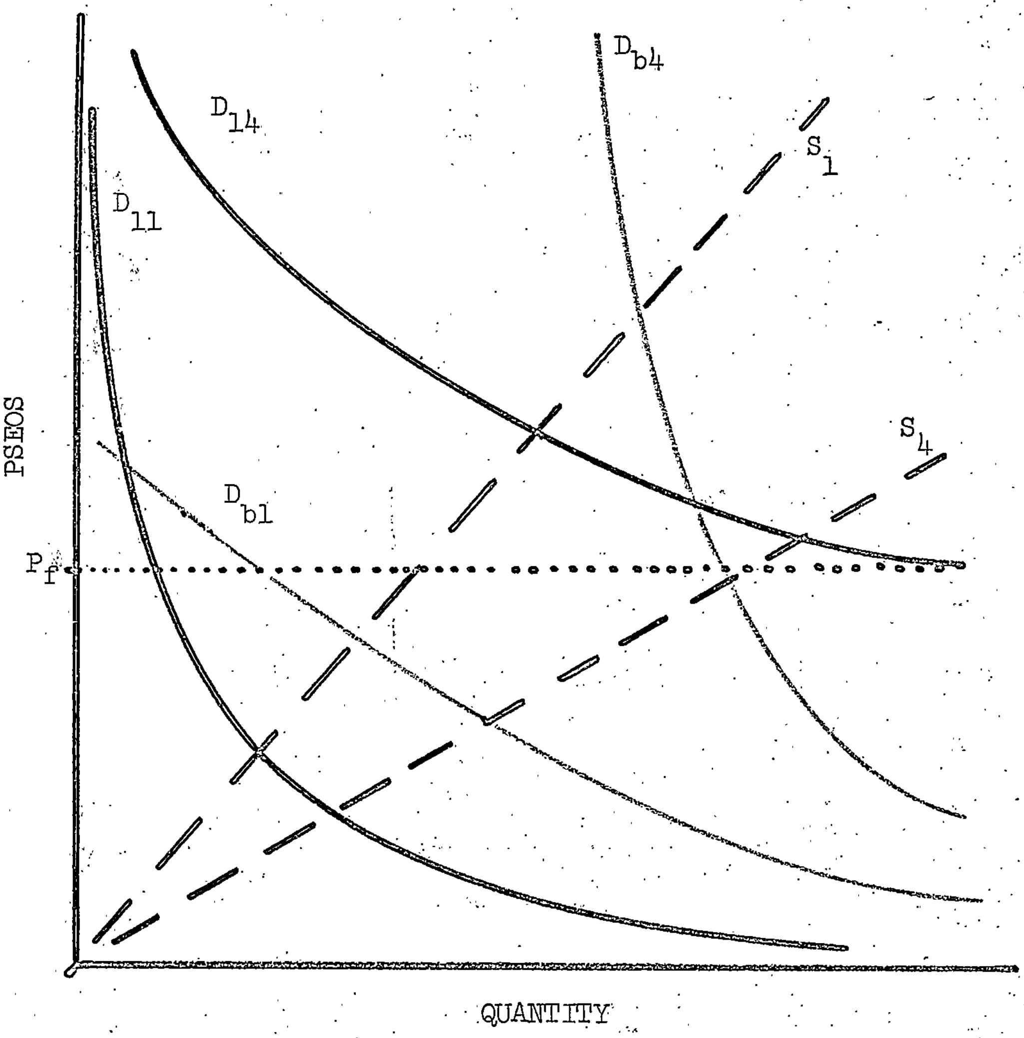


Figure 3: Shifts in Demand for Luxury and Basic Foods in a Developing Economy



both of these food groups. In this supply-demand model, aggregate consumption patterns shift with rising income from the basic toward the luxury foods. This model assumes that no less of the basic foods will be demanded; indeed, it assumes that more will be demanded with rising incomes. This might be explained partly by an increasing population base, and partly by a slightly increasing per capita consumption of the traditional diet. It is the excess spending capacity that is shifted toward an increase in the luxury foods consumption, e.g., the demand functions for the basic and the luxury foods are inversely related to the aggregate income of the country. As this income rises, the demand for basic foods shifts from price-elastic toward price-inelastic, while the aggregate demand for luxury foods shows the opposite tendency. If this model reflects actual conditions under the present relatively underdeveloped, and future relatively developed situations, then it would appear that the policy of the government is one of encouraging an increasing supply of the basic foods, paid for by producer price subsidies and/or allowed by increasing efficiencies of production and marketing. It would also appear that the policy includes letting prices of the luxury foods adjust freely to demand-supply conditions in the developing economy.

Firm Production Models

One could theorize about the production by individual producers in the Cauca valley that would fit the preceding models of supply and demand for the two classes of agricultural products. Something like this was attempted for the demand for refined sugar and the supply of sugarcane,10/ but this was meaningful only because all of the refined sugar consumed in Colombia is produced in the Cauca valley. No other food item of national consumption importance is produced only in the Cauca valley, and some foods of importance (such as potatoes, bananas, and wheat) that are consumed in the valley are not produced there.

There are some peculiarities of individual agricultural producers that require discussion in order to set the background for this thesis. The discussion is organized around four classes of producers:

(1) latifundia, beef cattle

(2) latifundia, sugarcane

(3) minifundia

(4) "commercial" producers

The word "latifundia" is translated as "large land-holding." This is a relative term that depends on the position of the observer, interacting with the socially accepted meaning of the term. A farmer operating 5 hectares might consider anyone who operated 50 hectares to be a latifundista, while society in general might agree that anyone operating 500 hectares is a latifundista, and the farmer operating 50 hectares would heartily agree. The term "latifundia" might be somewhat equivalent to the term "wealthy." One might get agreement between the individual definition and that of the

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10/ Maxwell I. Klayman and Don Bostwick. Analisis Economico de la Produccion de Cana de Azucar en el Valle del Cauca. Centro de Formacion Profesional e Investigacion Agricola, Monografia No. 11, Cali, Colombia: 1965.

public, only at an exceedingly high level of the index by which the condition is measured.

If we accept a definition of latifundia that would include only agricultural operations of 500 hectares (1235 acres) and above, we see that there are some 293 members of this set in the department of Valle del Cauca (cf. Table III). The average would be about 982 hectares in each farm, or about 2,426 acres.

The origin of such large land-holdings is in the history of the settlement and patenting of land in Colombia. When the Spanish conquistadores first came into the Cauca valley some 430 years ago, the flat part of the valley was largely forest and swamp, while the hillsides were brush and grass. The valley soils were obviously preferable to those of the mountainside. They were preempted by the new conquerors, and legalized by grants from the Crown of Spain. The initial improvements made by these new settlers were limited to the clearing of trees from the nonswamp lands, and the erection of fences that separated one hacienda from the next. The cultural concern for ownership of land, combined with the law of inheritance by primogeniture, has served to keep a significant portion of the land in the Cauca valley concentrated in the hands of a relatively few owners.

Now, a little more than halfway through the 20th century, an economist concerned with land use must include a class defined as "latifundia," with a subclass called "beef cattle." Large tracts of the land in the flat part of the Cauca valley are left in unimproved pasture that produces only beef. The land, the buildings, and the cow herd are all inherited by the son from the father; thus, there was no original cash investment by the present owner. A model of managerial goals for this type of hacienda might better be of a satisficing, rather than of an optimizing type. This means that the owner has a returns continuum that is divided into only two areas, separated by a boundary condition. The boundary condition is itself a zone characterizing the income states of "satisfactory" and "unsatisfactory."

The ownership of land is a satisficing criterion in which the objective function is defined most simply by the criterion: "more is better." This is much more of a social than an economic definition. The owner of a hacienda producing beef cattle does not consider that he has an investment on which to maximize returns. He is more or less constrained to cover variable production costs, depending on the nonfarm income that he can allocate to cover necessary family living costs in addition to the operating costs of the farm. Consequently, the objective function of the latifundistas, beef cattle, might best be approximated by some sort of satisficing goal defining a minimum level of personal effort, constrained by a minimal annual net disposable income. The problem for economists is that the objective function is of the satisficing type. It is given in ordinal (subjective) terms, with a cardinal (objective) constraint. Extant economic theory has difficulty in dealing with this sort of a farm firm, except to the extent that the variable costs of production must be covered by receipts from the production process.

The relevant data are those of annual variable operating costs, and the threshold level of income that is required by the owner of the latifundia. Thus, it is difficult to develop an economizing model for beef-producing latifundistas in the Cauca valley of Colombia.

The second class of agricultural producers is labeled, "latifundia, sugarcane." These operations may be as large as the beef cattle farms already discussed, and a few are quite large indeed. There are about a dozen sugar mills operating in the Cauca valley which depend to a greater or lesser extent on cane produced from their own lands. They also buy cane on ten-year contracts from growers, and lease land from individuals that is co-mingled with mill land for operating purposes. The larger sugarcane plantations under one ownership may include 10,000 hectares of good valley land, and few suppliers of cane to the mills operate less than several hundred hectares of sugarcane (often including "minor" enterprises such as cattle and corn in addition to the cane).

Sugarcane requires regular irrigation, fertilization, weed and insect control, and a year-round harvesting and reseeding program. Thus, the cash operating costs are a relatively high portion of the total costs. Labor wages are cash costs, and managers are hired on a cash salary. In most cases, the sugarcane latifundia are operated as stock or partnership businesses, and returns must be paid to shareholders and partners every year. Thus, it would be reasonable to assume that the standard economic maximizing model is applicable to the normal sugarcane producer. The objective function to be maximized would be annual net income.

Since the price of refined sugar is fixed by the government at the consumer level, the average cost of sugarcane per ton is fixed to the processor. The usual system is a contract price per ton delivered at the mill, plus or minus an adjustment for the sugar content, determined when the cane is processed. Thus, the avenues toward increased net incomes for the producer are increases in the economic efficiency of production, economic increases in sugar yield per ton of cane, or yield of cane per hectare, or some combination of these. Yields per hectare are not highly variable for any given field within a cane plantation, under the standard production practices. With input variables that are largely under the control of the producer, and a unit price that is fixed by long-term contract, expected gross income per hectare is relatively stable for large producers over several years.

The third class of agricultural producers is called "minifundia." This word means "small land-holding," and is no more precisely defined than are the latifundia at the opposite extreme of the land-holding scale. The minifundia with which this thesis is concerned are those that occur in the flat part of the Cauca valley. These very small farms are scattered widely throughout the valley, with concentrations in a few areas due to some forgotten historical event and with very few or none in other areas where large sugarcane plantations might occupy 12,000 or more hectares in a block.

Land use on the minifundia is characterized by a large number of crop and livestock enterprises, some of which are complementary and some of which are competitive for labor and other resources. The author has visited a number of minifundia on which the total land area available was three hectares or less, and on which there were as many as ten crop enterprises and three of poultry and livestock, each on an exceedingly small scale. One normally finds a small area in corn, a grove of plantain, some citrus and other fruit trees, coffee and cocoa interplanted under the plantain, random stalks of sugarcane, perhaps tobacco, tomatoes, a small field of manioc (for human consumption, not starch), plus other bits of this and that crop.

One might find a flock of half-wild chickens, a pig or two, and perhaps a cow, ox, or burro. One can make sense of this organization as an economic profit maximizing model with constraints. The corn is grown in two crops a year because it is a staple in the family diet, and there are not storage facilities that will maintain corn for more than three or four months in an edible condition. The plantain, sugarcane, and manioc are also staples in the family diet, and are produced for family consumption. The coffee and cocoa require shade, and plantain is admirably suited for this purpose. The valley is too low for good quality coffee and too high for good quality cocoa, but these crops yield a certain, even though low, cash income. Coffee and cocoa provide for the cash required to buy sugar, salt, hand tools, clothes, and other items that the farmer cannot produce for himself. The small areas of tomato, green pepper, cabbage, or other intensive products are purely speculative. The farmer invests a minimum of cash in seed, the other inputs being unpaid family labor and some imputed opportunity rate of return to the land in an alternative use. If the yields or prices of the speculative crops are high, the producer might get a substantial increase in his income stream that half of the year. If yields or prices are poor, the farmer has lost only a very small cash investment.

A number of minifundia in the northern part of the Cauca valley were included in a report published by J. F. Montoya and others in 1962. The report concluded that a major effort would be required to redistribute land from larger holdings to the minifundia, and that this effort must include irrigation and drainage works, the provision of supervised credit, and technical advice on both the production and marketing of agricultural products.11/ The land, labor, and money capital available to the minifundistas are all severely limited under present conditions, and they will continue in a subsistence mode of production until those conditions are changed.

The model that would seem to fit the minifundia would need to include both economic maximizing and survival-satisfying criteria. But under present conditions, there is always doubt that the short-run survival requirements of the family will be met, and it is not very meaningful to talk about solutions that try to maximize the very small quantity of net cash farm income beyond the survival threshold.

The fourth class of agricultural producers is that called "commercial." These are the producers who are larger in land area than the minifundias, and substantially smaller than the latifundias. They may be engaged primarily in dairying, or in the production of cash crops such as cotton, corn, soybeans, rice, or tobacco. A significant minority of these operations is carried out on rented land, compared to the low incidence of renting for the other classes of operators. The commercial producers tend to operate with some machinery. Rice producers are completely mechanized, cotton producers are mechanized up to the harvesting operation, and corn producers exhibit varying degrees of mechanization up to harvest. Cotton and corn are still harvested entirely by hand. Most of the labor in the

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11/ Analisis Economico de 109 Fincas en el Area del Proyecto Roldanillo - La Union - Toro, 1961-1962. Corporacion Autonoma Regional del Cauca, Cali, Colombia: Diciembre 1962, pp. 68-102.

production process is hired for cash wages, and there are relatively large cash outlays for such production inputs as seed, insect and disease sprays, machinery operation and maintenance, and transportation of the product from field to the first step in the marketing channel.

The commercial producers are engaged primarily in a market, rather than a subsistence oriented operation. These market oriented operations might be represented in the aggregate by standard economic optimizing models, having maximum net farm income per crop, as an objective function. Many of the commercial farmers are still producing under conditions of increasing returns that are associated with Stage I of the normal production process. This would indicate that significant returns would result from increasing the use of fertilizers, machinery, supplemental irrigation, and other technical production components. Some of the more successful farmers are apparently producing under conditions of diminishing returns associated with Stage II. These are the farming operations that fit most readily into standard economic analyses, and the ones with which technical consultants are most prone to work.

There may be some satisficing goals sought by these commercial producers. Certainly land ownership is one such goal, and one to which very few Colombians are totally immune. Others may lead to purchase of machinery or highly bred dairy cattle, where these investments are not justified on purely economic arguments. But this is probably no more serious for normal maximizing models in the Cauca valley than it would be in similar situations in the agriculture of the United States.

Because of the relatively great importance of satisficing goals the two categories that have been called "latifundia, beef cattle," and "minifundia," must be eliminated from this thesis. One might argue that the former category includes a large proportion of the politically and economically important citizens, as well as a large proportion of the land resource. One might also argue that the latter category includes people who need relatively more economic and technical assistance than do producers in the other categories. The fact is that it has been difficult to interest the latifundistas producing beef cattle, in economic development of their agricultural resources. Conversely, the minifundistas are signally lacking in land and money, if not in managerial ability. Without these, one cannot effect much of significance in the economic development of agricultural production.

Agricultural Credit

Credit for agricultural producers is often considered to be a panacea by which underdeveloped agricultural economies could be improved. It is certainly one of the relevant variables in any consideration of the milieu of an underdeveloped economy. This thesis is not especially concerned with the role that agricultural credit might play in the rationalizing of agricultural production in the Cauca valley. But the availability of credit affects the current status of agricultural production, and would be important in any consideration of changes from this status. It is discussed below only as a part of the setting of the problem for the thesis.

Agricultural credit is available from a variety of public, quasi-public, and private institutions, and from some individuals. Some of the credit institutions are specialized with respect to the type or term of agricultural loans that they will make, and some are specialized with respect to the type of producer to whom credit is supplied.

Commercial banks are required by law to include agricultural credit in their loan portfolios. These loans are usually for a crop season, or a year, and are concentrated in the area of production credit. The banks are selective with respect to the high credit rating required of borrowers, but will make loans to a wide variety of "qualified" agricultural producers.

The Banco Cafetero lends only to coffee growers, but tries to satisfy all of the credit needs of this producer group. The Caja de Credito Agrario is a public institution that supplies the full range of credit to its agricultural producer customers. But it operates under the handicap of a very low maximum loan limit to any individual borrower, and so is a credit source of limited use to commercial and large-scale producers.

The maximum term of customary mortgage loans is ten years; a very short time in which to achieve full equity in the land resource. In 1964, the national land reform agency was organizing its mortgage credit for settlers on land reform projects for longer repayment periods. It is expected that other mortgage lenders will also adjust to somewhat longer terms.

Interest rates are highly variable, between a lower limit of four percent per year and an upper one of five percent per month. As a general rule, interest rates increase in proportion to the term of the loan, reflecting the expectation of lenders that inflation or devaluation are both highly probable and temporally close at hand. Some credit programs, such as that of the Banco Cafetero designed to encourage reseeding with improved coffee varieties, are carried at interest rates that constitute a governmental subsidy. One might also generalize that interest rates charged by private institutions exceed those of public banks, for similar terms and purposes, and that this is also a modest governmental subsidy to the agricultural sector. There is an unknown volume of credit granted by processors, distributors, and suppliers of agricultural products, and these tend to carry the highest rates of interest. Some governmental credit programs have been initiated specifically to attack the high rates charged by such noninstitutional sources.12/

Perhaps one of the more serious limitations on credit use by agricultural producers, is that of the general attitude toward credit that prevails throughout the society. The low-income majority of the population has never used enough credit to develop any sophistication with respect to terms, interest rates, and the obligation to repay the creditor. At the other end of the scale, the latifundistas use credit more or less regularly for their production operations, and it is granted to them as a favor by a friendly banker. Government loans are notoriously slow of collection, the prevailing concept being that these are really disguised grants, and are not intended to be paid back. Work is very much needed, and has already been started, to teach the potential users of credit the attitudes that are commonly presumed by lenders in Europe and North America.

12/ The data and descriptions in this discussion were taken from: Bernardo A. Diaz. El Credito Agropecuario en Colombia. Universidad del Valle, Cali: November 1963 (mimeographed).

Chapter II: Hypothesis and Methodology

The first chapter discussed some of the relevant background material relating to the climate and soils of the Cauca valley of Colombia, and to some of the institutional and organizational characteristics affecting agricultural production. This chapter establishes an hypothesis about agricultural production, and discusses sources of data and analytical techniques by which the subject matter of the hypoth s s can be established and tested.

An Hypothesis

The hypothesis that will be tested in this thesis is that agricultural production resources are now optimally allocated by the producers in the Cauca valley. The criterion for optimality that will be applied is that of the net return generated by the resource mix. In general this will be expressed as the net return to an enterprise.

Agricultural production resources satisfy the optimality criterion when they cannot be recombined with a resulting increase in net income. The hypothesis does not refer to net farm income for "whole" farms, but only for separable agricultural production enterprises. This is necessary because most of the data are available on an enterprise basis, and very little are available for whole farms.

The population to which the hypothesis refers must be further restricted to those enterprises on farms for which the net return criterion is applicable. Thus, the population will not include enterprises on minifundias. As was discussed in the previous chapter, the operators of these farms are only partly described by this economic goal, and inclusion of satisficing goals is not easily quantifiable in the same terms as net income. The category of "latifundia, beef cattle," was also dismissed from consideration in the previous chapter, for similar reasons. The data on beef cattle that appear in succeeding chapters are from large-scale extensive pasture operations, but they are not of sufficient scale as to be latifundia.

A Procedure

The hypothesis of this thesis, as stated above, is a general one, and untestable in that form, so it is necessary to supply data as subject matter. These data will be in the form of estimates of net returns to various enterprises on farms in the Cauca valley. They are tabulated as enterprise budgets in the following chapter of this thesis. The general hypothesis may be made more specific, and testable, by inserting the appropriate net returns figure for a given land use. Thus, a specific hypothesis would be of the form:

> "The net enterprise return of X pesos per hectare for corn producers in the Cauca valley cannot be increased by any recombination of the resources used in current corn production."

When an hypothesis is established in such a form, it may be tested by various means. Perhaps the most conclusive test would require that a statistical production function be estimated for the enterprise in question. From this, an input mix that would maximize net income could be computed, and this maximum net income could be compared to that given in the hypothesis.

If the data available do not lend themselves to estimation of a statistical production function, the specific hypothesis might be tested by other means. Enterprise budgets using different input mixes could be calculated, and the resulting net incomes compared to that of the particular hypothesis. The hypothesis may be rejected if the net income computed from the statistical production functions exceed that in the hypothesis. The hypothesis may be of questionable validity if an enterprise budget shows a net income above that of the hypothesis.

The remainder of this chapter includes a discussion of the data requirements, and the theoretical techniques by which data may be organized into enterprise budgets and statistical production functions. The discussion is limited to those aspects of research methodology that are appropriate to the data and hypothesis of this thesis.

The Enterprise Model

The enterprise model to be used in this thesis is of the usual static sort, i.e., it assumes timeless production processes; single-valued expectations from any given mix of inputs; no uncertainty, or no random element in the system that is not explained in the production function; and that decisions are rational with respect to the economic criterion of net income maximization.

A physical production function can be expressed in the following canonical form:

$$Y = f\,(X_1, \ldots, X_g / X_{g+1}, \ldots, X_n)$$

where Y is the output that depends on the actions of some variable inputs X_1, through X_g, with other inputs X_{g+1} to X_n being held constant at given levels. The well-known law of diminishing physical returns has been stated as follows:

> "When one of a group of production elements is increased in proportion to the others: (a) The output per added unit of the variable factor tends to decline either immediately or after an initial stage of increasing returns; (b) total production increases at first, but ultimately declines as the excessive supply of the variable factor hampers the functioning of the fixed factors."14/

It is presumed to be operative in the enterprise models for this thesis, unless the data explicitly indicate otherwise.

Total physical product (TPP) in the above canonical function is the dependent variable Y. Average physical product (APP) is defined as, "that portion of total product produced by the variable input divided by the amount of the variable input used."15/ Marginal physical product (MPP) of a variable input is defined as, "the increment in total production resulting from an increment in the variable input."16/

The "normal" production function model to be used in this thesis may be categorized into three stages. Stage I is defined as that part of the function in which MPP is positive and greater than APP. Stage II is defined as that part of the function in which MPP is positive, less than APP,

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14/ John A. Hopkins. Elements of Farm Management. Prentice-Hall, Inc., New York: 1947, p. 155.

15/ Lawrence A. Bradford, and Glenn L. Johnson. Farm Management Analysis. John Wiley & Sons, Inc., New York: 1962, p. 114.

16/ Loc. cit.

and decreasing. Stage III is that part of the function in which MPP is negative. If it pays to produce any of Y at all, it pays to produce at least to the quantity defined at the lower bound of Stage II. Since throughout the range of Stage I, MPP of any given variable input is always greater than its APP, it pays to use more to that variable input. Similarly, it never pays to produce at any level beyond the upper bound of Stage II, since any increment of an input X_1 always reduce TPP below its previous level while cost is increased by the additional input used. Therefore, one may eliminate consideration of input levels in either Stage I or III since one is always better off in Stage II. Stage II is called the area of rational economic production.

Given a production function of the above canonical form, one can graph total, average, and marginal physical products. The procedure requires that various levels of inputs $X_1,\ldots,X_g$ be substituted into the equation, which is then solved for the output Y at each level of each variable input. The APP curves may be plotted by carrying out the simple division of product produced by the quantity of each input used at each calculated point. Since the MPP curve is the rate of change in the TPP for given levels of inputs, $X_1,\ldots,X_g$, the curves may be plotted by taking the first derivatives of the function of Y with respect to $X_1,\ldots,X_g$ at selected points, and transferring these values to the graph. Examination of the resulting sets of curves will indicate the levels of the variable input $X_1,\ldots,X_g$ where the bounds of Stage II are defined.

In order to specify the level of the variable inputs that maximize net returns, one must multiply the product Y by its price, and the variable inputs $X_1,\ldots,X_g$ by their prices. Such a scalar transform does not affect the relationships between the variables, nor between the plotted curves. The TPP curve then becomes total value product (TVP); the APP curve becomes average value product (AVP), and first derivatives of the TVP curve become marginal value product (MVP). A line drawn parallel to the X axis, at a height of the price of one unit of the product Y, is called the marginal factor cost (MFC) line for that input, where MFC is the amount added to TC from using one more unit of an input. The model assumes that perfect competition obtains, and therefore that the quantity of any input X used in the production process does not affect the price paid for it; and that the quantity of output Y will be sold in the market at a constant price regardless of the volume produced.

The point at which MFC intersects MVP is the point at which the value of the single increment of output Y is just equal to the cost of the increments of the inputs $X_1,\ldots,X_g$ that were required in its production. This point gives the quantity of inputs $X_1,\ldots,X_g$ to be used, such that net returns are maximized.

But graphical solutions are both cumbersome and not highly accurate. One can achieve a more accurate result more easily, by substituting calculus for graphs. Knowing that the optimum level of inputs is defined as that level where MFC is equal to MVP, one can put this relation into a formula and solve for the proper values of the variable inputs. Since the MVP is the first derivative of the function Y with respect to each variable input, one need only set this derivative equal to MFC and solve the equations for the optimal quantity of each such input to be used, and the quantity of the output Y that will result from this production process.

In the usual case, there will be more than one variable input in the production process, as the X_1 to X_g in the canonical form given above. In this case, one must set the partial derivative of the function Y with respect to the input variable X_i (where i ranges from 1 to g), equal to the price of the input X_i. There will be exactly as many partial derivative equations as there are variable inputs in the production function. The values of the X_i's must then be substituted into the original production function, and the level of output Y calculated.

This procedure is illustrated by a hypothetical production function:

$$Y=4X_1 + .3X_1^2 + 6X_2 - .8X_2^2 + 5X_3 - .2X_3^2 + 3X_4 + 2X_5$$

where Y is the product, say corn; the variables X_1, X_2, and X_3 might be labor, seed, and other expenses; and the inputs X_4 and X_5 are land and irrigation water held constant. The first partial derivatives of the function with respect to the variable inputs are:

$$\partial Y / \partial X_1 = 4 - .6X_1$$

$$\partial Y / \partial X_2 = 6 - 1.6X_2$$

$$\partial Y / \partial X_3 = 5 - .4X_3$$

Since the second partial derivatives of these variables are all negative, it is certain that the solution of the original production function will represent a maximum of net income. If the prices for the three variable inputs are 2, 3, and 2 pesos respectively, the optimal economic amounts of these inputs to use are calculated as:

$$4 - .6X_1 = 2$$

$$X_1 = 3.33$$

$$6 - 1.6X_2 = 3$$

$$X_2 = 1.88$$

$$5 - .4X_3 = 2$$

$$X_3 = 7.5$$

The quantity of the product that will result from using the above quantities of variable inputs, under the relationships given by the production function is estimated as follows:

$$Y = 4\ (3.33) - .3\ (3.33)^2 + 6(1.88) - .8(1.88)^2 + 5(7.5) - .2(7.5)^2 + 3 + 2$$

$$Y = 49.7$$

Thus, under ther above assumed production function, 49.7 units of corn will be produced from a combination of 3.33 units of labor, 1.88 units of seed, 7.5 units of other expenses, 3 units of land, and 2 units of irrigation water.

The net return under this production system can be calculated as the value of the corn produced, less the costs of the inputs used in the production process. The unit costs of the variable inputs were given above as 2, 3, and 2 pesos for X_1, X_2, and X_3, respectively. If the unit price of the product is 2 pesos, and the unit costs of the constant inputs are 5 for land and 1 for irrigation water, then the net return (π) is:

$$\pi = Y(P_y) - (X_1\ (P_{x1}) + X_2\ (P_{x2}) + X_3\ (P_{x3}) + X_4\ (P_{x4}) + X_5\ (P_{x5}))$$

$$= 49.7\ (2) - (3.33\ (2) = 1.88\ (3) = 7.5\ (2) = 3\ (5) = 2\ (1)$$

$= 99.4 - 44.3$

$\pi = 55.1$ pesos

This is the maximum net return given the production relationships as stated in the production function, and the prices of the inputs and the product. If the production relationships change due to the introduction of higher-yielding seed, for instance, then one must compute a new production function before an optimum can be calculated. If the prices of any of the inputs (or of the output) change, then the above solution will no longer necessarily maximize net return. The calculations must be repeated through all of the above steps in order to find the new optimum input combination, the new output level, and the new net return that would result from the production process.

Statistical Estimates of Production Functions

The discussion of the preceding paragraphs indicates the relative ease with which one can estimate optimum input mixes, and the associated level of net income, from a production function. The more difficult part of the analyst's job is to find production functions for the various land uses of the Cauca valley. Since these are not already computed, statistical estimates of the factor-product type must be sought as the basis for further economic analysis. French, among others, is of the opinion that the method of least-squares regression is most adequate for statistical estimates of onfarm factor-product type functions.17/ If, as Heady and Dillon state,

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17/ Burton L. French. "Simultaneous Economic Relationships and Derivation of the Production," in Heady, Johnson, and Hardin, Resource Productivity, Returns to Scale, and Farm Size. Iowa State College Press, Ames: 1956, p. 104.

"An infinite number of functional forms are possible in productivity studies," 18/ then one of the principal requirements, before one may fit functions, is to select the form or forms most appropriate to the data at hand. There seems to be no unique way of deciding on the functional form to be used. One must select the form on the basis of the data available, the logical situation, and the prospects for getting the numerical computations performed. When a statistical estimate has been made, one may then perform statistical tests to estimate the reliability of the fit.

In the present case, there was no possibility of gathering data specifically for production function analysis in the Cauca valley, and little chance that numerical computations could be carried out for any functional forms other than those requiring a first or second-degree polynomial. Thus, the two forms of production functions that were considered in this thesis were the second degree polynomial and the Cobb-Douglas (fitted as a first degree polynomial, the data being read in logarithmic form).

The canonical form of a quadratic (second degree polynomial), equivation is:

$$Y = a + b_1X_1 + b_2X_2 - b_3X_1^2 + b_4X_2^2 + b_5X_1X_2 + e\ ,$$

where Y is the product, X_1 and X_2 are variable inputs, the b's are the coefficients to be estimated, a is a constant term, and e is the error term. In this form, the production surface will be a hyperbola with its apex at the point of maximum TPP, defining the upper bound of Stage II of this

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18/ Earl O. Heady, and John L. Dillon, _Agricultural Production Functions_, Iowa State College Press, Ames, 1961, p. 73.

production process. MPP will decline over the entire range of the function, and will become zero where the total product is at a maximum. This point is given by the formula:

$$TPP_i = .5b_{i2}b_{i3}^{-1} \text{ for each variable input } x_i,$$

according to Heady and Dillon.19/ The MPP in this form of the quadratic function must also be a hyperbola, with intercepts along the input axes, and a surface that declines by a constant absolute amount with increases in the quantities of the inputs. This must be so since the second derivatives of the functions with respect to either input is a constant.

If one were to assume that the squared terms in the above canonical form of the function were preceded by positive rather than negative signs, then MPP would be increasing rather than decreasing. There would be no maximum TPP and the only solution to the question of optimum input quantities would be to use an infinite amount.

Some of the enterprises on minifundia in the Cauca valley are very likely still in Stage I, along with a sample of the other agricultural production operations on larger scales. One knows, intuitively, that these operators badly need to increase the scale of their inputs. Fitting a quadratic production function to data taken from present operations, will not allow one to estimate how much of an increase is economically optimum. A suggested approach to this problem would seem to be to fit a production function to those enterprises already in Stage II, to calculate economically optimum levels of inputs from the function, and then to suggest that all

19/ Earl O. Heady, and John L. Dillon, op. cit., p. 78.

producers in Stage I bring the scale of their inputs up to that suggested for Stage II optima.

The problem of using only data already available from other field studies is that they may not provide a sufficient number of observations over the full range of the function. If this is the case, then one will get a statistical estimate that is biased toward the heavily represented area, and/or subject to error if extrapolated toward the lightly represented areas of data. A second problem is that there may not be data for all of the relevant variables in all of the field data available. There is as yet nothing approaching a "production process standard" for the principal land uses in the Cauca valley. Fertilizer inputs, for example, ought logically to be included in production functions for the cultivated crops. But when one examines the available field data, one finds so few that include any sort of fertilizer input that one is forced to eliminate this as an independent variable. The net result is that one must define a variable in which one attempts to aggregate a miscellany of inputs, not normally distributed in the population, or else to place a heavy burden on "e," the error term in the canonical form of the function.

The canonical form of the Cobb-Douglas function is:

$$Y = aX_1^{\,b}\, X_2^{\,c} X_3^{\,d} \; \ldots .$$

Where Y is the output, the X_i's are variable inputs, and the b, c, ...'s are the coefficients to be estimated by regression. This function allows either increasing, constant, or decreasing marginal productivity for the variable inputs, but only one of these, not any combination.20/ Thus, like the quadratic function discussed above, the function may give results that include a hidden bias, if, in fact, the observations used to estimate the function have been drawn from production situations that are in both Stages I and II of the normal production process. The TPP curve that may be estimated from the use of a Cobb-Douglas type of function, is asymptotic to some maximum level of the outputs.21/ Thus, the upper bound of Stage II may only be approximated, but this approximation may be made closely enough for practical purposes.

One further point that applies to both the Quadratic and the Cobb-Douglas forms of production function estimates, concerns the problems of classifying the inputs. Johnson suggests that good complements be grouped together, and good substitutes be grouped together in defining production inputs.22/ Quintana 23/ found that this sort of grouping of man-labor with animal power into one variable, lead to a statistically better fit of a production function for corn, than was obtained with the two inputs as independent and separate variables. The apparent reason was that animal power is always accompanied by human labor, but not vice-versa. This should be done with caution, lest the researcher try to group two inputs

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20/ Earl O. Heady. "Technical Considerations in Estimating Production Functions," in Heady, Johnson, and Hardin. Op. cit., p. 11.

21/ Heady and Dillon. Op. cit., p. 76.

22/ Glenn L. Johnson. "Classification and Accounting Problems in Fitting Production Functions to Farm Record and Survey Data," in Heady, Johnson, and Hardin. Op. cit., p. 90.

23/ Emilio U. Quintana. Resource Productivity Estimates for Five Types of Philippine Farms, University Microfilms Inc., Ann Arbor, Michigan: 1960. P. 63. (Microfilmed Ph.D. Thesis) that are good substitutes in the physical production process, but that are not precisely substitutable in economic terms. As an example, Johnson 24/ suggests the grouping of family, hired, and operator labor into one input variable. With certain enterprises such as corn or cotton in the Cauca valley, most of the labor input may be from family or operator labor, or from hired labor that has the same opportunity cost. But the labor hired for the harvesting operation is either of a different quality, or is hired at a critical time (e.g. when operator and family labor are most limiting), and may have an actual cost in excess of labor from any source at other stages of the production process. If these inputs are substitutable only over a narrow range, then they must be entered into the production function as independent variables in order that the estimate of their respective marginal productivities may accurately be calculated, and the optimum quantities of the two inputs be estimated, for optimum net income to result.

Enterprise Budgets

The technique of enterprise budgeting has been used in numerous instances, over several decades, by farm production researchers in the United States. The final result of an enterprise budget can be almost any datum that is desired by the researcher, but is most frequently some form of net income. In this usual form, an enterprise budget is a summation of the expected gross value product, less the sum of the costs of the inputs used in the production process.25/ In applied farm management, these data

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24/ Hady, Johnson, and Hardin. Op. cit., p. 91.
25/ Lawrence A. Bradford, and Glenn L. Johnson. Farm Management Analysis. John Wiley and Sons, Inc., New York: 1962, p. 329.

are given by relevant production functions, and/or by a historical record of actual input-output data for the enterprise being studied.

While the quadratic and Cobb-Douglas functions discussed above estimate a "slice" of a production surface, enterprise budgets estimate one point on such a surface. All inputs are fixed at given levels, and a net return is calculated for these levels of the inputs, the output, and prices. One cannot derive an estimate of the marginal returns to various inputs from a single enterprise budget. To do so would require a comparison of the rate of change from a neighboring point on the production surface, as levels of the input under study were varied. The budget gives only one point. If one is interested in estimating the marginal product of a given input, one may vary the input quantity in two otherwise identical budgets, and estimate a rate of change in the gross product between the resulting two points on the product surface. If one has an enterprise budget in which there are a number of variable inputs to be studied, this process can be a long one.

In research, enterprise budgeting is often used to estimate modal practices for a given enterprise, based on sample survey data. One may estimate the modal value for each studied input separately, and then combine these values in the enterprise budget. It is common to use, if necessary, different numbers of observations for different inputs, and one is not required to eliminate <u>all</u> of the data of one respondent who happens not to be able to supply an observation on one of the studied variables. Enterprise budgeting is therefore a more efficient user of field survey data than are the techniques by which statistical production functions are normally estimated. The resulting datum is, of course, not nearly so powerful a research tool, as compared to a statistically reliable production function.

A further common use of the enterprise budgeting technique is as a preliminary to more sophisticated production function research. In an area such as the Cauca valley of Colombia, not enough is known of the production processes for the various land uses, so that the researcher can be sure that any given functional form, or any given array of inputs, will adequately describe the production surface. One may calculate some enterprise budgets from field data and use these to probe for the most likely array of input variables and production processes.

In this thesis, enterprise budgets were calculated according to the following general model (Figure IV).

The depreciation figure in each enterprise budget is taken from a specified source, and was gathered in the first instance as a response in a field interview. It is not calculated, but is based on the figure furnished by the respondent. Interest on operating costs in the enterprise budgets is estimated as 4 percent per annum of the total variable cash costs reported by a given respondent. Interest paid on production credit, if any, was not included in this estimate, but is given separately in the list of cash costs. Interest on land, livestock, and machinery and equipment, was estimated at 8 percent per annum of the market value of these investments. These two imputed charges are included in noncash costs, and are considered to be the opportunity rates of return to their respective terms and types of investments. For a more detailed treatment of the

Figure 4: Form of Enterprise Budgets

Budget i, ---

Item	Amount
Gross Income *	. . .
Cash Costs	
Contract labor	. . .
Seed	. . .
. . .	
Total Cash Costs	. . .
Non-cash Costs	
Depreciation	. . .
Interest on operating capital	. . .
. . .	
Total Non-cash Costs	. . .
Total Costs	. . .
Net Cash Income	. . .
Net Enterprise Income	. . .
*Yield, in kilograms/hectare	

Source: . . . .

original criteria, the reader is referred to the thesis of Ayora and Morales, especially pages 5 through 8.26/

The crop enterprises considered in this study require varying amounts of time for each crop cycle. The variation is from three or four months for soybeans, to eighteen months or more for sugarcane. Since it is customary to produce no more than two cultivated crops on the same ground in any calendar year, the budgets for the "annual" cultivated crops in this thesis were adjusted to reflect costs and returns for a crop season of six months. Permanent pasture and sugarcane were adjusted to reflect costs and returns on an annual basis. The above budget form was modified to fit particular characteristics of the various enterprises when required. An example would be the partitioning of the gross returns for the dairy enterprise to reflect cash returns from sales of milk and meat, and inventory changes.

26/ Cesar Ayora and Hernan Morales. "Costos de Produccion del Maiz en el Valle del Cauca." Universidad del Valle, Facultad de Ciencias Economicas, Cali, Colombia: June 1964. (Unpublished bachelors' thesis)

Chapter III: Quantification of the Hypothesis

There are no production functions already extant from which one might estimate optimum input quantities, and the resulting net incomes, for any of the agricultural production enterprises in the Cauca valley of Colombia. The subject matter of the hypothesis has been derived from a series of enterprise budgets as first approximations of the status quo relative to the important land uses in this area. This chapter presents and discusses these budgets.

For discussion purposes, the budgets are divided into the following three categories of land use: permanent crops, cultivated crops, and permanent pasture. The budgets include all of those enterprises for which data were available. All of the current major land uses are included, but there are many others of a minor sort about which too little is known to provide even an enterprise budget. Some of these are intensive crops such as table grapes and vegetables, and some are extensive crops such as sesame and grain sorghum. These and other potentially profitable land uses need to be studied and the results included in any planning models that aim toward a rational allocation of the agricultural production resources of the valley. This must be left to a succeeding research effort.

Permanent Crops

The permanent crops under consideration here are sugarcane, cocoa, and plantain. Oranges, grapes, sisal, pineapple, and coffee are other permanent crops found in the Cauca valley. Some of these are promising for commercial production as specialty crops, and some are probably doomed to be eliminated by the competition of other, more profitable, land uses.

The coffee grown in the flat part of the Cauca valley is both lower yielding and of a lower quality than that grown in the higher producing areas nearby. Coffee probably will be eliminated as the minifundistas in the valley become more a part of the money economy, and more sophisticated with respect to income-optimal enterprises. There are a number of producers of table grapes in the valley, and this land use appears to be profitable. But there are no data available on which enterprise budgets could be calculated. Citrus fruits are found widely in the valley, but only rarely on a scale that could be called "commercial." Horticultural experts are of the opinion that citrus could become an important land use, if it could be produced, processed, and marketed domestically or on the world export markets at competitive prices. But there are no data that are sufficient to estimate production costs and returns, nor are data available on processing and marketing costs and margins. So the economic prospects for citrus must be left for some later study.

Sugarcane

The Cauca valley of Colombia is one of few locations in the world where sugarcane grows and may be harvested the year around. The sugarcane grown in the valley is processed into the two rather distinct products of refined sugar and panella. The former is processed through a more-or-less standard centrifugal refining process in relatively large industrial plants. Panella is a crude sugar obtained by passing the juice of the cane through a series of kettles, where water is boiled off and impurities are skimmed from the surface. The result is a molded cake somewhat resembling brown sugar, the color indicating the degree of purity. Panella mills are located throughout the Cauca valley and elsewhere in Colombia. They are uniformly small, private ventures that depend on the purchase of cane from other growers in the locality to supplement that grown on land owned by the panella mill itself.

Consequently, sugarcane can be found in production units of a hectare or two, on minifundia or small commercial farms, for sale to a local panella mill. Cane can also be found in production units of twelve thousand hectares, produced by a sugar refinery for its own use. Between these extremes, sugarcane is grown on individual farms, in fields of 20 or 30 up to 200-300 hectares, the product of which may be sold to a refined-sugar mill or to a local panella mill, depending on whether the grower has a contract with the sugar refinery, and on the relative prices being paid by the two types of processors.27/

The summary enterprise budgets for sugarcane were prepared from results of a sample survey of nine individual producers located in the vicinity of the Castilla sugar mill, in the southern end of the Cauca valley, and from the production records of central Castilla. Practices vary among fields on the mill-operated lands, and between individual producers. An average practice of all commercial producers of cane intended for the refinery, is to plow and replant cane after every fifth cutting, with

27/ The consumer price of refined sugar is set by the Government, while that for panella is determined by supply and demand in the free market. Thus, the price that operators of panella mills can pay for cane is sometimes above the long-term contract price paid by producers of refined sugar. In such a situation, cane producers with delivery contracts to a refined sugar producer, sometimes siphon off part of their crop to the more profitable panella outlet.

Table V: Sugarcane Budget, Individual Growers
(pesos/ha. on twelve-month basis)

Item	1st Cutting	2nd-5th Cuttings	Average, Five Cuttings
Gross Income *	6,911.77	5,661.48	5,911.54
Cash Costs			
Labor	1,288.44	1,097.14	1,135.40
Seed	520.32	31.22	129.04
Herbicides	70.80	84.92	82.10
Fuel, oil, grease	69.84	11.14	22.88
Repairs	84.24	88.26	87.38
Hauling to mill	1,177.20	965.03	1,007.46
Income taxes	48.00	51.22	50.58
Fertilizers	---	229.27	183.42
Total Cash Costs	3,258.84	2,558.10	2,698.26
Noncash Costs			
Depreciation	142.68	152.18	150.28
Interest, operating capital	132.36	130.87	131.17
Interest, machinery	48.02	128.69	112.56
Interest, land	1,248.72	1,332.00	1,315.34
Total Noncash Costs	1,571.78	1,743.74	1,709.35
Total Costs	4,830.62	4,301.84	4,407.61
Net Cash Income	3,652.93	3,103.38	3,213.28
Net Enterprise Income	2,081.15	1,359.64	1,503.93
* Yield (tons/ha.)	105.09	86.08	89.88

Source: Gerado Garcia and Hernando Zuluaga. "Costos de Produccion de Cana de Azucar en la Zona Aledana al Ingenio Castilla." Universidad del Valle, Facultad de Ciencias Economicas, Cali, Colombia: Junio, 1964, pp. 36, 43, 46. (Unpublished Bachelor's thesis)

Table VI: Sugarcane Budget, Castilla Sugar Mill
(pesos/ha. on twelve-month basis)

Item	1st Cutting	2nd-5th Cuttings	Average Five Cuttings
Gross Income *	6,471.77	5,564.14	4,745.67
Cash Costs			
Labor	1,716.99	806.04	988.23
Seed	573.20	62.50	164.64
Herbicides	111.07	49.58	61.88
Hauling to mill	1,611.43	1,621.20	1,619.25
Fertilizers	104.22	168.75	155.84
Total Cash Costs	4,116.91	2,708.07	2,989.84
Noncash Costs			
Interest, operating capital	154.80	101.82	112.42
Interest, land	1,250.62	1,333.33	1,316.79
Total Noncash Costs	1,405.42	1,435.15	1,429.21
Total Costs	5,522.33	4,153.22	4,419.05
Net Cash Income	2,354.86	2,856.07	2,755.83
Net Enterprise Income	949.44	1,420.92	1,326.62
* Yield (tons/ha.)	98.40	84.60	87.36

Source: Gerado Garcia and Hernando Zuluaga. "Costos de Produccion de Cana de Azucar en la Zona Aledana al Ingenio Castilla." Universidad del Valle, Facultad de Ciencias Economicas, Cali, Colombia: Junio, 1964, pp. 59, 60. (Unpublished Bachelor's thesis) replanting after each cutting restricted to thin spots in the field. The first cutting is made after about 18 months, and the other four at about 15-month intervals, giving a crop cycle of about six and one-half years.

The two budgets for sugarcane are not strictly comparable, since the Castilla mill budget is taken from one very large cane production enterprise, while the other budget represents a number of individuals on much smaller units. The sugar mill hires the land preparation and planting operation, and most of the other jobs requiring machinery. Hence, the budget does not include items relating to machinery, and does show a higher amount for hired labor and for the hauling operation than does the budget for individual cane producers. There is reason to believe that the data gathered from the mill are more accurate than are those gathered from the individual producers, simply because the mill has a bookkeeping system designed to keep track of all expenses of the field production division. None of the individual producers kept books of the quality required for a tightly controlled industrial-producing operation.

The average annual enterprise income for the individual producers appears to be about 177 pesos per hectare greater than the same figure for the mill. This difference could be either an over- or an under-estimate of the real differences between the two types of cane producing organizations. A larger and broader sample, and more reliable answers to quantities and costs of inputs, would allow a more accurate comparison of these two types of cane producers.

Cocoa, Pure Stand

The primary data from field survey carried out in the northern part of the Cauca valley provide only six observations on which to base a budget for pure cocoa. This enterprise is always found on relatively small farms in the valley, and usually associated with plantain. The data from which this budget was developed were not gathered on an enterprise basis, but the budget coincides with other estimates of production costs and returns for similar areas of Colombia. In this budget no labor is hired, so the man-days are included in the noncash cost category, and are charged at the opportunity-rate for labor of 15 pesos per day. The initial costs of planting the seedling trees, and the costs of caring for them up to about the fifth year, are included in the budget as a noncash recapture item for year six and beyond. This budget therefore represents input and return conditions for cocoa in full production.

Cocoa-Plantain

Cocoa-plantain is one of the prime examples of joint products in the agriculture of the Cauca valley. Cocoa trees must be grown under shade. The plantain tree 28/ provides generous shade, and a cash crop in addition. The bulk of the labor for both of these tree crops, in addition to harvesting the fruit, is the periodic cleaning of grass and weeds from beneath the trees, and the occasional application of irrigation water. Irrigating and weed control are jointly done, and only the harvesting is done separately for the two crops.

28/ Identical in appearance to the banana, except for a different color of stem.

Table VII: Cocoa Budget, Pure Stand
(pesos/ha. on twelve-month basis)

Item	Pesos
Gross Income *	1,115.00
Cash Costs	
Insecticides	30
Other Cash Costs	10
Total Cash Costs	40
Noncash Costs	
Recapture of Foundation Costs (5 years)	52
Interest on Land	273
Unpaid Family Labor	304
Total Noncash Costs	629
Total Costs	669
Net Cash Income	1,075.00
Net Enterprise Income	446
* Yield (kg.'s/ha.)	201

Source: Unpublished field data gathered by the author.

Plantain produces the first year after planting at about one-half of the full production level. Shoots come up around the base of the mature tree at about the time the fruit sets. When the producer harvests the bunch, he also cuts the original stem and all but one of the shoots. This remaining shoot will produce a bunch of fruit and a new generation of shoots the second year. Plantain is a staple vegetable in the Colombian diet, and is grown in stands of a tree or two in backyards, and by commercial producers in larger concentrations ranging up to pure stands of several hectares in area. There are no input or production data available for pure commercial plantations of plantain in the Cauca valley.

Cultivated Crops

The cultivated crops under consideration here include cotton, corn (maize), beans, soybeans, tobacco, and rice. Sorghum for grain was a new crop in the valley in 1964-65, and is being produced in a rapidly expanding quantity every season. Sesame was also produced on an occasional field as an oil crop, although without striking economic results. Manioc, of the edible varieties, is produced widely by the minifundistas as a starchy staple in the diet. There are also a few commercial producers of manioc for starch, particularly in the southern end of the valley. But there were no reliable data available from which input-product budgets could be calculated for sorghum, sesame, manioc, and the other cultivated crops that are found in the valley.

Cotton

Cotton has been a major land use in the Cauca valley for only a few years, but has been so successful as to be an important part of the food

Table VIII: Cocoa-Plantain Budget, Joint Products
(pesos/ha. on twelve-month basis)

Item	Pesos
Gross Income *	2,386.00
Cash Costs	
Insecticides	30
Other Cash Costs	21
Total Cash Costs	51
Noncash Costs	
Recapture of Foundation Costs	52
Interest on Land	281
Unpaid Labor	830
Total Noncash Costs	1,163.00
Total Costs	1,214.00
Net Cash Income	2,335.00
Net Enterprise Income	1,172.00
* Yields: Cocoa (kg.'s)	198
Plantain (bunches)	222

Source: Unpublished field data gathered by the author.

and fiber product of the area by 1965. All cotton production operations are mechanized, except for the harvest, which is still done exclusively by hand. The crop is produced only on the medium-scale and larger farms. By law, cotton may be grown in the Cauca valley only in the first half of the calendar year, and in northern Colombia only in the second half of the year. This measure was designed to keep the pest and disease populations from building up. It also effectively prevents field trials on the new varieties of perennial cotton.

The farmer does not normally put any of his own labor into the production of cotton, on the scale of farm represented by typical cotton producers. Labor is therefore included as a cash cost in the budget. The data from which these budgets were calculated were gathered in the summer of 1963. By the summer of 1965 pest control costs had gone up substantially, with no significant increase in yields. Cotton growers were concerned both about insect pest control, and about the problems associated with cotton picking labor. They and technicians working for the cotton producers federation (IFA), both expect that cotton will gradually shift from the Cauca valley to new lands being opened up, and so far less afflicted with cotton pests.

Corn

Corn is a staple in the Colombian diet, and has been a traditional land use since centuries before the Spanish conquest. One may observe examples of completely hand-labor produced corn, generally on fields of less than twelve hectares, in the Cauca valley. One may also observe a few examples of corn produced under completely mechanized conditions, including

Table IX: Cotton Budget, Two Areas in the Southern Valley
(pesos/ha. on a six-months' basis)

Item	Roldanillo	Cartago
Gross Income *	4,629.00	4,906.00
Cash Costs		
Contract labor	146	372
Harvest labor	855	1,441.00
Other labor	642	680
Seed	29	51
Fuel, oil, grease	31	77
Hauling	99	107
Machinery repairs	60	54
Insecticide, herbicide	510	755
Income taxes	18	25
Other cash costs	458	561
Total Cash Costs	2,848.00	4,123.00
Noncash Costs		
Depreciation	61	79
Interest, land and machinery	381	69
Interest, operating costs	54	130
Total Noncash Costs	496	278
Total Costs	3,344.00	4,401.00
Net Cash Income	1,781.00	783
Net Enterprise Income	1,285.00	505
* Yield (Kilograms)	2,258.00	2,393.00

Source: Ayora, Cesar and Morales, Hernan: "Costos de Produccion del Maiz en el Valle del Cauca." Universidad del Valle, Facultad de Ciencas Economicas. Cali, Columbia, Junio, 1964. pp. 124-127. (Unpublished bachelor's thesis) the use of picker-shellers for the harvest. One may, in fact, observe these two extremes on opposite sides of the same fence.

In their thesis, Ayora and Morales 29/ generated corn production data according to a number of classifications. Since the same basic observations were used over and over in each of the series of classifications, one cannot compare the summary data across the classificatory lines. One may, however, support the notion that there is not any single "system" of corn production in the valley, and that therefore, the hypothesis with respect to corn production and income should be a series of subhypotheses, each dealing with one of the important "systems" of production. One such system must distinguish the hand-production on relatively small fields that is common in the valley. Perhaps there should be an intermediate system under which the scale with respect to hectares is larger than for the hand system, and there are also present some more technical inputs, such as the degree of mechanization, use of herbicides and insecticides, and use of hybrid seed. One might also require a third system that includes relatively large-scale producers, and a relatively complete degree of mechananization. The data were not classified in these systems before they were combined into summary budgets by Ayora and Morales, and the summary budgets cannot now be taken apart for a reclassification. Nevertheless, the summary budges (Tables XII and XIII) indicate the extent to which there seems to be changes in the basic systems of corn production in the valley.

Corn may be produced at any time of the year, and one can usually find fields in various stages of growth and maturity at any given point

29/ Op. cit., pp. 29-90.

Table X: Corn Budgets, Four Hectare Scale Classes
(pesos/hectare on a six-months basis)

Item	3.2 ha.	3.3-13 ha.	13-32 ha.	32 ha.
Gross Income *	814	1,793.00	2,026.00	2,609.00
Cash Costs				
Contract labor	58	187	151	128
Other hired labor	410	370	366	330
Seed	28	50	53	62
Fuel, oil, grease	---	81	39	29
Hauling	19	41	28	59
Machinery repairs	---	148	66	89
Insecticide, herbicide	9	53	74	68
Income taxes	13	12	22	14
Other cash costs	45	95	103	115
Total Cash Costs	582	1,037.00	902	894
Noncash Costs				
Depreciation	8	94	94	94
Interest, land and machinery	286	175	175	175
Interest, operating costs	9	13	13	13
Building repairs	11	20	3	15
Unpaid family labor	229	---	---	---
Total Noncash Costs	543	302	285	297
Total Costs	1,125.00	1,339.00	1,187.00	1,191.00
Net Cash Income	232	756	1,124.00	1,715.00
Net Enterprise Income	-311	454	839	1,418.00
* Yield (kilograms)	930	2,049.00	2,315.00	2,982.00

Source: Ayora, Cesar and Morales, Hernan: "Costos de Produccion del Maiz en el Valle del Cauca." Universidad del Valle, Facultad de Ciencas Economicas. Cali, Colombia, Junio, 1964. pp. 42-90. (Unpublished bachelor's thesis)

Table XI: Corn Budgets, Mechanization and Tenure Classes
(pesos/ha. on a six-month basis)

Item	Hand Grown	Mechan-ized	Owned Land	Rented Land
Gross Income *	893	1,796.00	2,231.00	2,844.00
Cash Costs				
Contract labor	54	131	134	123
Other hired labor	321	359	393	311
Seed	30	59	57	64
Fuel, oil, grease	---	37	43	29
Hauling	19	46	39	54
Machinery repairs	---	97	73	104
Insecticide, herbicide	9	70	78	24
Income taxes	13	20	20	---
Land rent	---	---	---	440
Other cash costs	28	104	92	118
Total Cash Costs	474	913	929	1,267.00
Noncash Costs				
Depreciation	8	94	94	94
Interest, land and machinery	286	175	175	70
Interest, operating capital	9	13	13	13
Building repairs	13	14	9	19
Unpaid family labor	230	---	---	---
Total Noncash Costs	546	296	291	196
Total Costs	1,020.00	1,209.00	1,220.00	1,463.00
Net Cash Income	419	883	1,302.00	1,577.00
Net Enterprise Income	-127	587	1,011.00	1,381.00
* Yield (kilograms)	1,021.00	2,053.00	2,550.00	3,250.00

Source: Ayora, Cesar and Morales, Hernan: "Costos de Produccion del Maiz en el Valle del Cauca." Universidad del Valle, Facultad de Ciencas Economicas. Cali, Colombia, Junio, 1964. pp. 29-90. (Unpublished bachelor's thesis.

in time. The commercial production tends to be concentrated so as to take advantage of the bimodal rainfall distribution over the calendar year. Corn is one of the favorite crops to rotate with either cotton or soybeans, and is frequently grown on a continuous basis. Hybrid varieties have been developed especially for the condition of the Cauca valley, at the Palmira Experiment Station near Cali. These hybrids produce yields on check plots of over six metric tons per hectare (over 100 bushels per acre). Normal yields expected by commercial producers are little more than one-third of this level under conditions of average weed and insect control, no fertilizer and no irrigation. It was estimated by the manager of a hybrid seed supplier, that about 90 percent of the corn produced for the market in the flat part of the Cauca valley, was from hybrid seed. No other input of an advanced technological nature is used so widely as this.

Beans

Beans are also a staple in the Colombian diet, and are grown extensively on the commercial farms in the Cauca valley, as well as in small plots, or interplanted with corn, on the small hill farms. The usual mode in the Cauca valley includes production that is mechanized up to harvest. The plants are pulled by hand and piled in windrows, then threshed by a combine with a pick-up attachment. Like the cotton budget, all labor is hired in the typical case for bean production in the valley.

The budget for beans does not include any credit for nitrogen fixed by the bean plant, and available for the following crop. The reason is that these soils do not, by nature, contain the required bacteria, and the practice of innoculating seed is little used. Agronomists invited to

Table XII: Bean Budget, Cartago Area
(pesos/ha. on a six-months basis)

Item	Pesos
Gross Income *	3,357.00
Cash Costs	
Contract labor	260
Other hired labor	683
Seed	353
Fuel, oil, grease	63
Hauling	39
Machinery repairs	201
Insecticide, herbicide	98
Income taxes	44
Other cash costs	88
Total Cash Costs	1,829.00
Noncash Costs	
Depreciation	220
Interest, land and machinery	376
Interest, operating capital	73
Building repairs	36
Total Noncash Costs	705
Total Costs	2,534.00
Net Cash Income	1,528.00
Net Enterprise Income	823
* Yield: (kilograms)	1,583.00

Source: Gerado Garcia and Hernando Zuluaga. "Costos de Produccion de Cana de Azucar en la Zona Aledana al Ingenio Castilla." Universidad del Valle, Facultad de Ciencias Economicas, Cali, Colombia: Junio, 1964, pp. 118-121. (Unpublished bachelor's thesis) estimate the agronomic results that might follow from the use of innoculants, developed a notion that the marginal return per peso spent on innoculant might be in the order of 500 pesos. They expected that this striking result would rapidly diminish as a population of the nitrogen-fixing bacteria was built up in the soil. These estimates could be in error by a factor of even 10 or 20, and expenditure for innoculants would still be an uncommonly profitable one.

Soybeans

Soybeans have been grown extensively in the Cauca valley for a number of years, and support two modern plants for the extraction of edible oils. This crop is commonly rotated with cotton and corn, and is produced by a system very similar to that used for the production of beans. The situation with respect to the use of innoculants on soybeans is also similar to that for beans. It was estimated by the distributor of innoculants in the valley, that enough innoculant was sold for slightly over 100 hectares of the second soybean crop in 1964. This would represent well under 0.1 percent of the soybean acreage seeded in that crop cycle.

Tobacco

The tobacco produced in the Cauca valley is of less than top quality, even among domestic Colombian tobaccos, due apparently to the interaction of variety, climate, and predominating production systems. The crop is relatively labor-intensive, and is produced on small acreages throughout the valley. Labor inputs for tobacco proved difficult to gather in a very precise form. The total of about 124 man-days per hectare is believed to be reasonable, and about half of this was supplied by the operator and his family, in the sample from which this budget was developed. Thus, the labor input in this budget is split half and half between the cash and the noncash cost categories.

Permanent Pasture

The land uses included in the category of permanent pasture are grazing for beef and dairy cattle. There are so few sheep raised in the Cauca valley as to be curiosities, and no goats at all. The native pasture most common in the valley is Guinea grass. This is commonly found in woody clumps waist high, with paths between clumps where cattle may pass and nibble at the newer shoots on the periphery. Some fields have been seeded to introduced varieties, with Para' and Pangola being most favored for use on irrigated, or on naturally wet lands. Generally speaking, the term "permanent pasture" can be taken to mean unimproved native grasslands.

Beef Cattle

The average stocking rate for beef cattle on native pasture is 0.9 animals per hectare, or about 3 acres per animal, for year-round grazing. This may sould like an intensive stocking rate to range beef cattle producers in the western United States, but it is not too impressive for 365-day growing season on Class I lands. The beef animals are almost all Cebu (Brahma), or various mixtures of Cebu with the so-called native breeds (Criollo), whose bloodlines trace back to Spanish origins. There is no open range in the valley, but the fenced pasture can be found in rather large chunks. The largest pasture known to the author, in the flat part of the valley, comprises some 5,000 hectares (12,000 acres). The average

Table XIII: Soybean Budget, Cartago and Roldanillo Areas
(pesos/ha. on a six-month basis)

Item	Cartago	Roldanillo
Gross Income *	1,813.00	1,589.00
Cash Costs		
Contract labor	55	---
Other hired labor	370	170
Seed	62	53
Fuel, oil, grease	31	69
Hauling	50	16
Machinery repairs	72	58
Insecticide, herbicide	64	38
Income taxes	20	16
Other cash costs	69	100
Total Cash Costs	793	520
Noncash Costs		
Depreciation	108	102
Interest, land and machinery	220	242
Interest, operating capital	19	53
Building repairs	16	---
Total Noncash Costs	363	397
Total Costs	1,156.00	917
Net Cash Income	1,020.00	1,069.00
Net Enterprise Income	657	672
* Yield (kilograms)	1,774.00	1,555.00

Source: Gerado Garcia and Hernando Zuluaga. "Costos de Produccion de Cana de Azucar en la Zona Aledana al Ingenio Castilla." Universidad del Valle, Facultad de Ciencias Economicas, Cali, Colombia: June, 1964, pp. 113-116. (Unpublished bachelor's thesis) Corporacion Autonoma Regionial del Cauca. Analisis Economico de 109 Fincas en el Area del Projecto Roldanillo La Union - Toro, 1961-1962. Cali, Colombia: Septiembre, 1964. pp. 127-128.

Table XIV: Tobacco Budget, Small Commercial Producers
(pesos/ha. on a six-month basis)

Item	Pesos
Gross Income	2,169.00
Cash Costs	
Hired labor	618
Fuel, oil, grease	53
Machinery repairs	105
Insecticide, herbicide	16
Total Cash Costs	792
Noncash Costs	
Depreciation	135
Interest, land and machinery	354
Unpaid family labor	618
Total Noncash Costs	1,107.00
Total Costs	1,899.00
Net Cash Income	1,377.00
Net Enterprise Income	270

Source: Unpublished field data gathered in 1961-64.

pasture is probably around 1,000 hectares, and very few are less than 100 hectares in area.

When the data of this budget were collected, there was cause for some despair and an attempt to revise the sample design. It appeared that beef enterprises were, without exception, "managed" by hired majordomos, with many absentee landowners residing permanently outside of Colombia. The majordomos are paid a monthly wage of about half again the daily wage for unskilled laborers. They are usually functionally illiterate, and make no decisions other than those connected with the day-to-day operations; nor are they either rewarded for profits or penalized for losses. It was the general feeling among the field interviewers that the data collected from the majordomos of beef cattle enterprises were more of the nature of idle gossip, than of reliable input-output information.

A year later a specialized study of beef and dairy operation was made by a livestock specialist.30/ The results of that study confirmed those reported on the budget developed for this thesis. It will be noted that there is little detailed breakdown of the input costs in Table XVII. The reason is that the majordomos could not separate out such variable cash costs as medicines, vaccines, and purchased feeds. Likewise, it proved impossible for the interviewers to get consistent estimates of cattle numbers, and the values of livestock and of land in the current inventory. The more aggregate data are the most accurate in this instance.

30/ F. T. Landagora. "Situacion Lechera en el Sur del Valle del Cauca." Centro de Formacion Profesional y Investigacion Agricola, Cali, Augusto, 1964. (Unpublished mimeograph release)

Table XV: Beef Cattle Budget
(pesos/ha. on an annual basis)

Item	Pesos
Gross Income *	913
Cash Costs	
Hired labor	115
Other variable cash costs	38
Fixed cash costs	32
Total Cash Costs	185
Noncash Costs	
Depreciation, interest on investment, etc.	588
Total Noncash Costs	588
Total Costs	773
Net Cash Income	728
Net Enterprise Income	51
* Yield: (kilograms of meat)	351
Inventory change (pesos)	-89

Source: Unpublished field data gathered in 1963, in the Cartago area of the Cauca valley.

The net cash income of 728 pesos shown in the beef cattle budget, adjusted for inventory change, leaves 639 pesos per hectare per year available to the landowner. The small net enterprise income indicates that the investment returns for the land and livestock resources used in beef production are not as high as are the opportunity rates of return imputed to the money capital that these resources represent. These data suggest that beef production in the Cauca valley, under the current system, is not in a state of long-run equilibrium.

Dairy Cattle

One might classify dairy operations in the Cauca valley according to the type of cattle that predominate in the milking herd. There are some herds of grade Holstein, or crosses of predominantly Holstein breeding, and other herds of Holstein and Cebu crosses. There are one or two herds of pure Brown Swiss, and perhaps a majority of herds of cattle whose bloodlines are so confused as to be untraceable. This majority is called Criollo. The budget for dairy cattle represents the Criollo herds rather than those few of relatively purebred stock.

The bulls are usually run with cows and heifers, with no attempt at controlled breeding. The bull calves and heifers not needed for herd replacements are sold for slaughter at a day or two of age. The system of concentrate feeding, when it is used at all, is in terms of some specified number of kilograms of feed (often 3) per milking cow per day, without regard to the production level of the individual cow. Some dairy producers feed green cut grass in addition to, or instead of, concentrates. The preferred varieties are Elephant and Imperial. The grass is frequently irrigated by sprinkler or from gravity ditches, and is cut and fed daily. The average milk production per cow per day is about four bottles (3,000 cc's). This very low level of productivity is probably a result of the interplay of breeding, management, and feeding practices. At the same time, there is a substantial and chronic shortage of fluid milk for direct consumption and for manufacturing purposes in the valley.31/

31/ F. T. Landagora and Angelo Michielin, "La Alimentacion Y Manejo de Las Novillas de Reemplazo de Las Vacas Lecheras en el Valle del Cauca," Servicio de Extension Agropecuaria, Colombia, Junio 1965, p. 5. (Unpublished mimeograph release)

Table XVI: Dairy Cattle Budget, Criollo Breeding
(pesos/ha. on an annual basis)

Item	Pesos
Gross Income *	1,436.00
Cash Costs	
Hired labor	346
Fuel, oil, grease, electricity	17
Purchased feed	191
Veterinary services	10
Drugs, vaccines	48
Income taxes	29
Total Cash Costs	641
Noncash Costs	
Depreciation	52
Interest on land and buildings	979
Interest on operating capital	46
Building and fence repairs	18
Unpaid operators labor	5
Total Noncash Costs	1,100.00
Total Costs	1,741.00
Net Cash Income	755
Net Enterprise Income	-12
* Yield: Milk (bottles of 750 cc's)	566
Meat (kilograms)	200
Gross sales	1,396.00
Milk consumed on the farm	40
Inventory change	293

Source: Ayora, Cesar and Morales, Hernan: "Costos de Produccion del Maiz en el Valle del Cauca." Universidad del Valle, Facultad de Ciencas Economicas. Cali, Colombia, Junio, 1964. pp. 129-30. (Unpublished bachelor's thesis)

Chapter IV: Testing The Hypothesis

The budgets in the last chapter provide sub-hypotheses regarding various land-use enterprises in the Cauca valley of Colombia. The specific sub-hypothesis for each of the enterprises is given below:

(1) The net enterprise income of 1,504 pesos per hectare per year is an optimum for sugarcane produced by individual growers.

(2) The net enterprise income of 446 pesos per hectare per year is an optimum for pure stands of cocoa.

(3) The net enterprise income of 1,172 pesos per hectare per year is an optimum for cocoa and plantain produced as joint products.

(4) The net enterprise incomes of 1,285 pesos and 505 pesos per hectare per crop season are optima for cotton produced in the Roldanillo and Cartago areas, respectively.

(5) The net enterprise income of 1,418 pesos per hectare per crop season is an optimum for corn produced at enterprise scales of more than 32 hectares.

(6) The net enterprise income of 823 pesos per hectare per crop season is an optimum for bean production.

(7) The net enterprise income of 657 pesos per hectare per crop season is an optimum for soybean production.

(8) The net enterprise income of 270 pesos per hectare per crop season is an optimum for tobacco production.

(9) The net enterprise income of 51 pesos per hectare per year is an optimum for beef cattle production on pasture.

(10) The net enterprise income of -12 pesos per hectare per year is an optimum for dairy production on pastures.

The most desirable method of testing the above hypothesis is to fit a statistical production function for each of the 10 land uses. One might then compute the net enterprise income at the optimum point of the function, and compare this with the value hypothesized to be an optimum. However, such a procedure requires more data than were available in the Cauca valley, for most land uses. The data needs appear to be met only for sugarcane and corn, and statistical production functions for these land uses are discussed in the latter sections of this chapter.

There were field-trial data available for beef and dairy production on pasture. Such data do not allow for a statistical test of the hypothesis. They are included in the following sections of this chapter because they indicate incomes very much higher than those hypothesized to be optimal. One cannot accept or reject the hypothesis on the basis of these pasture data, but one can be highly suspicious that the hypothesis will be rejected when data are available to test it. The other six land uses are left completely untested, since there were almost no data beyond those used to establish the hypothesis.

Beef Cattle

The experiment reported here was carried on jointly by Abonos Colombianos (a fertilizer company) and a private beef grower. The pasture is located along the Cauca river a few miles from Cali, on land that is probably in capability class II. This location would be more or less typical of the valley as a whole with respect to soil, rainfall, and general agricultural productivity. An area of about 100 hectares on one side of the landowner's pasture was reseeded to pangola, and fenced off into 4-hectare lots on both sides of a central lane.

Cattle are rotated from one pasture to the next every four days, returning back to any given lot every 45th day. The stocking rate is a little over nine animals per hectare, on a continuous year-round basis. The day after cattle are moved off a lot, it is irrigated from an aluminum pipe sprinkler system. The water is pumped from the nearby Cauca river, and urea is bled into the water at the rate of one metric ton per hectare per year (about 880 U. S. pounds per acre). The cattle used are grade Cebu steers, picked up in random lots from the livestock market in Cali. They are bought as two-year-olds, and slaughtered when they reach the usual slaughter weight of 500 kilograms (1,100 U. S. pounds).

The data on which the following enterprise budget was based were made available by Abonos Colombianos, and represented one year from the continuing experiment. Since this trial was carried out with a higher quality of managerial and technical advice than one could reasonably expect under normal conditions, the gross income used in Table XVII is reduced 25 percent from that actually recorded; e.g., sales of beef actually were 3,438 per hectare per year, and computed net enterprise income shown in the source documents is 4,928 pesos per hectare per year.

All of the cost and income items in this beef cattle budget were computed by Sr. Henao, of Abonos Colombianos, for his reports on this field trial. The three interest charges were computed at current opportunity rates of return on the market value of the land, livestock, and production inputs used. The depreciation item is for the pipe and pump used, and does not include any depreciation of fences or other tools and equipment.

The data of Table XVII were generated from a field trial under controlled conditions, and are corroborated by other similar trials carried out by the same company in the Cauca valley, and elsewhere in Colombia. These data are, in all likelihood, more accurate than the sample survey data tabulated in Table XV.

The net enterprise income computed in Table XVII is higher than that in sub-hypothesis number 9. Thus, a net enterprise income of 51 pesos per hectare per year for beef cattle produced on pasture is unlikely to be optimal, and the hypothesis is suspect.

Dairy Cattle

The data for Table XVIII are based on the experience of a commercial dairy herd of about 100 cows, in the central part of the Cauca valley. The original data were taken directly from the books of this operation covering one calendar year of operation, and are demonstrably accurate.32/

The pasture is irrigated by flooding, is fertilized several times a year, and is rotated with one year of sorghum or elephant grass out of every five. The pasture is divided into small lots of varying sizes, but averaging about 4 hectares. Cows in the milking herd are rotated through

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32/ The author wishes to extend his formal thanks to the management of CICOLAC Ltd., of Bugalagrande, Colombia, for their complete cooperation in making available the confidential data summarized in this report.

Table XVII: Intensive Beef
(pesos per hectare per year)

Item	Pesos
Gross Income *	7,150.00
Cash Costs	
Labor	314.50
Fuel, grease, oil	200.00
Veterinary costs	75.40
Drugs and medicines	303.00
Fertilizer	1,200.00
Other operating costs	400.00
Maintenance of fences	.90
Property taxes	30.87
Total Cash Costs	2,524.67
Noncash Costs	
Interest on production capital	121.50
Interest on livestock	445.84
Interest on land	525.00
Depreciation on equipment	400.00
Total Noncash Costs	1,491.34
Total Costs	4,016.01
Net Cash Income	4,625.33
Net Enterprise Income	3,133.99

* Sale of 2,750 kilograms of beef at 2.60 pesos per kilogram.

Source: Roberto Astralaga, "Pastos y Forajes;" and Julio Henao, "Aspectos Economicos del Manejo de Praderas Fertilizadas." Abonos Colombianos, Bogota, Colombia, 1963. (Unpublished) these lots as rapidly as the grass is utilized - about every four days on the average. Heifers, calves, and dry cows are maintained on irrigated pastures separately from the milking herd.

The cattle in the herd are all purebred Brown Swiss, of both Swiss and American bloodlines. In recent years, the cows in the herd have been bred using frozen semen imported from the U. S., and the herd bulls have been used only for custom breeding of cows from other dairy herds in the area. The cows are fed a ration of fresh-cut sorghum or elephant grass at each milking, and a ration of commercial feed concentrate. The latter is measured out roughly in accordance with the milk production of each cow. The record of each cow is carried on a sheet that includes data on lactation period, semen donor, calving date, and the weekly record of milk produced in her present and previous lactations.

The dairy herd is a subsidiary of the parent company, and is maintained to supply a base amount of fluid milk to the dehydrating plant. It is also intended as a demonstration of the commercial prospects of improved management practices, for other dairy producers who might supply fluid milk to the dehydrating plant. Thus, the manager of the farm pointed out, there is at least one full-time man on the regular payroll beyond what would be required if the demonstration function were not to be fulfilled. A certain amount of time is given over to keeping the lanes mowed and the fenceposts painted, and to conducting visitors on tours of the operation. The hired manager is required not only to manage the commercial aspects of the dairy operation on a profitable basis, but also to be a publicity and demonstration agent. The situation in this case was similar to that in the

Table XVIII: Intensive Dairy Production
(pesos per hectare per year)

Item	Pesos
Gross Income *	21,445.32
Cash Costs	
Labor	11,250.00
Seed	1.50
Fuel, grease, oil	216.56
Feed	2,160.00
Veterinary costs	62.52
Drugs and medicines	60.00
Fertilizer	417.50
Other operating costs	12.84
Maintenance, fences and buildings	72.60
Property taxes	29.30
Total Cash Costs	14,282.82
Noncash Costs	
Interest on production capital	277.98
Interest on livestock and machinery	759.97
Interest on land	660.00
Depreciation on equipment	400.00
Total Noncash Costs	2,097.95
Total Costs	16,380.77
Net Cash Income	7,162.50
Net Enterprise Income	5,064.55

* Sale of 1,490 kilograms of meat @ 2.60 pesos, and 23.430 bottles of milk (of 750 cc's each) @ .75 pesos.

Source: Operating books of CICOLAC Ltd., Bugalagrande, Colombia.

intensive beef production trial reported in the previous pages. There is no doubt that a manager of the quality obtained by CICOLAC in their dairy operation is very scarce in Colombia, and well above what one could expect from the present population of agricultural managers. For this reason, the stocking rate of the pasture and the average milk production per cow in the milking herd have both been reduced 25 percent below the data taken from the books of the company.

A net enterprise income of -12 pesos per hectare per year was derived in Table XVI for dairy production on pasture in the Cauca valley. Table XVIII presents an example of a commercial dairy operation whose net enterprise income is conservatively estimated to be 5,064 pesos per hectare per year. On the basis of this contrary evidence, sub-hypothesis number 10 is highly suspect.

Corn

The hypothesis states that a net enterprise income of 1,418 pesos per hectare per crop season is optimal for corn produced on enterprises of more than 32 hectares. This hypothesis should be testable by fitting a production function for corn, and by comparing the computed optimal resource mix, and the resulting net enterprise income from this function to that in Table XI.

The data available from the experiments carried out at the Experimental Station at Palmira, in the heart of the Cauca valley, do not lend themselves to multi-variate analysis. There was neither the time nor the resources to set up and run experiments that would have provided data for a production function on corn. The author attempted to fit such a function to data selected from sample interviews carried out in the valley between 1961 and 1964. All of the several hundreds of original field schedules were sifted for data on corn production on a commercial scale, e.g., 30 hectares and above, and with at least the seedbed preparation and seeding carried out under mechanized conditions. Twenty-two sets of observations were selected that seemed to fit the requirements.

The model chosen for the production function was of the quadratic type:

$$Y = a_1L - b_1L^2 + a_2M - b_2M^2 + a_3C - b_3C^2 + a_4D - b_4D^2,$$

where Y is the production of corn in kilograms per hectare; L is the market value of the labor used; M is the value of the combined inputs of fertilizer, and weed and insect sprays; and D is the value of the machinery depreciation, for the machinery used in the corn production process, all in 1963 pesos. It was necessary to estimate the values of the a and b coefficients, using the least squares regression method. A computer was kindly made available for this effort by the IBM Service Bureau in Bogota.

The estimated value of the coefficient of correlation for these data was $R^2 = .237$, and none of the estimated coefficients were significant at or above the 10 percent confidence level. The sum of squares removed by the regression was 0.406, and the residual sum of squares was 1.314. The author concluded that the data to which the regression was fitted were not of sufficient accuracy or uniformity, and that there was no way of improving them short of a purposeful effort at new data generation and/or collection. This was not possible, and the effort to fit a statistical production function for corn had to be abandoned.

A search of available, partial data, was made to determine if these were sufficient for an enterprise budget that could be used to test the hypothesis. A report was found of an experiment carried out in the Cauca valley in 1959 by E. Patino. The design was of a three-way classification of seeding rate (or expected vegetal population), rate of application of irrigation water, and rate of application of fertilizer. In applying an economic analysis to these data, several assumptions were required from other sources of data. The cost of irrigating was assumed to have been 620 pesos per hectare, including labor, materials, and a discounted retrieval of the investment in land preparation and irrigation equipment. This figure was the best estimate of an irrigation engineer, and may be either too high or too low for other areas of the Cauca valley, depending on the pumping costs and the amount of original land leveling required. The cost of seed was estimated from sample survey data gathered in the valley in 1963 and 1964. The costs for the medium and high seeding rates were adjusted in proportion to the added amount of seed used beyond the low seeding rate.

Table XIX gives the gross value of the corn produced per hectare in 1963 pesos, for the three classifications of dryland-irrigated, seeding rates, and fertilizer treatment. Table XX gives the calculated net enterprise income for these same data. The soils on which the above experiment was run were reported to have 218 kilograms of potassium per hectare. The data indicate that the addition of 36 kilograms per hectare was economic on the dryland soils, but not on the irrigated soils, except at the high seeding rate. The same soil analysis showed 16 kilograms of available

Table XIX: Gross Value of Corn Produced per Hectare, Three-Variable Design

Fertilizer Treatment	Dryland			Irrigated		
	Seeding Rates			Seeding Rates		
	10,500	15,000	17,400	10,500	15,000	17,400
0 - 0 - 0	828	1,068	768	948	1,500	1,206
36- 0 - 0	870	1,098	1,014	1,122	1,638	1,452
72- 0 - 0	1,026	1,236	1,062	1,080	1,260	1,506
108-0 - 0	990	1,176	1,026	942	1,452	1,482
0 -36 - 0	1,050	1,332	1,092	1,242	1,524	1,356
0 -72 - 0	1,026	1,158	894	1,224	1,764	1,506
0 - 0 -36	888	1,164	942	1,194	1,416	1,446
36-36 - 0	882	1,344	1,416	1,218	1,488	1,512
72-72 - 0	1,038	1,176	888	1,026	1,464	1,368
108-36- 0	1,092	1,254	816	1,176	1,518	1,560
108-72- 0	984	1,170	1,176	1,188	1,536	1,542
36- 0-36	750	1,152	1,128	1,194	1,554	1,332
72- 0-36	1,206	1,272	966	1,128	1,428	1,134
108- 0-36	1,014	1,260	1,158	1,332	1,548	1,476
0 -36-36	1,008	1,152	918	1,296	1,602	1,470
0 -72-72	1,050	1,236	1,272	1,260	1,512	1,608
36- 36-36	1,026	1,140	1,134	1,212	1,438	1,524
72 -72-36	948	1,302	1,140	1,272	1,752	1,470
108-36-36	1,014	1,290	1,326	1,140	1,704	1,482
108-72-36	1,014	1,302	1,164	1,284	1,476	1,560

Source: Edgardo Patino, and Kirk Lawton, "Grandes Rendimientos de Maiz en Colombia," (unpublished paper).

phosphorus per hectare. The addition of 36 and 72 kilograms was generally economic, with the exception of dryland corn at the high seeding rate, and irrigated corn at the low and medium seeding rates.

The source document did not give the base content of nitrogen from the soils analysis. The data do not indicate great responses to the addition of nitrogen, except at the level of 36 kilograms per hectare on irrigated soils, and at the high seeding rate on the dryland soils. Moving on through the data, especially of Table XX, giving calculated net enterprise returns, one can see cases in which there was an economic response to fertilizer, but there is no clear pattern. With respect to the seeding rate variable, there is evidence here that the middle and high seeding rates were generally more economic than the low one, but not uniformly so. Likewise, the net returns to irrigation, indicated by these data, are generally favorable at the middle and high seeding rates, but not at the low one.

In all cases, the net value of the corn produced in each cell of this experiment is less than that of the hypothesis, and the hypothesis cannot be rejected on the evidence of these data.

Other bits of scattered data relating to corn production were found, but none of them were of sufficient breadth or detail to provide a test of the hypothesis. As a consequence, the hypothesis with respect to the optimality of corn production in the Cauca valley cannot be rejected, given the data so far available.

Table XX: Net Value of Corn Produced per Hectare, Three-Variable Design

Fertilizer Treatment	Dryland			Irrigated		
	Seeding Rates			Seeding Rates		
	10,500	15,000	17,400	10,500	15,000	17,400
0 - 0 - 0	828	1,068	768	535	1,087	793
36- 0 - 0	771	909	915	610	1,126	940
72- 0 - 0	840	978	670	415	853	757
108-0 - 0	711	855	621	586	892	760
0 -36 - 0	963	1,173	999	604	784	1,030
0 -72 - 0	966	1,128	690	224	979	1,021
0 - 0 -36	952	1,138	988	491	1,001	1,031
36-36 - 0	864	996	732	649	1,189	931
72-72 - 0	660	846	852	451	799	805
108-36- 0	690	876	912	487	739	835
108-72- 0	525	879	717	436	916	634
36- 0 -36	751	1,027	805	643	866	896
72- 0 -36	514	916	892	545	905	683
108-0 -36	691	805	811	464	680	776
0 -36 -36	949	1,231	991	728	1,010	842
0 -72 -72	1,042	1,108	802	551	851	557
36-36 -36	682	1,144	1,216	606	875	899
72-72 -36	652	898	796	557	773	701
108-36-36	616	892	928	329	893	671
108-72-36	553	841	703	410	602	686

Source: Edgardo Patino, and Kirk Lawton, "Grandes Rendimientos de Maiz en Colombia," (unpublished paper).

Sugarcane

The hypothesis states that the net enterprise income of 1,504 pesos per hectare on a twelve-month basis is optimal for sugarcane produced by individual growers in the Cauca valley. An attempt was made to fit a statistical production function to certain data on sugarcane, in an effort to test the hypothesis. The opportunity was provided by a study of the operations and future prospects of the Castilla sugar mill in the Cauca valley, carried out in late 1964 and early 1965.33/

About 12,000 hectares are operated by the Castilla mill at any given time. Roughly two-thirds of this is land owned by the mill, and one-third is land leased on ten-year contracts from other land owners in the area. Cane for processing is also bought at the mill from individual producers, but this is not a concern of the production part of the organization. The land operated by the mill is laid out in several large divisions, with each division being divided into lots of an average size of about 12 hectares. These lots are the basic unit on which the books are kept for the field production operations.

The universe was stratified by divisions, by the estimated level of the soil fertility within each division (high, medium, and low), by the variety of cane, and by the age of the cane at harvest. A random sample of lots was drawn within the above stratifications, covering all cane harvested at any time during the calendar years from 1958 to 1962, inclusive. There were 355 observations for the two important varieties of cane,

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33/ Klayman and Bostwick, Analysis Economico de la Produccion de Cana de Azucar en el Valle del Cauca, op. cit., Chapter 2.

accounting for 5,161 harvested hectares of the 45,000 that were harvested altogether during the five years.

It was intended that fertilizer and irrigation water would be included in the variables, but this turned out not to be possible as the data were gathered for the analysis. Fertilizer is applied to all lots according to a standard, so that it is a constant in the equation. Irrigation water is applied according to the need evidenced by the condition of the plants, but the data available were such that the amounts applied to any given lot were not separable. Irrigation is therefore an unstudied input variable, for which costs are included in other variables.

The form of the function chosen for the estimate was that of a Cobb-Doublas, since the nature of the data was not suitable for estimating an absolute maximum of the product, but only a maximum in the neighborhood of the available data. The variables were defined as follows:

$Y =$ the dependent variable, expressed as tons of cane produced per plaza per calendar year, where a plaza is a local unit of area equivalent to .64 hectare, and the total tons of cane recorded were divided by the age of the cane at cutting;

$X_1 =$ the wages paid for field labor per calendar year, expressed in 1963 pesos;

$X_2 =$ the total cost of materials used in the field per calendar year, in 1963 pesos;

$X_3 =$ other field costs that were occasional, or were not separable, in 1963 pesos per calendar year;

X_4= the contract costs paid for cutting and loading the cane, expressed in 1963 pesos per calendar year;

X_5= the costs of transporting the cane from the field to the mill, in 1963 pesos per calendar year;

X_6= general overhead costs per calendar year, including supervisory salaries, fuel, and maintenance of machinery, and taxes;

X_7= rainfall received per calendar year of the crop, in millimeters.

The data were collected with respect to the above variables and converted to logarithms. The linear least-squares fit of these converted data was done on the computer made available by the IBM Service Bureau in Bogota. The initial fits produced coefficients that were statistically undifferentiable from random results. Further fits were attempted with apparently weak variables left out, strata combined, etc., while waiting for an alternative computer program to arrive.

Alternative ways of defining variables were explored, and a search was made for additional data that might increase the functional fit. Coefficients of correlation of the order of .75 were achieved with some trial runs, and others of considerably lower magnitude. But no combination of efforts produced an acceptably high coefficnent of correlation together with coefficients that were significant at or above the 10 percent level of significance. The "improved" alternative program never did arrive in Bogota, and the author was about to be transferred to a post removed from Colombia. The report was concluded without a production function for sugarcane, and when the data and the preliminary results of the computations toward a statistical production function were lost in transit, the entire effort had to be written off as a substantive loss. The hypothesis could not be tested by the data from the Castilla sugar mill.

Other data regarding responses of sugarcane to various isolated inputs are available for the Cauca valley. But these do not provide data upon which an enterprise budget may be constructed, and so the hypothesis must remain untested.

Conclusions

Of the ten sub-hypotheses developed in Chapter III, the two regarding beef and dairy production on pasture, were put in question by contrary evidence. The sub-hypotheses regarding corn and sugarcane production, were left untested due to the failure of the data adduced in each case to lead to statistical estimates of production functions. Additionally, the partial data available from a three-variable test of corn production were not conclusive. For the remaining six sub-hypotheses, there were no data available by which they could be tested.

The conclusion of this attempt to test the hypothesis is that there simply are not enough reliable and detailed data available on the major agricultural enterprises in the Cauca valley, to allow hypotheses of optimality to be tested, with the two exceptions of beef and dairy production. The detailed suggestions by which this state of affairs might be remedied, are the subject of the concluding chapter.

Chapter V: Recommendations

The comparisons of net enterprise returns developed for major land-use enterprises in the Cauca valley foundered on the shoal of inadequate data. This concluding chapter discusses several questions addressed to the apparently inadequate data currently available for these enterprises in the valley. The first section discusses the kinds of additional data needed, while the second addresses itself to the procedures by which more adequate data might be gathered.

Data Needs

Certain background data are necessary whether the researcher is developing enterprise budgets, or fitting statistical production functions to enterprise input-output data. One category of background data is that of accurate maps on which to base stratifications by soil type, rainfall pattern, land use capability class, geographic location, land ownership, and other such criteria. Aerial photographs of the flat part of the Cauca valley are available in the 1:10,000 scale, from the Instituto Geografico "Agustin Codazzi" in Bogota. These photographs were made from flights over a period of several years, and are not exactly comparable in detail, but they are a very good basis for making maps of river courses, of roads and towns, and of other items of interest. One can also use the more recent of these photographs as the basis for land-use maps, subject to verification on the ground in order to enter any recent changes.

Reconnaissance soils maps are available from "Agustine Codazzi" for most, if not quite all, of the flat part of the Cauca valley. In addition, some areas of the valley have been mapped on a detailed basis, and two areas have been mapped for irrigation capability. In time, it is expected that the detailed mapping will be extended to more of the area of the valley, and that this will provide one further datum to the researcher interested in drawing the boundaries for a sampling based on soil types or capability classes.

Rainfall and temperature data are available for six locations in the Cauca valley for at least the ten years prior to 1965. Additional recording stations have been established, but their period of record is not yet long enough to be of much value as an explanatory variable in production studies.

Tenure maps drawn on the base of aerial photographs are a considerable aid to enterprise studies. One of these was prepared for a study in the northern valley, but it was very costly and covered only some 12,000 hectares involved in a proposed project. The ownership and leasehold data necessary for such maps are not readily available, but can be obtained by any researcher with the required time and money resources at his disposal.

For purposes of economic research, one requires not only such basic maps as those listed above, but also reliable technical interpretation of the gross data that they present. For example, expert technical advice is required to classify a given basic soil type into productivity (or use-capability) classes, according to the land use that is to be investigated. There is no doubt that a certain soil might be in one use-capability class for corn and soybeans on dryland, and in another for these same crops under irrigation. The same soil that was, say, Class I for corn under irrigation might be Class III for tobacco on dryland, and perhaps Class II for sugarcane under irrigation. Such data are essential for economic analyses, but they cannot be generated by an economist. Experience has shown that it is not enough for the soil classification expert just to put soils into classifications; he must also define the differences in terms of yields, increased management costs, or some other relevant criterion. Unless this last step is taken by the classifier, the economist interested in constructing enterprise budgets finds that the soil classifications are only names for his ignorance, and not cures for it.

Given the above sorts of background data, the economist requires data of technical production relationships. This means that the experimental data developed at the Experiment Station and from field trials need to be designed with multi-variate analyses in mind. The economist wants to be able to compute marginal products resulting from various combinations of variables such as plant population, fertilizer treatments, weed control practices, and levels of irrigation water applied. This appears to be a simple requirement, until one tries to find the money and land and time resources that are required to carry out an experiment with, for instance, three variables, under the necessary combinations of ranges and replications. It becomes very expensive, but it is still necessary if more accurate input-output data are to be generated.

A further category of data required by the economist interested in production studies might be called "economic and political expectations." Such data include projections for the prices that an agricultural producer might expect to pay for his purchased inputs, and to receive for the products that he sells. The projections must include ranges rather than one set of precise points; the range for each commodity or input price depending on alternative assumptions regarding local, domestic, and foreign supply and demand conditions, and prospective import-export policies. It is also necessary to make some estimates of possible changes in the availability of potentially critical inputs such as hybrid seeds, improved commercial mixed livestock and poultry feeds, materials for the chemical control of insect, disease, and weed infestations, new or improved fertilizers for specified crops, changes in the technology of irrigation, and changes in the machine technology of crop and livestock production.

Such projections depend partly on the "state of the arts," and partly on policy considerations of the central government. They are subject to rather wide margins of possible error in any economy that is changing as rapidly as is that of agricultural production in the Cauca valley of Colombia. Nevertheless, these kinds of data must be included among the assumptions or constraints that the production economist makes in the course of estimating optimal resource input combinations for various land uses.

Data Gathering Procedures

Having mentioned in a general way the kinds of background data that are needed for production studies, it is appropriate to say something about the ways in which proper data might be gathered for these studies in the Cauca valley. The analyses in this study did not even proceed as far as a complete series of budgets that would have indicated optimal input mixes for the major land uses. The first job is, therefore, to gather data that will allow such analyses to be made.

While this might reasonably constitute the first priority of the researcher in production economics, it may not be of the highest priority to his employers. In fact, the need for production economic research in the Cauca valley far exceeds the ability of the few trained researchers who are available to do it. Irrigation and land resettlement projects have been and will continue to be proposed, that require benefit-cost analyses for various program proposals covering large land areas. It will be required that analyses provide some basis on which to establish a minimum size of farm policy for land reform projects. Other requests will be made that require time and effort in generating various sorts of general economic intelligence, that have little or nothing to do with enterprise analyses.

Thus, before the researcher is content with his analyses of the principal land uses, he will be required to use these data to estimate whole-farm budgets, and to aid in the planning of farm units on a whole-project basis. As an illustration, all of the data in and behind this study were gathered for purposes other than the one of estimating enterprise budgets and/or statistical production functions, with the exception of the data gathered from the Castilla sugar mill.

The purposes for which data are gathered set limits on the ex post analytical uses to which they may be put. Some data were gathered on specific land use enterprises, toward a quick benefit-cost analysis of a supplemental irrigation proposal. Later, it proved impossible to synthesize the data that would have converted these data to whole farm budgets. Likewise, some data gathered on a farm basis were later scrutinized for inclusion as enterprise data, but it proved impossible to separate the enterprise inputs with sufficient accuracy for this ex post purpose.

It is possible to gather primary data such that it can be analyzed in terms of enterprises or in terms of farm units. But the critical information that identifies joint inputs or joint products, and that allows machinery use and general overhead expenses to be partitioned among enterprises, must be included explicitly in the original data gathering process. In many cases the researcher is dealing with farm producers who not only do not keep farm records, but could not read them. In these cases, it may not be possible to gather the sort of detailed data that enterprise budgets or statistical production functions require. One can force such data, egregious in detail, into budgets, or even into least-squares estimates of production functions, as was done for corn in an earlier part of this study. But the results are not worth the effort involved, and if one is tempted to use them anyway because they impress the nontechnical sponsor of research, then one is guilty of a compounded error.

Therefore, the appropriate strategy for the generation of accurate physical input-output data would appear to be to encourage properly designed experiments and field trials. Optimal resource combinations and production practices can be estimated by land use categories from such data.

During the several years that such an ideal data generating program would require for its fruition, the researcher can get approximate enterprise budgets from carefully selected primary field interviews. Johnson suggests that purposive rather than random samples can be used to generate the data of statistical production functions on an enterprise basis. The purposive sample, he says, does not bias the marginal value products, but it "reduces the standard errors of the regression coefficients and of the MVP, thereby increasing the reliability of the important information acquired about the production function itself."34/

There are agricultural producers in the Cauca valley who keep accurate and reasonably detailed records, and who are willing to furnish them to the inquiring production economist. The difficulty is that such producers do not represent the entire range of important land uses, and even less the entire range of farm sizes and stages of mechanization and technification. The producers that one might include in purposive samples, aimed at the generation of statistical production functions, will tend to be producers of "annual" crops such as cotton, corn, and soybeans, and they will tend to be of the "commercial" scale of 50 to perhaps 150 hectares. Minifundia and latifundia are important segments of the agricultural production economy, but they are not likely to be productive of the data that one requires for production function analysis on an enterprise basis.

Recommended Strategies

The final section of this study attempts to draw together the various observations made above, in the form of some strategies that would seem to be most recommended for researchers interested in developing a complete

34/ Glenn L. Johnson. "Classification and Accounting Problems in Fitting Production Functions to Farm Record and Survey Data." Heady, Johnson, and Hardin, Resource Productivity, Returns to Scale, and Farm Size. Iowa State College Press, Ames, Iowa, 1956, pp. 95-96.

analytical coverage of the important agricultural production enterprises in the Cauca valley. These stragegies are:

(1) It is essential that the researcher interested in developing analytical models of production enterprises, cultivate and maintain the closest possible liaison with researchers at the government experiment stations and elsewhere. It is important to encourage, and to help design, physical experiments that will provide response data over a wide range of probable inputs, even though some levels of activity are obviously beyond both the physical and the economic points of maximum productivity. The extremal data are necessary to ensure reliable estimates of the surface of the response functions, and it is tempting to economize on scarce research resources by including only levels of activity closer to the expected central tendency. Experiments need to be planned from which multivariate analyses can be made. The production economist needs the data of response of corn to fertilizer, for instance, but he also needs these data at various levels of irrigation water input and plant populations, for the important soil types, and for the half-dozen or so most promising corn varieties. Such research is complicated and costly, but it provides input data

for the production economist that he might not be able to generate otherwise, even through careful field interviews.

(2) The local researcher in production economics also needs to maintain a close cooperation with the various nongovernmental sources of field and laboratory experimentation. Specific reference is made to ABOCOL in the fertilizer area, to CICOLAC for dairy production and processing, to Central Castilla and others for sugarcane production, processing, and marketing, to MAIZENA for experience and research on commercial livestock feeds and various manufactured corn products, to FRUCO for production and other data of fruits and vegetables, and to various other commercial companies in the Cauca valley. These companies, and various individuals within them, have been most cooperative in providing data, field contacts, research funds, and the invaluable experience and guidance of their various technicians for researchers interested in analyzing the ecnomics of agricultural production in the valley. These contacts provide research leads, and suggest priorities to be considered, as well as considerable help in organizing and interpreting research results.

(3) Even if work cannot immediately be organized to

generate data for production function analyses, it is always possible to add small bits to a field survey schedule, for instance, that will make the data gathered amenable to production studies at some later date. It would seem provident to organize such data so that the problems of preservation, retrieval, and interpretation at some subsequent time are minimized. Certainly, piles of edited field schedules are easily misplaced, and the data that they contain, therefore, effectively lost for any use other than that made of them in the first instance.

(4) Close liaison should be maintained by production economics researchers with agricultural producers in the area who are interested in, and capable of carrying out, careful field trials. Such trials are not altogether a substitute for data developed under the rigidly controlled conditions of the experiment station. Rather, such field trials can provide a pragmatic control on the research assumptions, procedures, and overall models into which experimental data are placed for economic analysis.

(5) An appealing stragagem would be for the researcher to try to fit a production function, or to develop a detailed enterprise budget, from time to time, and as access to data, computing facilities, and time permit.

The researcher can only discover the details of the kinds and qualities of data that he requires through a process of attempting an analysis with the data then available, and then examining the deficiencies that the attempt uncovers. The type of exploratory activity might include not only the variables that seem to be relevant to production, but also statistical models and methods of estimating the unknown coefficients. The process might well result not only in the refinement of data and analytical techniques, but also in the refinement of the relevant hypothesis to be tested.

(6) The researcher working toward an eventual file of relevant production functions will also require peripheral data that will probably not be supplied by other researchers. This would include information on credit availability and interest rates, on the costs and availability of specified kinds of labor for hire, on improved insecticides and herbicides, and on the availability of specialized or new types of machinery. One would expect to keep up to date on these kinds of data from intercourse with specialists in farm credit, in farm machinery, etc. But the researcher in production economics in the Cauca valley, in the near future, is not likely to have these other kinds of specialists from whom he can gather updating information. This

situation has the disadvantage that the production economist may see his professional concern thinned out over a broad area that normally would be the separate provinces of the specialists in farm management, agricultural finance, land economics, labor and marketing, as well as production economics. But the situation also has the advantage that the production economist has the opportunity to collect data in these peripheral specialities in an organized manner. If the researcher is forced to gather production and marketing data, and data on such things as rental rates and land prices; or the wages and availabilities of various types of hired labor, all with respect to some given research problem; he might find that the answers to his production research supplies are realistic from other viewpoints. He might find that good research in production economics, under the above conditions, does not turn out to be poor farm management or poor marketing, and does not make unrealistic assumptions about credit availability and use.

(7) Perhaps the overriding strategy suggested is that, in this area where almost everything is yet to be reduced to reliable knowledge, the researcher can remain receptive and flexible to data and notions from a wide range of sources, and can profitably consider a wide range of

data and techniques when organizing research on any given problem. The situation mitigates against a high degree of specialization, and this can be turned to the advantage of the learning process of the individual researcher, even though he operates from a research point of view that normally is specialized.

APPENDIX

Appendix Table A-1

Mean Monthly Temperatures (Centigrade)

Station Elevation (m.) Period of Record Months	Cali 1000 1933-47	Santander 1100 1933-42	Cartago 940 1933-45
January	24.3	25.6	24.4
February	24.8	25.2	24.3
March	24.8	25.0	24.9
April	24.3	24.6	24.4
May	24.0	24.2	24.1
June	24.3	24.3	23.8
July	24.5	24.5	24.5
August	24.5	24.5	24.2
September	24.6	25.2	21.2
October	23.7	24.7	23.7
November	23.6	24.7	23.7
December	24.0	25.0	23.9
Average	24.3	24.8	24.2

Source: Reese, W. F. and Goosen, Doeko: "Reconnaissance Soil Survey of the Flat Part of the Cauca Valley." CVC and FAO of the UN; Cali, Colombia, 1957. p. 17.

Appendix Table A-2

Mean Monthly Humidity (Percent Relative Humidity)

Station Period Months	Cali 1933-47	Santander 1933-42	Cartago 1933-45
January	64	70	66
February	62	71	60
March	64	72	65
April	65	74	68
May	67	74	72
June	65	73	72
July	57	68	62
August	59	67	62
September	60	69	67
October	67	70	74
November	68	74	71
December	65	72	68
Average	63	71	67

Source: Reese, W. F. and Goosen, Doeko. Op. cit., p. 18.

Appendix Table A-3

Mean Monthly Precipitation (millimeters)

Station Period of Record	Cali 1925-54		Santander 1954-56		Cartago 1929-48	
Month	Milli-meters	Percent	Milli-meters	Percent	Milli-meters	Percent
January	97	8.1	135	8.0	65	4.3
February	75	6.2	133	7.9	71	4.7
March	98	8.2	147	8.7	151	10.0
April	153	12.7	167	9.9	214	14.3
May	139	11.6	172	10.2	193	12.9
June	83	6.9	79	4.7	122	8.1
July	36	3.0	45	2.7	92	6.1
August	48	4.0	52	3.1	110	7.3
September	87	7.2	106	6.3	78	5.2
October	153	12.7	231	13.9	167	11.1
November	121	10.1	238	14.1	120	8.0
December	111	9.3	177	10.5	120	8.0
Annual Average	1,201	100.0	1,682	100.0	1,503	100.0

Source: Reese, W. F. and Goosen, Doeko; op. cit., p. 19.

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