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IRRIGATION AND NON-IRRIGATION ALTERNATIVES FOR REDUCING SUGAR CANE TRANSPORTATION COSTS IN SANTA CRUZ, BOLIVIA

E. Body Wennergren, et al

Utah State University

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DEPARTMENT OF ECONOMICS
UTAH STATE UNIVERSITY

CUSUSWASH

BOYD WENNERGREN
ALLEN LEBARON
LEE BAILEY
MORRIS WHITAKER

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in conjunction with increased plant capacity. The fifth alternative was to relocate or re-establish production in the drier southern areas in conjunction with supplemental irrigation and fertilizer.

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by

E. Boyd Wennergren

Allen D. LeBaron

Lee Bailey

Morris D. Whitaker

UTAH STATE UNIVERSITY
DEPARTMENT OF ECONOMICS

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SUMMARY

Weather and economic trends in the Santa Cruz region of Bolivia for the last five years culminated in a 45 percent reduction in sugar cane production in 1971. Drought conditions and high world market prices for cotton have induced northward shifts of sugar cane production areas, with cotton replacing sugar cane in many of the traditional growing areas.

Due to the increased distance over which "northern" growers must transport their cane, overall transportation costs have risen drastically in the last few years. Estimates suggest that transportation costs now represent as much as 50 percent of the total production costs for sugar cane. After over 20 years of steady expansion, the cane industry may be losing its viability.

The purpose of this study was to investigate possible cost-reducing options for cane transportation in Santa Cruz. Physical factors and costs involved in the production of sugar cane, transportation costs, locations and distances of growers from mills, and volume of cane transported constitute the main data needed for a least-cost transportation model. All relevant data were collected in the Santa Cruz region in June and July of 1972.

Five alternatives for lowering costs were analyzed. The initial alternative considered was through more efficient transportation patterns. The second was shifting the site of the most uneconomical mill (San Aurelio) nearer the current areas of production. The third involved closing the most uneconomical mill and accepting a reduction in total processing capacity of the country. The fourth alternative considered closes the most

uneconomical mill and increases the capacity of the remaining two mills by either (a) extending the processing season or (b) extending the processing season in conjunction with increased plant capacity. The fifth alternative was to relocate or re-establish production in the drier southern areas in conjunction with supplemental irrigation and fertilizer.

The least-cost transportation model for the 1971-72 season shipment pattern and tonnage showed that $b1.08 million pesos could be saved annually if cane were transported more efficiently to the existing factories. This constitutes a cost savings of about 3.5 percent.

Moving the most uneconomical mill (San Aurelio) to the northern region would cost about $b68.75 million. The yearly savings in transportation costs for the entire system would only be $b4.19 million.

If the San Aurelio mill is closed and the milling season of La Belgica and Guabirá increased to 180 days from the present average of 157 days, the two mills could process 1,134,000 metric tons of cane yearly and $b4.29 million could be saved in annual transportation costs. This is a reduction of about 15 percent in current costs. National milling capacity, however, is reduced 18 percent below current production of cane.

If San Aurelio is closed and the daily capacity of La Belgica and Guabirá is increased by 25 percent, with a 176 day milling season, then all of the cane being currently produced could be processed while $b5.51 million per year could be saved in transportation costs. The costs of increasing the capacity of La Belgica by 25 percent would be $b16.35 million and the cost of increasing the capacity of Guabirá by 25 percent would be $b8.86 million. The annual amortized value of the expansion costs would be less than the annual transport cost savings.

In general, the potential benefits from increasing transport efficiency or changing mill locations do not appear to be great. Reversing the northern shift of cane production by introducing irrigation and heavier reliance on fertilizers in the southern or traditional cane zone appears to be viable if river irrigation can be used. A yearly savings in transportation costs of $b5.28 million would be realized by shifting the production of 256,469 metric tons of sugar cane (2,137 hectares) from the northern region back to the southern region. Land in the south, near the city of Santa Cruz and existing cane mills, would have to produce 120 metric tons per hectare of sugar cane (the current yield in the more humid "northern" lands) if current national production levels are to be maintained. This assumes that no sugar cane would be produced further north than 30 kilometers from the northern-most mill (Guabirá).

Four types of irrigation projects could be developed in the southern region. The total annual costs of developing feasible irrigation projects and fertilizing 2,137 hectares is as follows for the various systems: (1) sprinkler irrigation from a well, $b6.89 million; (2) sprinkler irrigation from a river, $b5.02 million· (3) flood irrigation from a well, $b6.82 million; and (4) flood irrigation from a river, $b1.97 million.

Allowing for fertilizer and flood irrigation from a river, the cost would be about one half the potential annual transport savings (1). Cost for the other forms of irrigation equal or exceed transportation savings. Whether or not cane production in this area would really be competitive with cotton would depend mostly on cotton prices.

The annual savings in transportation exceed the annual costs of only three of the alternatives analyzed. The one that would cost the least and be the easiest to implement, would establish "zones of influence" for the present production system by means of the least-cost transportation model. The second likely alternative is to close San Aurelio and increase the capacity of the other two mills. Production could then be concentrated in the northern region where soils are more fertile and rainfall more plentiful. The third viable alternative is to relocate cane production from the northern region to the southern region and utilize irrigation.

The development of irrigation in the southern region solely for sugar cane production is unlikely, however, in the absence of a general soil improvement program and reduced competition from other crops. In terms of the total agricultural situation in Santa Cruz, other crops such as soya beans and cotton would certainly also benefit from irrigation. Such benefits may be sufficient to make irrigation "pay." In that case, sugar cane would undoubtedly enter into crop rotations. Since only 2,137 hectares of sugar cane need to be grown in the southern region in order to maintain current production levels, it is highly probable that this would be achieved under a general water development program in the southern region.

INTRODUCTION AND OBJECTIVES

The Department of Santa Cruz is a large state in southeastern Bolivia. It has a semi-tropical climate with a wide range of soil types and native plants. Significant agricultural development started near the city of Santa Cruz about 1954. Sugar cane was one of the first crops to be cultivated on a commercial basis. Planting and production steadily increased until 1970 (Table 1).

Table 1. Sugar Cane Production in Northern Santa Cruz

Years	Cultivated Areas (Hectares)	Production (Metric tons x 1000)	Price ($b/ Metric Tons)
1967	29,750	993	66
1968	32,950	1,106	66
1969	36,90C	1,303	66
1970	N.A.	1,187	66
1971	15,545	759	66

N.A. = Not Available
Source: (8)

In 1949, only 249 metric tons of sugar were produced. In 1970, 109,543 metric tons were produced. Then, in 1971, production fell to 67,737 metric tons. This represented a 45 percent reduction from the preceeding year and was the first time since 1963 that Bolivia had to import large quantities of sugar to meet domestic demand. Cane production also declined from 1,186,502 metric tons in 1970 to 758,856 metric tons in 1971.

Many reasons have been given for the drastically decreased production in 1971. These include: inferior plant varieties, prolonged exploitation of the soil without adequate fertilizer applications, plant diseases, poor conservation practices, decreased profitability of cane relative to cotton, and a prolonged drought throughout Santa Cruz (but especially near the south of the city Santa Cruz). Government policies have also played a role. Until 1971, producer prices at the mills were fixed at $b66/MT. These prices were high enough to induce production (and refined sugar) surpluses which could not be worked off profitably in international markets. The Bolivian Government introduced production controls in the form of quotas assigned to a "selected" group of farmers at the cane mills. However, some quota holders do not produce cane at all, but act as intermediaries, purchasing from newly colonized areas having no quotas and reselling at a profit to the mills.

The production of sugar cane has largely shifted north, away from the city of Santa Cruz to where soils are more fertile and the drought has been less severe. The three sugar cane mills in the area, however, are in the south: near Santa Cruz; 30 kilometers north of Santa Cruz near Warnes; and 55 kilometers north of Santa Cruz near Montero. As production has shifted, the distances that producers must transport cane for processing has increased. These cost increases have more than offset the yield benefits from the shift to the north; meanwhile yields in the south are too low and the mass of the traditional growers of cane, between Santa Cruz and Montero, have turned to cotton instead.[1]

The overall objective of this study was to investigate various ways to reduce the annual transportation bill for sugar cane in Santa Cruz, Bolivia. The alternatives included irrigation and non-irrigation possibilities: (1) minimize the cost of transportation for the existing production area by

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[1] The government began reassigning quotas in 1971 and raised the 1972 season support price to $b.92/MT. This price is higher than the equivalent world price and represents a subsidy that may alter the profit situation but it will not change the basically high cost character of Bolivian cane production.

designating plants to which each producer should deliver; (2) relocate the existing mills to the northern region where production is now taking place; (3) close the most uneconomical mill and increase the capacity of the remaining two mills by either extending the length of the processing season alone or extending the season in conjunction with expanded capacity; (4) return sugar cane production to the traditional regions of Santa Cruz by employing on-farm irrigation, improved inputs, and management.

The specific objectives were:

(1) To determine a minimum cost system for distributing existing sugar cane production among processing facilities as presently located.

(2) To evaluate a relocation of sugar cane production with special emphasis on developing irrigation water for this purpose, or altering the locations and capacities of processing mills.

PROCEDURES AND SOURCES OF DATA

The main sources of information on transportation costs are in the sugar cane grower registry and surveys recently made by the Comisión Nacional de Estudio de la Caña y Del Azúcar (CNECA). These sources were checked during June and July of 1972 by personal interview with CNECA officials. Other estimates of transportation and cane production and irrigation costs were taken from: (a) budget studies from the Utah State-Bolivia/Study team (1), and (b) budget studies from Carlos Castro of the Guabirá mill (2).

The sugar cane grower registry lists the location of each grower, the quantity of sugar cane sold to each processing mill by individual growers, and the distance of the farms from the processing mills. Data were also collected from each of the three processing mills, Guabirá, La Belgica, and San Aurelio concerning plant production capacities, number of work days, etc. Managers of these plants were interviewed to verify the accuracy of the registry data where necessary.

The Transportation Model

Under present conditions, producers choose the mill to which they deliver their cane. The pattern of cane movement between producers and mill sites establishes transportation costs for the entire system. The cost of the present pattern was determined by the amount of cane tonnage being delivered from each farm and the distance it is transported. The cost per ton of cane transported was also calculated.

Our derived matrix system (Figure 1) includes all factories to which cane is delivered and all grower origins. The sites are represented by the columns

		FACTORY SITES				Total
		S_1	S_2	S_3	S_m	
GROWER ORIGINS	O_1	X_{11}	X_{12}	X_{13}	X_{1m}	B_1
	O_2	X_{21}	X_{22}	X_{23}	X_{2m}	B_2
	O_3	X_{31}	X_{32}	X_{33}	X_{3m}	B_3
	O_n	X_{n1}	X_{n2}	X_{n3}	X_{nm}	B_n
Total		T_1	T_2	T_3	T_4	

Figure 1. Matrix of Conceptual Distribution of Observed Activity

in the matrix and the origins by the rows. Two matrix systems were developed. One is based on the total volume of product delivered among all sites and origins; the other is based on transportation costs (value) for all combinations of origins and sites.

In the first system, the matrix encompasses the distribution of the total volume of cane transported from all mills to all origins where:

O_i = producer origins (i = 1, ... n)

X_j = mill sites (j = 1, ... m)

X_{ij} = observed tonnage moved between origin (i) and site (j)

B_i = total tonnage from an origin (i)

T_j = total tonnage to a site (j)

The second matrix is the same except the X_{ij}'s reflect the cost per unit of cane transportation among the origins and factory sites.

Cane registry information on 3,426 producer origins and three mill sites was consolidated into 54 producer areas. Each producer is an origin representing producers within the area. The reduction in number of origins makes the data more manageable and detracts very little from the accuracy of the analysis. The step creates a 3 x 54 matrix system.

The estimated cost of transporting the total cane harvested during 1972 under current conditions serves as the basic transportation cost for the study and is the standard to which all other alternatives are compared.

The formal conditions of the linear programming procedure were:

(1) Let subscript i indicate origins or producer areas from 1 ... n (in our study n = 54).

(2) Let subscript j indicate sites or processing mills from 1 ... m (in our study m = 3).

(3) X_i = amount of cane transported from each origin (i).

(4) X_j = capacity of each mill (j).

(5) X_{ij} = amount of cane from producer area i to mill j.

(6) C_{ij} = per unit cost of transporting cane from origin i to site j.

(7) C = Total cost of transportation for the system.

So given,

$$X_i,\ X_j,\ C,\ C_{ij},$$

find

X_{ij} for all i and j which minimize

$$C = \sum_{i=1}^{n} \sum_{j=1}^{m} X_{ij}\ C_{ij};$$

subject to these restrictions:

$$X_i = \sum_{j=1}^{m} X_{ij}$$

$$X_j = \sum_{i=1}^{n} X_{ij}$$

$$\sum_{i=1}^{n} X_i = \sum_{j=1}^{m} X_j.$$

$$X_{ij} \geq 0.$$

The linear programming procedure theoretically redistributes tonnage among plants and producer areas, reflecting the arrangement that would result if only proximity or location were involved in transportation decisions. It identifies the distribution of cane deliveries among plants and origins that would minimize the cost of delivering the total harvest of sugar cane for the 1972 season.

Comparing the resulting data matrix to the original matrix indicates which transport pattern is the most economical--the pattern as it operated in 1972 or the redistributed system defined by the least-cost program.

Variations in the Analysis. Modifications were subsequently imposed on the least-cost delivery system for the existing grower-mill matrix. The effects of closing or relocating the most uneconomical mill (located in the southern portion of the region) simultaneously increasing the capacities of the remaining mills were analyzed,[2] as was the impact of the transportation costs of relocating producer origins. The relocation alternative would transfer production areas to the south and introduce irrigation systems and fertilizer use.

Data for the analysis of relocating cane production came from several sources. These include a study of major soil systems in the Santa Cruz region by Dr. T. T. Cochrane of the British Agricultural Mission (4); CNECA studies dealing with the possible use of irrigation water, fertilizers and other improved methods of cane production (5); studies completed by the experiment station at Saavedra on the use of improved cultivation practices in the production of sugar cane (6); and a report by the USAID Study Team (1) that provides information concerning the feasibility of irrigation developments in the Santa Cruz region. Based on these sources, new sugar cane growing

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[2] Mill capacities and plans for future expansion were obtained by personal interview with officials of the three mills.

areas are hypothesized. The costs of transportation for the matrix system with existing mill locations but new areas of production were calculated and the cost results compared with existing transport pattern costs.

Unit Cost of Transport

It is difficult to formulate a representative kilometer cost for transportation in the Santa Cruz Region. Each producer negotiates his own rate with the truck owners based on individual situations and conditions. However, prices quoted by truck owners tend to be a function of three variables: (1) distance to the mill, (2) type of road,[3] and (3) amount of cane.

Tables 2, 3, and 4 summarize the transportation costs of cane for various distance zones to the three processing mills, Guabirá, La Belgica, and San Aurelio. Transport costs per ton increase as distance from the mill increases.

Annual Transportation Costs for All Cane

The cost of delivering cane to each of the three mills had to be determined as an average due to the limited data dealing with individual producer transportation costs.

The cost data situation is complicated by the fact that many growers deliver their cane to more than one mill according to their quota assignments. Sugar production quotas are established for certain growers but these may or may not be compatible with the delivery or acceptance quotas assigned

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[3] Based on the data for the Guabirá mill, there is some evidence that type of road surface influences the transportation costs. But the averages calculated in this study fail to illustrate a conclusive trend.

Table 2. Unit Transportation Costs to the Guabirá Mill

Location	Distance to Mill Km.	Type of Road	Cost $b/Ton
From 5 km.	5	Asphalt	10
Santa Maria	9	Asphalt and Unpaved	12
From 10 Km.	10	Asphalt	12
Naico	10	Unpaved	15
La Florida	10	Asphalt	12
Turobito	10	Asphalt and Unpaved	14
Portachuelo	12	Asphalt	15
Saavedra	12	Asphalt	15
Perserverancia	12	Asphalt and Unpaved	15
La Loma	12	Asphalt	15
Las Charras	13	Asphalt and Unpaved	15
Marino	13	Asphalt and Unpaved	15
Las Maras	16	Asphalt	17
Soledad	18	Asphalt	18
Aroma	20	Asphalt and Unpaved	21
Mineros	23	Asphalt	19
San Juan	25	Asphalt and Unpaved	22
Santa Martha	27	Asphalt and Unpaved	22
Caimanes	28	Asphalt and Unpaved	23
La Senda	30	Asphalt and Unpaved	23
Cuatro Ojitos	32	Asphalt	23
Chane	40	Asphalt	23

Source: Carlos Castro, Cane Manager of Guabira, 1971.

Table 3. Unit Transportation Costs to the La Belgica Mill

Location	Distance to Mill Km.	Cost $b/Ton
From 5 Kms.	5	10
Warnes	8	12
Chane Roda	11	14
Juan Latino	15	15
El Tajibo	18	20
Montero	28	20
Puesto Mendez	34	25
Santa Maria	39	25
Saavedra	40	25
Mineros	53	30

Source: Carlos Castro, Cane Manager of Guabirá, 1971

Table 4. Unit Transportation Costs to the San Aurelio Mill

Location	Distance to Mill Km.	Cost $b/Ton
Warnes	40	18
Puesto Mendez	68	25
Santa Maria	72	25
Saavedra	75	25
Charas	75	25
Portachuelo	78	30
Mineros	85	30
Cuatro Ojitos	93	34

Source: Carlos Castro, Cane Manager of Guabirá, 1971 individual growers by the mills. An individual grower may be forced to accept a partial quota from more than one mill in order to guarantee a market and to maintain a line of credit (which is based on a showing that he has a quota). The government tries to restrict each grower to obtaining a quota at only one mill in the region. Producers can circumvent this regulation by shipping cane to other mills under the names of wives or children. All this makes accurate identification of all individual producer locations and quantities being delivered very difficult.

Consequently, estimates of average costs of transportation for each mill are based on interviews with appropriate managers. The following delivery cost estimates were obtained: (1) Guabirá, $b20 per metric ton; (2) La Belgica, $b25 per metric ton; and (3) San Aurelio, $b30 per metric ton. These estimates are within the limits suggested in Tables 1, 2, and 3. The estimates are heavily influenced by the more distant areas that deliver to the plants which, in turn, suggests that significant amounts of cane are coming from the outlying regions of the production area.

Estimated annual production capacity of each plant is: (1) Guabirá, 445,200 metric tons of raw cane per season; (2) La Belgica, 539,000 metric tons of raw cane per season; and (3) San Aurelio, 401,200 metric tons of raw cane per season. Total milling capacity is 1,385,400 metric tons.

Given these estimates, the annual total grower cost of transporting cane to the mills would be $b8,904,000 for Guabirá, $b13,475,000 for La Belgica and $b12,036,000 for San Aurelio. The annual transportation bill for the entire present system based on average cost is $b34,415,000 per year. This is the basic cost figure against which all potential cost-reducing policies are measured.

RESULTS OF THE STUDY

Least-Cost Distribution for Present Cane Production

The production areas (54) defined for the Santa Cruz region, their distances from each of the mills, production for each area and the numbers of growers are listed in Tables 5 and 6. By forcing each production area to transport its cane in the least-cost pattern (Table 7), the total transportation cost for the entire system would be $b33,336,330 per year. This represents a yearly savings of $b1,078,670 or 3.2 percent over the present system.

According to the least-cost transportation pattern, certain areas can be defined as production areas or "zones of influence" from which cane should be delivered if the total transport costs of the system are to be minimized (Figure 2).

According to the least-cost model, Guabirá would receive most of its cane from north of Montero up to and including Cuatro Ojitos. This area is bounded on the west by the Rio Piray and on the east by the Rio Grande. There is also an additional zone of influence in the Buena Vista region which includes part of the production from San Carlos, Buena Retiro, and Santa Rosa.

La Belgicas's main zone of influence is bounded on the north by the main east-west highway, on the west by the Portachuelo area and on the east by the Monte Verde and Los Ciervos region. Yapacani and Aroma would contribute minor amounts of cane.

San Aurelio, which is located south of the main cane-producing region, must take the cane that is left after the needs of Guabirá and La Belgica

Table 5. Existing Production Areas in Santa Cruz and their Distances from the Mills (in kilometers), 1972.

PRODUCTION AREA		DISTANCES FROM THE MILLS		
Number	Name	Guabirá	La Belgica	San Aurelio
1	California	39	74	94
2	Aroma	24	58	82
3	Cuatro Ojitos	40	78	98
4	Caimanes	44	81	101
5	Portachuelo	22	52	76
6	Yapacani	79	109	131
7	Mineros	30	68	88
8	Chane	49	84	105
9	Candelaria	42	26	46
10	Los Ciervos	52	38	61
11	Illimani	46	84	104
12	Los Amarillos	33	71	93
13	Los Chacos	34	68	91
14	Chuchio	44	35	32
15	San Felix	20	57	79
16	Asusaqui	20	29	52
17	La Belgica	32	4	35
18	La Guardia	88	58	29
19	Palmar Viruez	67	42	14
20	Naico	11	45	67
21	La Loma	9	39	62
22	San Pedro	70	103	126
23	Warnes	31	16	38
24	Saavedra	19	56	78
25	Guabira	4	37	61
26	San Salvador	30	69	90
27	Terebinto	44	21	33
28	Tocomechi	45	26	46
29	La Angostura	105	85	61
30	Villa Arrien	73	53	22
31	Tarumaco	35	16	37
32	Santa Teresa	22	59	79
33	Sta. Rosario	45	28	50
34	Santa Rosa	33	69	94
35	Sta. Martha	31	69	90
36	San Miguel	29	66	87
37	San Juan	29	63	85
38	San Carlos	58	94	115
39	San Aurelio	59	38	4
40	San Antonio	37	19	34

Table 5. (Continued)

PRODUCTION AREA		DISTANCES FROM THE MILLS		
Number	Name	Guabirá	La Belgica	San Aurelio
41	Okinawa	63	60	76
42	Paurito	43	48	18
43	Naranjito	12	23	54
44	Montero Joyo	76	51	45
45	Monte Verde	51	84	112
46	Monte Cristo	42	30	53
47	Los Munecas	46	82	103
48	El Naranjal	12	32	53
49	Juan Latino	23	15	43
50	Cotoca	69	48	22
51	Buena Vista	48	85	105
52	Colpa	44	11	38
53	Pico de Monte	24	61	83
54	Buen Retiro	63	98	122

Table 6. Existing Production and Number of Producers from each Production Area, 1972

Production Area Number	Total Production Metric Tons	Number of Producers
1	19,722	53
2	46,349	175
3	140,998	455
4	27,081	158
5	35,595	65
6	69,377	75
7	111,433	224
8	103,143	343
9	27,212	57
10	6,490	19
11	6,418	54
12	21,439	124
13	57,849	191
14	26,802	51
15	13,561	64
16	78,180	102
17	35,950	50
18	12,970	50
19	21,000	57
20	89,375	123
21	38,570	45
22	14,620	67
23	48,260	71
24	66,635	185
25	63,360	80
26	6,713	46
27	8,597	28
28	12,760	31
29	336	2
30	3,080	3
31	15,590	19
32	340	4
33	692	8
34	790	4
35	7,908	33
36	4,280	11
37	7,545	34
38	7,820	15
39	6,930	12
40	2,654	21

Table 6. (Continued)

Production Area Number	Total Production Metric Tons	Number of Producers
41	7,740	17
42	7,545	28
43	1,730	3
44	10,100	2
45	1,540	4
46	7,310	11
47	2,240	5
48	20,560	16
49	21,430	29
50	4,690	16
51	7,250	28
52	4,260	5
53	14,480	26
54	9,240	9
	Total: 1,385,400	Total: 3,408

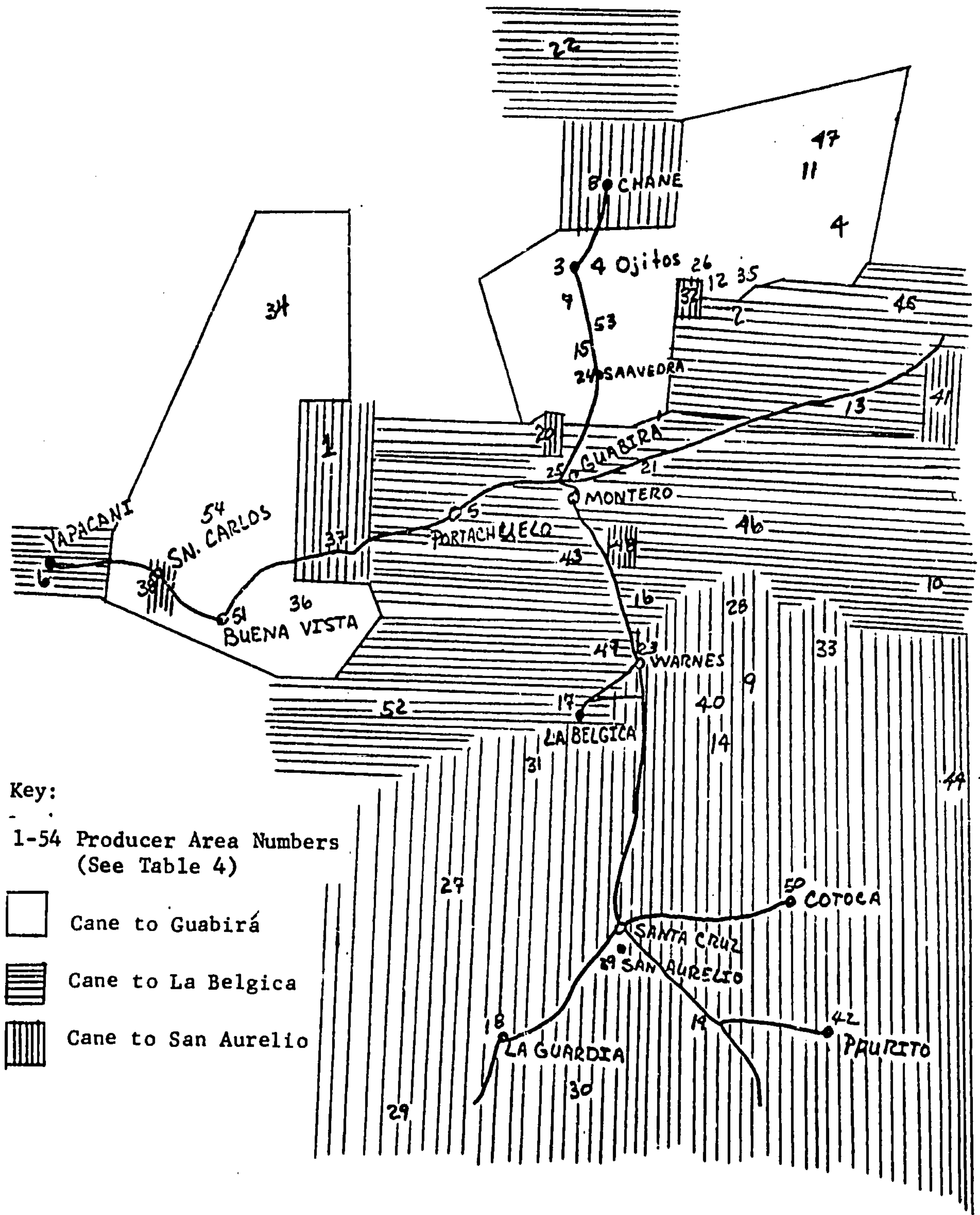
Table 7. Distribution of Grower Origins and Processing Mills for Minimum Cost System for Transporting Sugar Cane in Santa Cruz, 1972.

Producer Area (O_i) Number	Name	Mill Site (S_j)	Amount Delivered (X_{ij}) Metric Tons	Cost (C_{ij}) $b
3	Cuatro Ojitos	Guabirá	140,998	3,242,954
4	Caimanes	"	27,081	649,944
7	Mineros	"	111,433	2,340,093
11	Illimani	"	6,418	154,032
12	Los Amarillos	"	21,439	493,097
15	San Felix	"	13,461	216,965
24	Saavedra	"	66,635	1,066,160
26	San Salvador	"	6,713	140,973
34	Santa Rosa	"	790	18,170
35	Santa Martha	"	7,908	181,884
36	San Miguel	"	4,280	89,880
38	San Carlos	"	4,734	118,350
47	Los Munecas	"	2,240	53,760
51	Buena Vista	"	7,250	174,000
53	Pico de Monte	"	14,480	304,080
54	Buen Retiro	"	9,240	240,240
	TOTALS:		445,200	$b9,484,593
2	Aroma	La Belgica	46,349	1,158,725
5	Portachuelo	"	35,595	889,875
6	Yapacani	"	66,238	2,384,568
10	Los Ciervox	"	6,490	149,270
13	Los Chacos	"	47,849	1,504,074
16	Azusaqui	"	78,180	1,641,780
17	La Belgica	"	35,590	431,400
20	Naico	"	59,529	1,428,696
21	La Loma	"	38,570	887,110
22	San Pedro	"	14,620	526,320
25	Guabira	"	63,360	1,457,280
43	Naranjito	"	1,730	36,330
45	Monte Verde	"	1,540	46,200
46	Monte Cristo	"	7,310	153,510
49	Juan Latino	"	21,430	342,880
52	Colpa	"	4,260	68,160
	TOTALS		539,000	$b13,106,178
1	California	San Aurelio	19,722	670,548
8	Chane	"	103,143	3,713,148
9	Candelaria	"	27,212	653,088
14	Chuchio	"	26,802	616,446
18	La Guardia	"	12,970	272,270
19	Palmar Viruez	"	21,000	336,000

Table 7. (Continued)

Producer Area (O_i) Number	Name	Mill Site (S_j)	Amount Delivered (X_{ij}) Metric Tons	Cost (C_{ij}) $b
20	Naico	San Aurelio	29,846	775,996
23	Warnes	"	48,260	1,109,980
27	Terebinto	"	8,597	197,731
28	Tocomechi	"	12,760	306,240
29	La Angostura	"	336	8,736
30	Villa Arrien	"	3,080	64,680
31	Tarumaco	"	15,590	358,570
32	Santa Teresa	"	340	9,180
33	Santa Rosario	"	692	16,608
37	San Juan	"	7,545	226,350
38	San Carlos	"	3,086	111,096
40	San Antonio	"	2,654	61,042
41	Okinawa	"	7,740	208,980
42	Paurito	"	7,545	120,720
44	Montero Joyo	"	10,100	242,400
48	El Naranjal	"	20,560	514,000
50	Cotoca	"	4,690	98,490
	TOTAL		401,200	$b10,775,559
	GRAND TOTALS:		1,385,400	$b33,366,330

Figure 2. Least-cost Transportation Model for Existing System



have been met. It would take all the cane production to the south of Santa Cruz, the lands bounded on the west by Terebinto, on the east by Monte Hoyo, and on the north by the Tocomechi area. In order to operate at capacity, San Aurelio must draw cane from several distant regions, including Okinawa, Chane, Station Tereba, part of Naico, and a production area near California (which includes San Juan and part of San Carlos).

Obviously, the least-cost model minimizes the transportation bill for the entire system, not necessarily the cost for each plant. Cane is forced to go to the most economical plant in terms of the whole system. The choice is based on producer distance from the mills, the unit cost of delivery per ton, and amount of cane to be delivered. If "nearby" production is adequate to meet capacity needs of a particular mill, any "left over" may be even further from the next best plant.

Minimizing the transportation bill for the entire delivery system does not insure that each individual producer will realize his least-cost alternative. Growers operating near Warnes, especially to the east, would find delivery to the La Belgica plant less costly than to either of the two other plants (Figure 2). Yet the least-cost solution of delivery for the entire system pushes the production of this area to the San Aurelio plant, with higher costs to these individual producers.

Such results are inherent in any program in which the welfare objective is defined in terms of the total system, i.e., in this case the minimization of the transport bill for the entire area. The same feature is inherent to greater or lesser degree in all of the alternatives presented in this study.

As indicated above, the cost of transportation for the present system is approximately $b34,415,000 per year. This represents an average cost of $b20 per ton for cane delivered to Guabirá, $b25 for cane delivered to La Belgica and $b30 for cane delivered to San Aurelio. For the least-cost distribution of the present system, the total cost would be $b33,336,330, which is an annual savings of $b1,078,670. This represents an average cost of $b21.30 per ton for cane delivered to Guabirá; $b24.32 per ton for cane delivered to La Belgica; and $b26.86 per ton for cane delivered to San Aurelio.

Alternatives for Reducing Transportation Costs

There are three other major alternatives, which if implemented, might reduce the overall cost of cane transportation. The mill most distant from the regions of current cane production could be moved closer. The most distant mill could be closed and the capacity of the other two mills increased. The areas of production could be moved to the south, closer to the existing mills.

Relocating and/or increasing the capacity of the mills. In terms of transportation costs, San Aurelio has the least advantageous location of the mills. The average cost of transporting the cane to this mill is $b30 per ton. Under the least-cost model, the cost decreases to $b26.86 per ton. The management of San Aurelio plans to shift part of their operation to the Buena Vista area. This is 60 kilometers northwest of the present location.

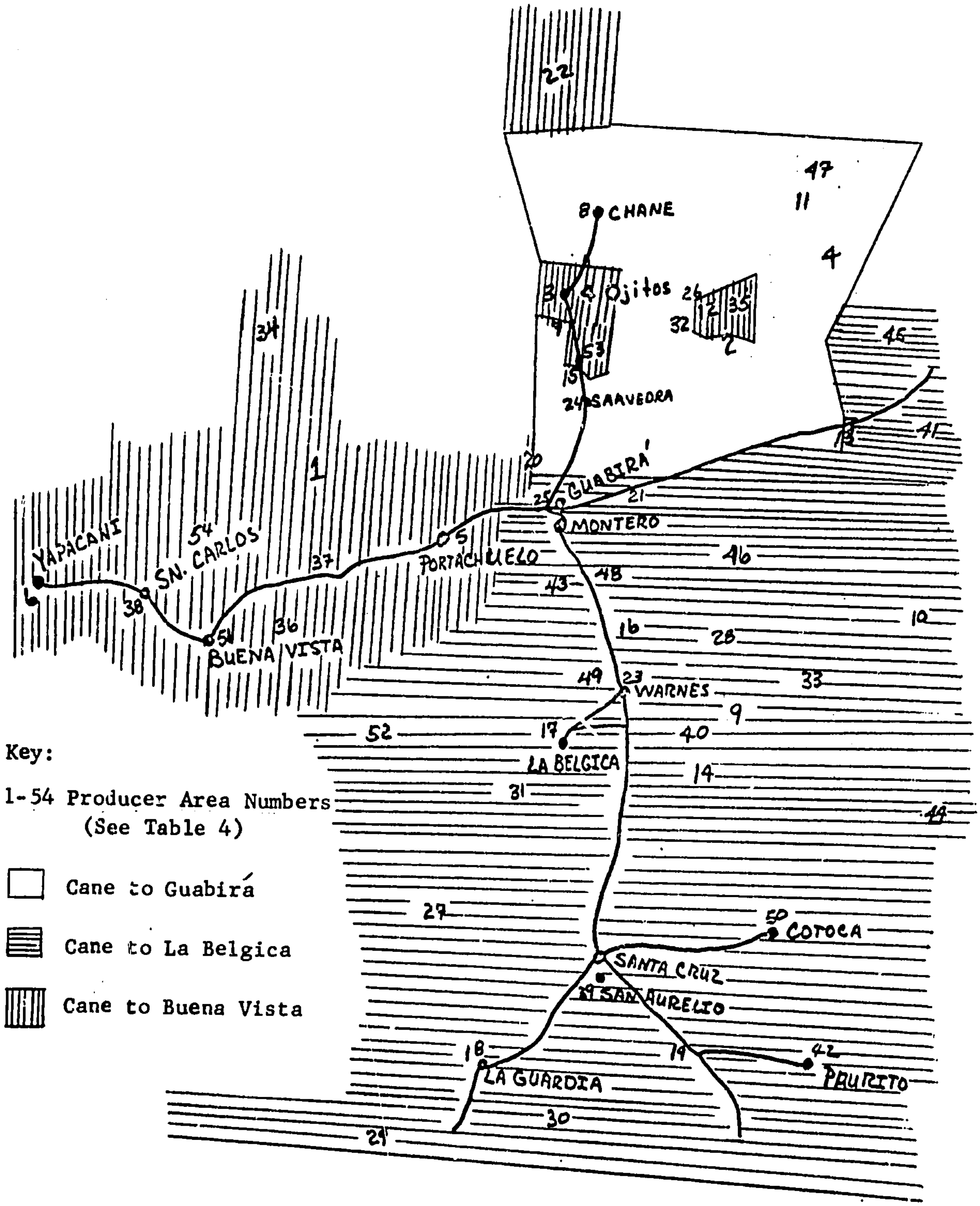
Moving the San Aurelio mill to Buena Vista would affect the entire least-cost distribution system. The 1972 transportation cost of the distribution system with San Aurelio at its present location is $b34,415,000. The cost with the plant at Buena Vista is $b30,225,465. This represents a savings of $b4,189,535 per year (Figure 3). If the costs of moving the San Aurelio plant to the Buena Vista area are assumed to be $b68.75 million (the average estimate of knowledgeable people in Santa Cruz), this amount can be amortized over the life of the plant and can be compared with the annual savings that would be gained from lower transportation costs.

The quoted interest rate in Santa Cruz is 15 percent. If the plant had a life of 20 years, the annual amortization of the $b68.75 million relocation investment would be $b10,983,500. For a plant life of 25 years, the annual figure would be $b10,635,556, and for a 30-year life, $b10,470,625. This shows that for any reasonable life, the annual amortization cost is more than twice the expected annual savings from transportation ($b4,189,535).

A second alternative is to close San Aurelio and have the cane presently being delivered to San Aurelio go to La Belgica and Guabirá.

The climate and harvesting situation in Santa Cruz could support a milling season of about 180 days. Over the past five-year period, however, the milling season for La Belgica and Guabirá has averaged 157 days and the average for San Aurelio has been 118 days. If San Aurelio were closed, La Belgica and Guabirá could extend their milling seasons to 180 days. The combined capacity of the two mills would allow 1,134,000 metric tons of cane to be milled per 180-day season. This is 254,539 metric tons less than is currently being milled per season by the three processing plants. This alternative provides large savings in transportation costs with no additional capital investment in plant sites. It should be emphasized that this alternative would handle about 82 percent of the 1972 deliveries, so there would be an effective reduction in milling capacity.

Figure 3. Least-Cost Transportation Model with San Aurelio Deleted and Buena Vista Added

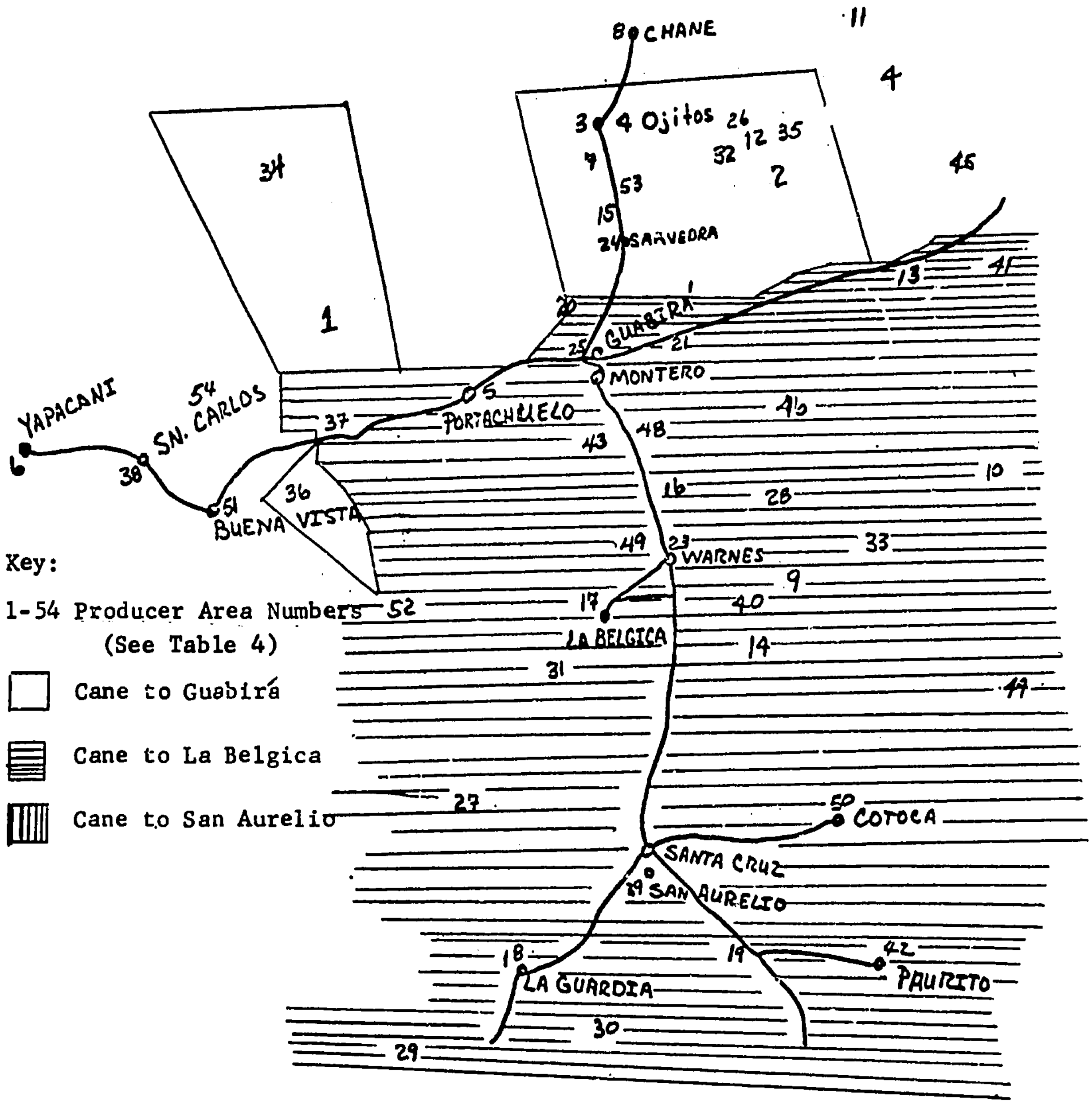


Under the least-cost distribution system, the annual cost of transporting the cane to Guabira and La Belgica would be $b23,885,633. If 1,134,000 metric tons (deliveries for 1972 less 18 percent) of cane were delivered under the existing pattern of shipment to three plants, the total bill would be $b28,179,900. Thus, by closing San Aurelio and delivering only to the other two mills, a yearly savings of $b4,294,267 could be realized. However, the savings of this alternative are also associated with an 18 percent reduction in cane delivery and processing. The distribution of influence areas is shown in Figure 4.

By increasing the daily capacity of Guabirá and La Belgica by 25 percent each, and lengthening the milling season to 176 days per year, the total amount of cane now being produced in Santa Cruz could be handled by just these two mills. This represents an increase in the capacity of Guabirá from 445,200 metric tons per season to 616,000 metric tons per season and an increase in the capacity of La Belgica from 539,000 tons per season to 770,000 tons per season. The estimated cost of increasing the daily capacity of Guabirá by 25 percent is $b8,862,000 (7). Increasing the daily capacity of La Belgica by 25 percent would require an estimated $b16,352,875 (7). The total investment of $b25,214,875 for the two plants would provide the total milling now being supplied by three plants.

The total annual transportation bill for the expanded two-plant system would be $b28,903,321. This represents a savings of $b5,511,679 per year over the present system. If the cost of increasing the capacity of Guabira and La Belgica by 25 percent is amortized over the life of the plants, a direct comparison can be made between savings in transportation costs and costs of increasing plant capacities. Assuming life of the plants to be 20

Figure 4. Least-Cost Transportation Model with San Aurelio Deleted and a 180 Day Milling Season for Guabirá and La Belgica



years and the interest rate 15 percent, the annual repayment figure for a total investment of $b25,214,875 would be $b4,029,337. For a 25-year period, the annual repayment figure would be $b3,840,225 which is less than the transport savings. The distribution of influence zones delivering to the two expanded plants is illustrated in Figure 5.

The alternatives by which the sugar cane industry might lower transportation costs are compared in Table 8.

Irrigation and Shifting Production
Areas Nearer Existing Mills

The most logical way of overcoming the effect of the drought in the southern region and relocating cane production to this area is to develop irrigation projects. The feasibility of irrigation projects in the southern region depends upon many factors. One of the most important is the type of land available for cane production. Most Santa Cruz areas especially suitable for cane production would be amenable to the development of irrigation projects (Figure 6). The area designated as Soil Type #2--Colpa is such an area. According to Cochrane (4), this area has drainage problems and the natural fertility of the soil has been depleted. Minor possibilities do exist in this area for cane production, but a large-scale irrigation project may not be physically feasible. Area #20--Chapparal, is described as a low-lying semi-swamp area, which eliminates is adaptability for irrigation development. With these two areas excluded, Area #21--Piray is the most likely candidate for large-scale irrigation projects. Piray includes all of the land between Santa Cruz and Montero and is the area where cane was initially grown.

Figure 5. Least-Cost Transportation Model With San Aurelio Closed and a 25 Percent Increase in the Capacities of Guabirá and La Belgica

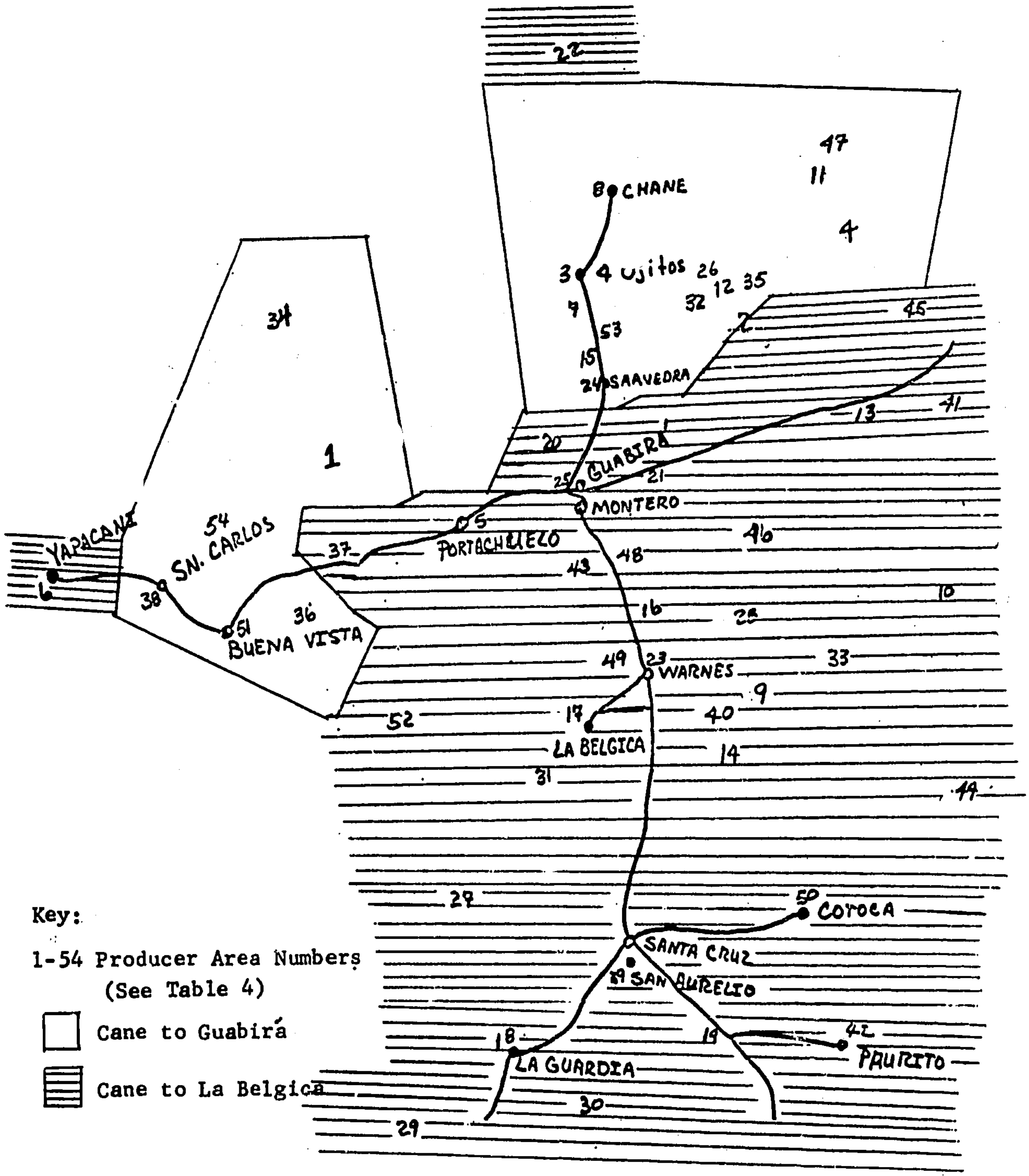


Table 8. Alternatives for Reducing Sugar Cane Transportation Costs in Santa Cruz

	Matrix System	Total Amount of Cane Available (M. T.)	Total Capacity of Plants (M. T.)	Total Transportation Cost ($b)	Net Transportation Savings ($b)
Present Situation	----	1,388,539	1,385,400	34,415,000	---
Alternative 1	3 x 54[1]	1,388,539	1,385,400[2]	33,366,330	1,048,670
Alternative 2	3 x 54	1,388,539	1,385,400[3]	30,225,465	4,189,535
Alternative 3	2 x 54	1,388,539	1,134,000[4]	23,885,633	4,294,267[5]
Alternative 4	2 x 54	1,388,539	1,386,000[6]	28,903,321	5,511,679

[1]Three plants sites, 54 producer origins.

[2]Based on a milling season of 149 days for Guabirá with a 2800 M. T. per day capacity, 154 day milling season for La Belgica with a 3500 M. T. per day capacity, and a milling season of 118 days for San Aurelio with a 3400 M. T. per day capacity

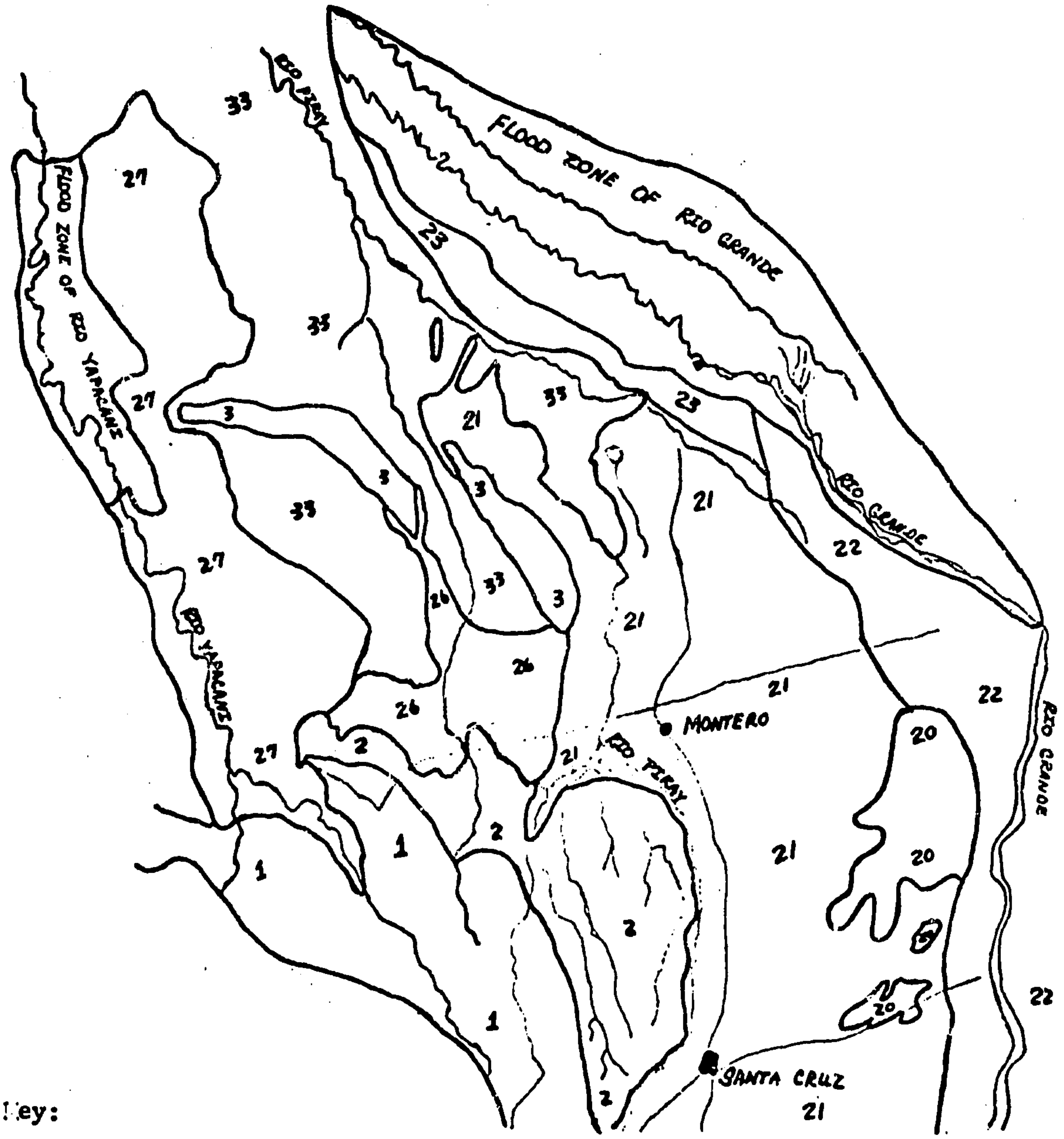
[3]Same as #1 except Buena Vista is substituted for San Aurelio

[4]Based on a 180 day milling season for La Belgica and Guabirá

[5]Based on the assumption that 1,134,000 metric tons of cane would be distributed among the three plants at a total transportation cost of $b28,179,900 as compared to $b34,415,000 for 1,385,400 metric tons

[6]Twenty-five percent increase in capacity of Guabirá and La Belgica with a 176 day milling season

Figure 6. Land Systems Map of the Santa Cruz Region (4).



Key:

1.	Caranda	22.	Rio Grande Central
2.	Colpa	23.	Rio Grande Norte
3.	Santa Rosa	26.	Pampas De Portachuelo
20.	Chaparral	27.	Yapacani-Palacios
21.	Piray	33.	Central Hidromorphic Zone

The economic feasibility of relocating sugar cane production from the northern to the southern region is based on the comparison of the savings from transportation costs (if production takes place in the southern region) with the change in production costs associated with the move. In this case, the change in costs involve irrigation project and fertilizer costs. This comparison utilizes the least-cost transportation model.

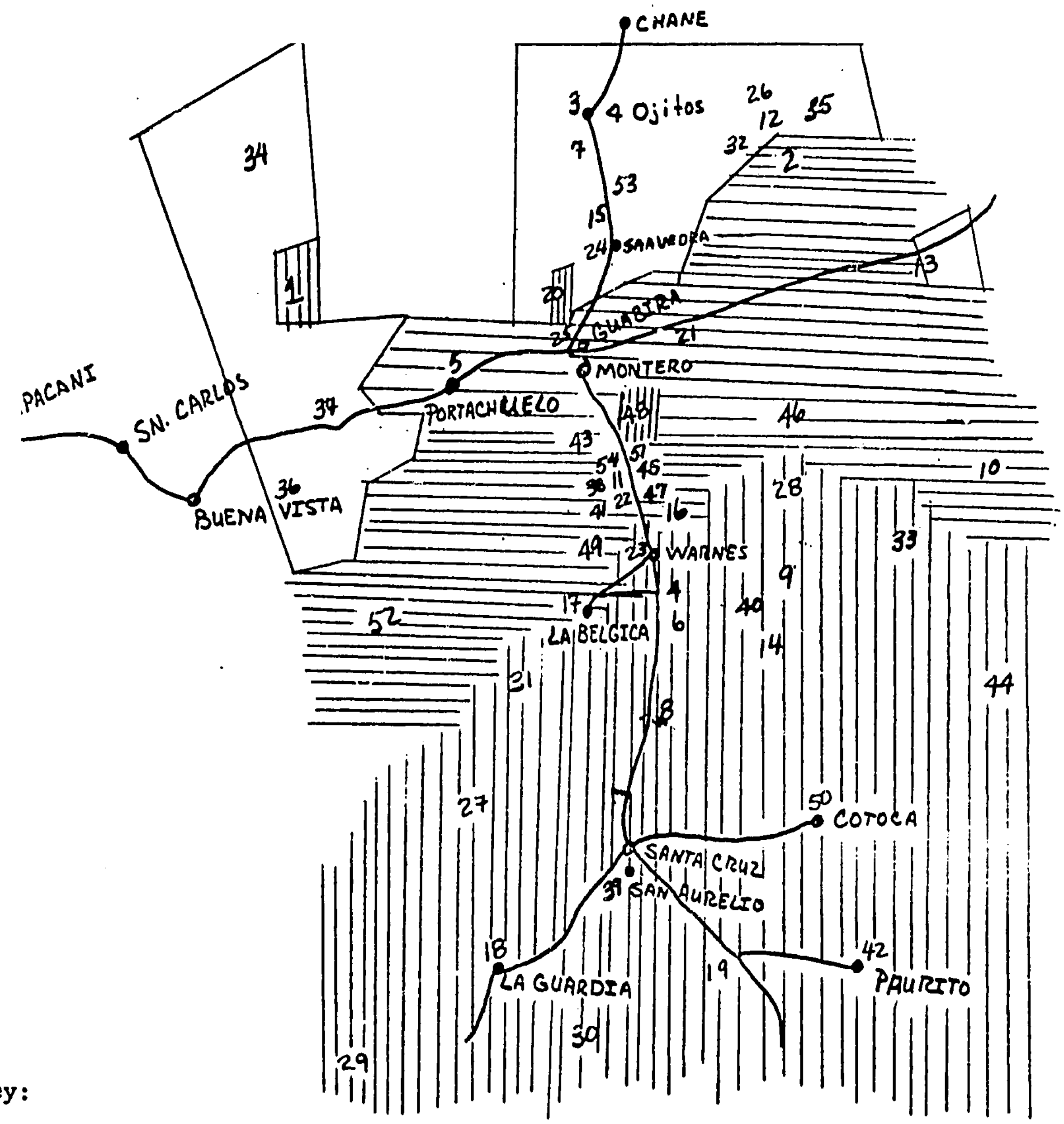
For the purposes of this portion of the study, the sugar cane production occurring beyond 30 kilometers to the north of Guabirá is hypothetically shifted to the area between Santa Cruz and Montero. The distance of 30 kilometers is used because current production within that distance approximates the amount formerly grown in the southern region. If this northern production were shifted back to the southern region, the sugar cane production pattern would closely resemble the original production situation.

Production that would logically be shifted in the southern region includes the following producer areas: No.'s 4, 6, 8, 11, 22, 38, 41, 45, 47, 51, and 54 (See Table 4). The tonnage involved is 256,469.

If all cane production occurring more than 30 kilometers to the north of Guabirá were shifted to the southern region, the total annual transportation bill for the system would be $b29,139,450 per year. The total per year for the existing system is $b34,415,000. The production shift represents a savings of $b5,275,550 per year. On a per ton basis, the average transportation cost of the existing system is $b24.08. With the relocation of the production areas, the average cost would be $b21.03 per ton of cane transported. The zones of influence are shown in Figure 7.

According to the USAID Study Team report (1), if the land in the Santa Cruz area is irrigated, and fertilizer is used, a yield of 120 tons per hectare

Figure 7. Least-Cost Transportation Model with Production of Northern Regions Shifted to the South



Key:

1-54 Producer Area Numbers (See Table 4)

☐ Cane to Guabirá

☰ Cane to La Belgica

Cane to San Aurelio

could be achieved. An irrigation project capable of irrigating at least 2,137 hectares would be needed.

The cost of implementing such a project varies greatly with the type of water delivery system chosen. The USAID Study Team (1) considered four methods: (1) sprinkler irrigation from a well, (2) surface irrigation from a well, (3) sprinkler irrigation from a river, and (4) surface irrigation from a river. The per hectare costs are based on an assumed unit size of 150 hectares for sprinkler irrigation and 100 hectares for surface irrigation. This results in per hectare costs estimated at: (1) sprinkler irrigation from a well, $b2505; (2) surface irrigation from a well, $b2470; (3) sprinkler irrigation from a river, $b1630; and (4) surface irrigation from a river, $b675. These may turn out to be conservative estimates if some economies of scale can be realized in a large project.

Some positive economies of scale might be realized in irrigating 2,137 hectares. Using the USAID figures, the total annual cost of developing these systems to irrigate 2137 hectares would be: (1) sprinkler irrigation from a well, $b5,353,185 per year, (2) surface irrigation from a well, $b5,278,390 per year, (3) sprinkler irrigation from a river, $b3,483,310 per year, and (4) surface irrigation from a river, $b1,431,790 per year (Table 9).

Fertilizer is also essential if 120 tons per hectare are to be grown in the southern region. The soils in the area between Santa Cruz and Montero are depleted and would require fertilizer application if a yield of this magnitude is to be realized. Table 10 gives the cost of fertilizers and the types available in the Santa Cruz area. To rehabilitate the land in the area between Santa Cruz and Montero, 300 kg. per hectare per year would be necessary. Allowing an average cost of $b120 per 50 kgs., the cost of fertilizer per

Table 9. Annual Costs of Irrigating 2137 Hectares in Santa Cruz

Type of System	Annual Cost per Hectare $b	Annual Cost for Irrigating 2137 Hectares $b
1. Sprinkler from well	2,505	5,353,185
2. Surface from well	2,470	5,278,390
3. Sprinkler from river	1,630	3,483,310
4. Surface from river	675	1,431,790

Source: Irrigation Analysis for Selected Crops, Santa Cruz, Bolivia, USAID Study Team, 1972.

Table 10. Fertilizers Available in Santa Cruz and Fertilizer Costs

Unit	Product	Price
Sack (50 kilos)	15-15-15	$b119.00
"	18-46-0	124.00
"	13-39-0	
"	16-20-0	
"	Urea 46%	115.50

Source: Grace and C. I. A. (Bolivia) S. A, 1972.

hectare would be $b720. The total cost of fertilizing 2137 hectares would be $b1,538,640.

The costs of developing irrigation projects and fertilizing the land in the southern regions are compared with the savings that would be obtained from lower transportation costs in Table 11.

Two types of irrigation development would cost less per year than the yearly savings from transportation costs. These two systems are: (1) sprinkler irrigation from a river which would cost $b5,021,950 annually to irrigate 2137 hectares; (2) surface irrigation from a river which would cost $b2,970,430 annually to irrigate 2,137 hectares. The annual savings of transportation costs are $b253,600 and $b2,305,120 respectively.

Another factor that must be considered if cane production is to be relocated in the southern region is the question of regional comparative advantage. The major crop now being produced in the southern region is cotton. If sugar cane is relocated to this area, it must compete with cotton on an economic basis. According to the study completed by the USAID Study Team, sugar cane is second to cotton as the most profitable crop in the Santa Cruz region. With fertilizer use and gravity irrigation in the southern region, the estimated net return per hectare of cotton is $b5,773 and the net return per hectare of sugar cane is $b3,762. As these data are estimates for the total Santa Cruz region, and not just the southern area, sugar cane data reflect the higher transportation costs associated with the present distribution of cane production and delivery. Individual producer situations and/or those related specifically to the southern region will reflect more favorable transportation costs and consequently the returns versus cotton will improve. Furthermore, sugar prices in Bolivia have been increased approximately 30 percent since the USAID Study Team Report.

Table 11. A Comparison of the Cost of Developing 2137 Hectares in the Southern Region of Santa Cruz, with the Savings from Lowered Transportation Costs

Type of System	Annual Irrigation Costs per Hectare $b	Annual Fertilizer Costs Per Hectare $b	Total Annual Cost for 2137 Hectares $b	Total Annual Transportation Savings $b	Net Gain or Loss $b
1. Sprinkler from a well	2,505	720	6,891,825	5,275,550	-1,616,275
2. Surface from a well	2,470	720	6,817,030	5,275,550	-1,541,480
3. Sprinkler from a river	1,630	720	5,021,950	5,275,550	+ 253,600
4. Surface from a river	675	720	2,970,430	5,275,550	+2,305,120

The high return for cotton depends in large part on the present world prices for hand-picked cotton. If this market should falter, cotton would lose much of its profitability. On the other hand, Bolivia's sugar cane production is consumed in Bolivia and is not as susceptible to risk of fluctuating prices. Moreover, a portion of Bolivia's sugar production is linked to a sugar quota from the United States which adds additional stability to future prices. Whether irrigated cane production would support irrigation development as a single crop or become part of a broader crop rotation is a matter for speculation at this point in time. Sugar cane is normally replanted each five years and rotates with legumes, green manure or in a fallow cycle as do other competitive crops in the region. But cane production can be sustained in a continuing production cycle with commercial fertilizer in the same manner as cotton, soya, etc. Consequently, the reality of cane production in the south is dependent upon its relative profitability at a given point in time and under relative economic conditions. The issue cannot be conclusively resolved on the basis of existing information. But the qualitative projection does suggest good probabilities that sugar cane could compete with other crops in the southern region, given the irrigation development essential to attaining the projected yield levels.

RECOMMENDATIONS FOR FURTHER RESEARCH

The two most feasible producer-oriented alternatives were: (1) to develop "zones of influence" based on the least-cost analysis of the present system, and (2) develop surface irrigation projects from the rivers. Both of these alternatives are producer oriented. The "zones of influence" concept requires no additional investment by either the bills or the producers. The plants to which individual producers deliver their cane are designated so as to minimize the cost of transportation, given the existing spatial distribution of plants and producers. The development of surface irrigation projects would require investment by producers, but no investment from the mills, and would improve the spatial relationships among mills and producers.

If either of these alternatives were chosen, there would be a minimum of equity problems to be resolved. This is because investment costs would be borne by the producers and they would reap any forthcoming benefits in the form of transportation savings or net gains from greater yields.

However, if the alternatives of either shifting the mills nearer to production areas or closing the mill most distant from the current production areas were followed, equity issues may be relevant.

The mills would pass some or all of the cost of moving their operations or increasing their capacity on to the producers and/or the consumers. Closing or relocating a mill could affect the income distribution and economic conditions of the cane producers and mill workers. Predefinition of the equity issues and distribution of benefits and costs related to these two alternatives would be relevant to the development strategy of Bolivia and the Santa Cruz region. If either of these two alternatives were chosen, the producers would realize savings in their transportation costs. However, the mills might feel justified in requesting a price adjustment either by lowering the price they pay to the producers or the price received for their sugar in order to cover the costs of moving or increasing the plant capacities. Further research would be beneficial in explaining how these factor interrelate and the ultimate effect they would have on the distribution of income and the economic condition of producers in Santa Cruz.

Research dealing with the price elasticity of demand for sugar in Bolivia would help policymakers decide whether a portion of the cost of moving or of increasing the capacity of the mills could be borne by the consumers. It would also facilitate projections of future demand for sugar in Bolivia.

If sugar cane production is to be relocated by means of irrigation projects, a study dealing with the sources of credit in Santa Cruz would be helpful. Most cane producers in Santa Cruz have small operations and would find difficulties in raising the necessary capital required for an irrigation project. Possible sources of credit for these small producers would have to be predefined if irrigation projects were to be developed in Santa Cruz.

Finally, if sugar cane production is relocated to the southern region, the comparative advantage of sugar cane relative to other crops, especially cotton, should be evaluated.

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APPENDIXES

Appendix A

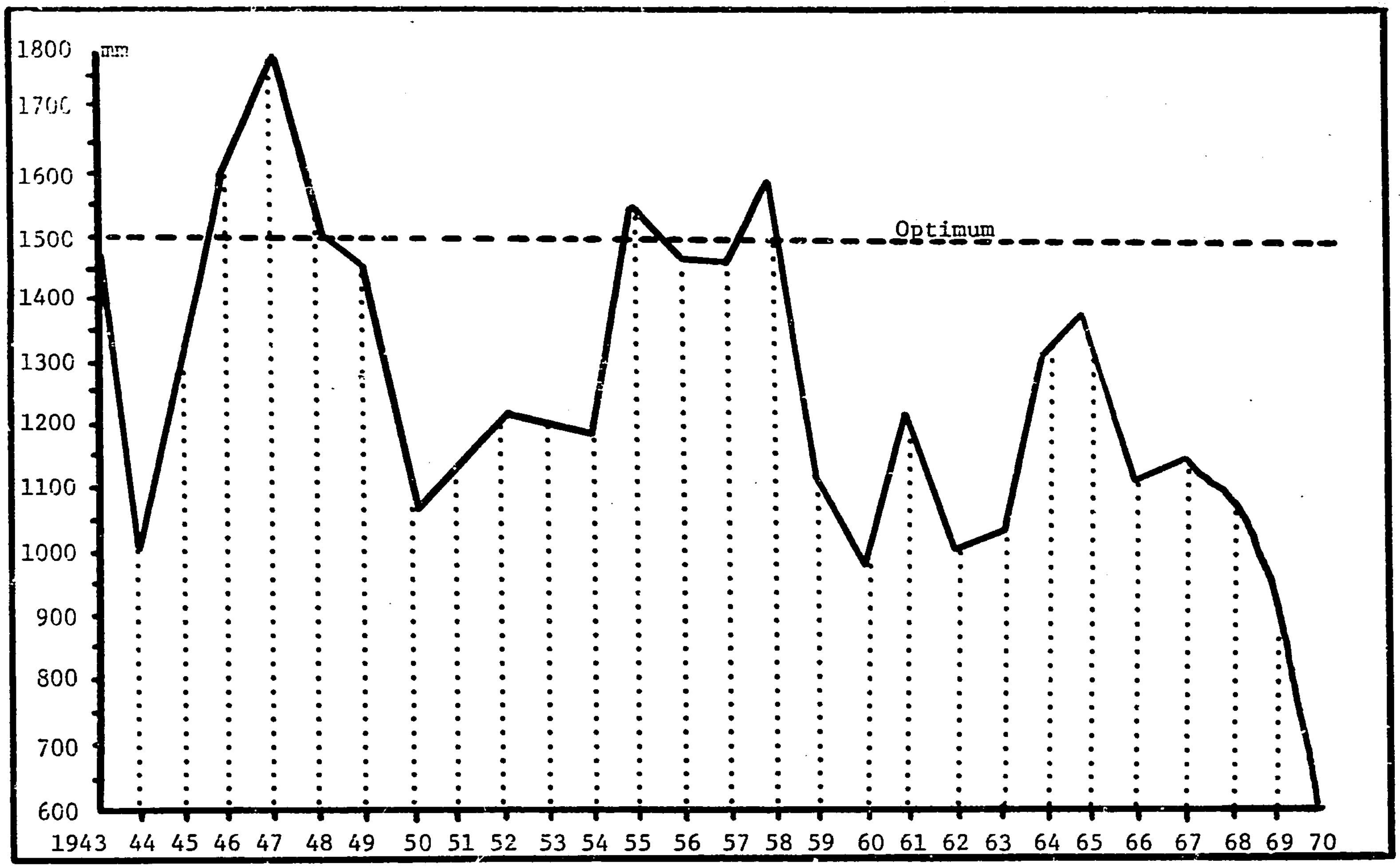
PRECIPITATION

The dependency of sugar cane production in the Santa Cruz area upon rainfall has severely limited production. Rainfall records have been kept at the experiment station at Saavedra from 1943 to the present. The station is located in the region where much of the past and present cane production takes place. According to the Station's records, since the production of sugar cane began in 1949-50, precipitation has exceeded the established optimum of 1500 mm. per year in only two years (1955 and 1958). This is illustrated in Appendix Table A1 and Figure A1.

As can be observed from Figure A1 yearly amounts of precipitation have steadily decreased from 1965 to 1970. From 1950 through 1970, an average of 5 months per year of serious moisture shortage have hampered good cane growth (1). In 1970, about 10 months were considered deficit (Figure A2).

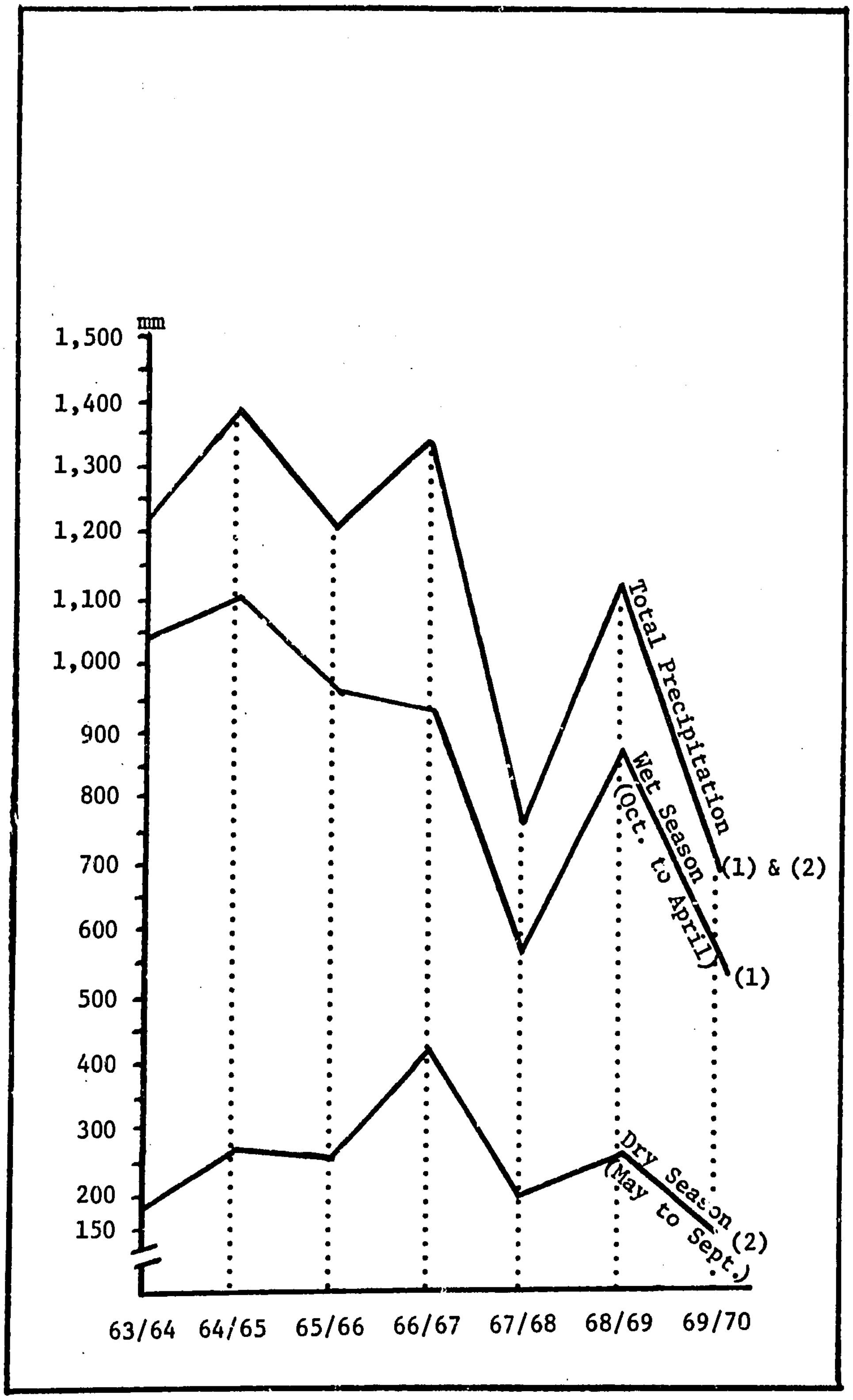
The drought has been most severe in the southern part of the region. According to the data collected near the city of Santa Cruz, the average rainfall for the last 20 years has been about 1000 mm. per year. The experiment station at Saavedra, which is 70 km. north of Santa Cruz, reports an average of about 1250 mm. per year for the same period. This difference has been greater during the last five years as a result of the period of severe drought in the southern region. Farther north, around the Rio Grande, annual rainfall averages over 130 mm. As one moves further north, there is a marked increase in annual rainfall. Although the area north of Montero receives less than the optimum amount of rainfall per year, it is still much more favorable for growing sugar cane than the southern region in terms of available moisture.

Figure A1. Recorded Rainfall at Saavedra, 1943-1970



Source: Saavedra Experiment Station (Santa Cruz)

Figure A2. Recorded Rainfall at Saavedra, Wet and Dry Seasons, 1963-64, 1969-70.



Source: Saavedra Experiment Station (Santa Cruz)

Table A1. Monthly Rainfall at Saavedra, 1943-1970 (millimeters)

Month	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
January	119.0	64.2	147.7	100.1	272.5	238.4	191.6	172.6	265.4	221.3
February	295.7	135.9	201.4	194.1	148.0	240.7	106.8	61.7	123.2	211.1
March	75.0	96.8	359.9	243.4	196.7	158.8	132.3	124.0	39.9	69.0
April	134.0	56.3	116.2	32.9	89.3	5.5	119.6	91.0	62.1	20.9
May	40.0	39.5	27.1	407.5	250.3	7.5	32.2	135.0	43.7	44.9
June	80.6	94.4	11.6	58.9	61.5	60.7	233.3	1.5	73.8	173.3
July	17.5	11.0	100.8	57.7	166.8	194.3	39.5	129.5	0.2	1.7
August	24.0	118.3	1.0	13.8	120.6	40.8	0.7	4.5	74.9	7.7
September	88.0	12.4	88.3	147.4	98.9	40.8	---	48.2	95.1	130.8
October	107.5	292.3	33.1	44.7	43.9	200.2	69.0	172.3	137.3	109.0
November	82.9	26.0	93.5	78.5	128.8	77.0	213.0	61.2	130.7	149.7
December	463.1	113.3	172.9	227.2	222.5	238.1	253.1	70.9	86.8	88.1
Total	1.527.3	1.060.4	1.353.5	1.006.2	1.799.8	1.503.1	---	1.072.4	1.143.1	1.227.6

Table A1. Continued

Month	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
January	66.8	191.1	395.9	220.8	132.0	106.6	218.4	111.7	160.0	175.0
February	48.0	114.8	127.7	167.6	162.5	231.1	93.9	137.1	266.7	132.0
March	189.3	221.5	105.2	20.3	48.2	48.2	154.9	114.3	83.8	157.4
April	252.4	201.2	125.5	220.9	96.5	152.4	147.3	142.2	106.6	22.8
May	173.7	116.8	73.2	50.8	93.9	53.3	12.7	71.1	53.3	30.4
June	28.8	80.9	104.7	76.2	73.6	63.5	91.4	12.7	60.9	15.2
July	3.9	32.1	149.5	88.9	223.5	35.5	71.1	33.0	53.3	5.0
August	0.0	18.0	23.3	58.4	96.5	0.0	30.4	60.9	0.0	48.2
September	35.8	81.5	0.1	58.4	180.3	165.1	0.0	63.5	20.3	66.0
October	126.8	25.0	55.7	152.4	96.5	149.8	99.0	63.5	76.2	96.5
November	184.6	24.0	232.0	91.4	147.3	160.0	109.2	81.2	109.2	66.4
December	100.3	79.0	157.4	269.2	114.3	434.3	129.5	71.1	254.0	190.5
Total	1.210.4	1.185.9	1.550.2	1.475.3	1.465.1	1.599.8	1.157.8	962.3	1.244.3	1.005.4

Table A1. Continued

Month	1963	1964	1965	1966	1967	1968	1969	1970	Average
January	127.0	132.0	281.0	177.8	281.9	134.6	114.3	73.7	174.7
February	213.3	259.0	160.0	132.1	127.0	180.3	96.5	109.2	160.3
March	144.7	195.6	71.1	137.2	53.3	15.2	71.1	33.0	120.0
April a	40.6	66.0	106.7	7.6	65.3	40.6	73.7	33.0	93.9
May	33.0	38.1	86.4	86.4	106.7	2.5	76.2	48.2	79.8
June	40.6	15.2	5.0	68.6	170.2	43.2	101.6	73.7	70.5
July	7.6	5.0	139.7	0.0	96.5	33.0	20.3	7.6	61.6
August a	7.6	35.6	35.6	0.0	27.9	91.4	17.8	7.6	34.5
September	40.6	81.3	2.5	96.5	10.2	25.4	44.5	2.5	63.9
October	78.7	190.5	180.0	144.8	45.7	119.4	68.6	83.8	109.4
November	132.0	147.3	96.5	93.9	38.1	78.7	170.2	53.3	109.2
December	170.2	154.9	228.6	170.2	111.8	307.3	63.5	96.5	179.9
Total	1.035.9	1.320.5	1.394.0	1.115.1	1.134.6	1.071.6	918.3	622.1	1.257.70

Source: Saavedra Experiment Station (Santa Cruz)

Appendix B

PHYSICAL FACTORS RELATED TO THE PRODUCTION OF SUGAR CANE IN SANTA CRUZ

Soil Types

The ten major soil types in the region of Santa Cruz have been classified by T. T. Cochrane of the British Agricultural Mission (See Figure 6). The ten areas of interest within Santa Cruz are distinguished primarily on the basis of differing soil types. These ten areas and their characteristics are described according to Cochrane's study (4).

Soil Type #1 -- Caranda

Area: 166,000 Hectares

General Topogrpahy: Small, even, steep sided on hills. Fairly young topography.

Characteristics of Agricultural Importance, Including Climate: The steep topography of these hills will largely limit agriculture to a small proportion of the lower gentler slopes. Rainfall in the region is in excess of 1300 mm. per year. The dry season includes the months of June to September, but is not too severe. There are frequent cool southerly winds between May and August.

Agricultural and Animal Product on Potentials: Some tree crops on lower stabler slope positions in the south and possibly cacao in the north. Only a small percentage of the total area might be used.

Soil Type #2 -- Colpa

Area: 106,000 Hectares

General Topography: Some small rolling to steep hills complexed with oldish plain surfaces and recent river valleys.

Characteristics of Agricultural Importance, Including Climate: There is a relatively small acreage of cultivatable soil, and the fertility of such appears to deplete very rapidly. Because of inherent drainage problems, the planosolic soils cannot be used for arable cropping without sub-soiling and artificial drainage. The climate is very similar to that of Caranda, but is possibly a little drier.

Agricultural and Animal Production Potentials: Minor agricultural possibilities do exist, including sugar cane and coffee. The region appears suitable for cattle production.

Soil Type #3 -- Santa Rosa

Area: 32,000 Hectares

General Topography: A series of small hills with moderate to steep slopes. Hills rise about 400 feet above surrounding plains.

Characteristics of Agricultural Importance, Including Climate: Topography and the sandy, infertile nature of these soils limit agricultural use. Soil moisture is adequate for coffee cultivation but marginal for cacao. Rainfall is in excess of 1300 mm. per year, with a moderate dry season from June to September. There are frequent cool, southerly winds between May and August.

Agricultural and Animal Production Potentials: Only those soils on relatively gentle more stable slopes might be cultivated, and preferably only for tree crop production. Such probably represents less than 30 percent of the total land surface.

Soil Type #20 -- Chaparral

Area: 45,000 Hectares

General Topography: Low, semi-swamp areas

Characteristics of Agricultural Importance, Including Climate: These soils are partly covered with flood waters for 4 to 6 months of the year.

Agriculture and Animal Production Potentials: There is the possibility of the cultivation of water-resistant pasture plants that might be used for dry season grazing.

Soil Type #21 -- Piray

Area: 397,000 Hectares

General Topography: Nearly flat, but gently undulating in areas subject to wind blow.

Characteristics of Agricultural Importance, Including Climate: While the predominant soils are poor, there are considerable areas of heavier soils, which with adequate fertilization might sustain arable cropping for some time. Rainfall in the region is in excess of 120 mm., and falls mainly during the warm summer months of November to April. The area is exposed to frequent cool southerly winds during the months of May to August, although the effect of such is not as severe as in the case of the Northern Chaco.

Agricultural and Animal Production Potentials: The region is the most developed agricultural region in Bolivia. Sugar cane is the principal crop. The marked drop of yield in sugar is a reflection of a number of agronomic factors including fertility. It appears that a more intensive study of this region is warranted to indicate the more suitable areas for sugar cane production and to find ways of improving cane yields either through fertilization and/or rotation. Alternative uses for the poorer land might profitably be investigated, with perhaps special emphasis on improving pastures for more intensive animal production, e.g., fattening cattle, dairying, etc.

<u>Soil Type #22 -- Central Rio Grande</u>

Area: 559,000 Hectares

General Topography: Nearly flat.

Characteristics of Agricultural Importance, Including Climate: There are extensive areas of well-drained, arable soils. Rainfall throughout the region is probably less than 1200 mm. The dry season is quite well-marked between the months of June to September. Cool southerly winds are commom between May and August.

Agriculture and Animal Production Potentials: Rice and maize can be produced successfully on a "small scale" farming basis, as evidenced by the success of the Okinawan colonists located on a part of the region. There appears to be sound prospects for the cultivation of soil-seed crops such as soya beans. Improved pastures should do well.

<u>Soil Type #23 -- Northern Rio Grande</u>

Area: 190,000 Hectares

General Topography: Nearly flat.

Characteristics of Agricultural Importance, Including Climate: There are considerable areas of well-drained, arable soils not subject to wet season water-logging. Rainfall in the region is in excess of 1300 mm. The dry season is not too severe. Cool southerly winds are common between May and August.

Agriculture and Animal Production Potentials: Small-scale arable farming, including rice, maize, oil seed and fibre production, might be suggested for extensive areas of the younger alluviums. The possibility of planting improved pastures on the older soils might be profitably investigated.

Soil Type #26 -- Portachuelo Pampas

Area: 51,000 Hectares

General Topography: Slightly undulating.

Characteristics of Agricultural Importance, Including Climate: The soils remain water-logged for considerable periods of each year. Rainfall is about 1200 mm. per year. The driest months are from July to September. Cool southerly winds are common between May and August.

Agricultural and Animal Production Potentials: Agricultural prospects do not appear to be very good. There may be some scope for the introduction of water-tolerant, improved pasture species, on the soils near Portachuelo.

Soil Type #27 -- Yapacani Palacios

Area: 242,000 Hectares

General Topography: Nearly flat.

Characteristics of Agricultural Importance, including Climate: There is a considerable acreage of arable land in the region, but the soils are only moderately fertile and will tend to lose their fertility fairly quick. Rainfall in the area averages about 1400 mm. per year. The dry season does not appear to be too severe. Cool southerly winds are common between May and August.

Agricultural and Animal Production Potentials: With the exception of the more recent Yapacani alluviums, because of the marginal nature of soil drainage and fertility, possibly only "hardier" crops including fibers, such as kenaf, might be suggested. A careful forest "inventory" of the northern part of the region should be taken to ascertain the value of the forest, especially in view of reputed belts of mahogany occurring in the extreme north.

Soil Type #33 -- Central Hydromorphic Zone

Area: 3,035,000 Hectares

General Topography: Flat and low. Micro-topography of surface often shows evidence of a "hog-wallow" effect.

Characteristics of Agricultural Importance, Including Climate: Over 80 percent of these lands appear to have serious drainage problems. The forest cover obviously plays a very important role in the hydrological control of the Beni Basin. Rainfall ranges from 1400 mm. to an excess of 2500 mm. per year. Cool southerly winds are common between May and August, but are not as severe as in the Santa Cruz region.

Agricultural and Animal Production Potentials: Immediate development prospects do not appear promising. A percentage of these lands may eventually be used for the cultivation of water-tolerant crops. However, careful investigations should be carried out, especially hydrological and ecological investigations, before any project of any scale to remove these forests is initiated.

Only five of the ten areas (2, 21, 22, 23, and 27) have significant potential for the production of sugar cane. Of these five areas (Figure 6), area 21 (397,000 hectares) seems the best suited for the production of sugar cane. This region, however, is the most developed area in Bolivia and because of the extensive development, soil fertility is a problem. Within area 21, the land from Montero northward still retains much of its natural fertility and is best suited physically for the production of cane. This is the area to which cane production, displaced in the southern region, has now been shifted.

Appendix C

USAID Study Team Budgets for Sugar Cane Production

Table C1. Sugar Cane - Per Hectare Costs, Revenues and Profits--Without Irrigation and Without Fertilizer

Practices	Plantation each 5 Year/Hectare	Annual $b. Hectare
Fixed Costs		
(1) Land Preparation	$b. 450.	$b. 134.
(2) Seed: 6 tons at $b.94.	564.	168.
(3) Planting: with tractor 2 hrs.	100.	30.
manual (10 men)	150.	45.
(4) Replanting: 7 men	100.	30.
Total Fixed Cost ---------------- (Amortized for 5 yrs. at 15%)	$b.1.364.	$b. 407.
Variable Costs		
(5) Cultivation with tractor, 2hrs. @ $b.50. (3 times)		$b. 300.
(6) Cleaning: 7 men (3 times) at $b.70.		210.
(7) Harvesting: $b.15./ton		525.
(8) Transportation: $b.25./ton at 35 ton/ha		875.
(9) Maintenance of field roads		20.
(10) Depreciation: tools, sheds, etc.		19.
(11) Repairs: tools, sheds, etc.		12.
Total Variable Costs ------------		$b.1.961.
(12) Interest on operating capital (1/2 total variable costs for 6 months at 15%)		74.
Total Annual Cost ---------------		$b.2.442.
Total Revenue: $b.90./ton at 35 tons/ha		$b.3.150.
Annual Returns to Land, Family Labor & Management		$b. 708.

Table C2. Sugar Cane - Per Hectare Costs, Revenues and Profits--With Irrigation and Without Fertilizer

Practices	Plantation each 5 Year/Hectare	Annual $b. Hectare
Fixed Costs		
(1) Land Preparation	$b. 450.	$b. 134.
(2) Seed: 6 tons @ $b.94. ea	564.	168.
(3) Planting: with tractor 2 hrs	100.	30.
Manual (10 men)	150.	45.
(4) Replanting: 7 men	100.	30.
Total Fixed Costs --------------- (Amortized for 5 years at 15%)	$b.1.364.	$b. 407.
Variable Costs		
(5) Cultivation with tractor 2 hrs @ $b.50. (3 times)		$b. 300.
(6) Cleaning: 7 men (3 times) $b.10. ea		210.
(7) Harvesting: $b.15./ton @ 85 ton/ha		1.275.
(8) Transportation: $b.25./ton at 85 ton/ha		2.125.
(9) Maintenance of Field Roads		20.
(10) Depreciation: tools, sheds, etc.		19.
(11) Repairs: tools, sheds, etc.		12.
Total Variable Costs -----------		$b.3.961.
Interest on operating capital (1/2 total variable costs for 6 months at 15%)		149.
Total Annual Cost --------------		$b.4.517.
Total Revenue: $b.90. ton at 85 tons/ha		$b.7.650.
(13) Gross Annual Return to Water, Land, Family Labor and Management		$b.3.133.

Table C2. Continued

Practices	Plantation each 5 Year/Hectare	Annual $b. Hectare
(14) Annual Irrigation Costs--		
Sprinkler from well	$b.2.505.	$b. 628.
Surface from well	2.470.	663.
Sprinkler from river	1.630.	1.503.
Surface from river	675.	2.458.

Table C3. Sugar Cane - Per Hectare Costs, Revenues and Profits--With Irrigation and Fertilizer

Practices	Plantation each 5 Years/Hectare	Annual $b. Hectare
Fixed Costs		
(1) Preparation of land	$b. 450.	$b. 134.
(2) Seed: 6 tons @ $b.94. ea	564.	168.
(3) Planting: with tractor 2 hrs	100	30.
manual (10 men)	150	45.
(4) Replanting: 7 men	100.	30.
Total Fixed Cost ---------------- (Amortized for 5 years @ 15%)	$b.1.364.	$b. 407.
Variable Costs		
(5) Cultivation with tractor 2 hrs @ $b.50. (3 times)		$b. 300.
(6) Cleaning: 7 men (3 times) $b.70. each		210.
(7) Harvesting: $b.15./ton at 120 tons		1.800.
(8) Fertilizer: 8 bags @ $b.60./bag		480.
(9) Maintenance of Field Roads		20.
(10) Depreciation: tools, sheds, etc.		19.
(11) Repairs; tools, sheds, etc.		12.
(12) Transportation to Plant: $b.25./ton @ 120 tons		3.000.
Total Variable Cost -------------		$b.5.741.
(13) Interest on operating capital (1/2 total variable cost for 6 months @ 15%)		215.
Total Annual Cost ---------------		$b.6.363.
Total Revenue: $b.90./ton @ 120 ton/hectare		$b.10.800.

Table C3. Continued

Practices	Plantation each 5 Years/Hectare	Annual $b. Hectare
(14) Gross Annual Returns to Water, Land, Family Labor & Management		$b.4.437.
(15) Annual Irrigation Costs--		
Sprinkler from well	$b.2.505.	1.932.
Surface from well	2.470.	1.967.
Sprinkler from river	1.630.	2.807.
Surface from river	675.	3.762.

Appendix D

Sugar Cane Budgets Prepared by Carlos Castro

Table D1. Evaluation of One Hectare of Forested Land, Within a 15 Kilometer Radius of Guabira'

The value of 1 hectare of land in this zone is $b1,500.

The investment required for 1 hectare of sugar cane grown on cleared land.

1st Stage

Manual forest removal @ $b450/ha	$b 450.
Leveling	50.
Burning	50.
Seed: 5 tons @ $b60/ton	300.
	100.
Planting	100.
Furrowing	100.
Total Investment for 5 years	$b1,150.

2nd Stage

Two weedings @ $b150 each	$b 300.
Harvesting @ $b16/ton, 60 tons/ha	960.
Transporting @ $b13/ton	780.
Total 1st year expenses	$b2,040.

NOTE: The 5 year investment total of $b1,150 will be pro-rated over the period.

1st Year

Expenses for 1st year	$b2,040.
Social Benefits for Workers	200.
Pro-rated fixed investment	230.
Total Investment	$b2,470.
For 60 tons @ $b65/ton	$b3,900.
Total Cost	2,470.
Return	$b1,430.

Table D1. Continued

NOTE: The expenses for the 2nd year will be the same as for the 1st year because yields are the same.

1st and 2nd Year Cost/Ton

Weeding	\$b 300.
Pro-rated fixed investment	230.
Total Investment	\$b 530.

$\frac{\$b530}{60}$ = \$b8.83/ton ready to be harvested

Cane ready to be harvested	\$b 8.83/ton
Harvesting and transporting	29.00/ton
Total Cost at Mill	\$b 37.83/ton
Average price paid for cane at the mill	\$b 65.00/ton
Less costs for cane	37.83/ton
Return	\$b 27.17/ton
Pre-harvest interest costs	\$b 1.20
Net return per ton	\$b 25.97

Percentage of price paid at mill returned to the producer for the 1st and 2nd year = 40%

3rd Year

Average yield = 50 tons/ha.

Two weedings @ \$b150 each	\$b 300.
Harvesting @ \$b16/ton, 50 tons/ha.	800.
Transporting @ \$b13/ton	650.
Total 3rd Year Expenses	\$b1,750.
Expenses for 3rd Year	\$b1,750.
Social Benefits for Workers	200.
Pro-rated fixed investment	230.
Total Investment	\$b2,180.

Table D1. Continued

50 tons/ha @ $b65/ton	$b3,250.
Total Cost	2,180.
Return	$b1,070.
Cost Per Ton	
Weeding	$b 300.
Pro-rated fixed investment	230.
Total Investment	$b 530.
$\frac{\$b530}{50\ \text{ton}}$ = $b10.60/ton ready to be harvested	
Cane ready to be harvested	$b 10.60/ton
Harvesting and transporting	29.00/ton
Total Cost at Mill	$b 39.60/ton
Average price at mill	$b 65.00/ton
Less costs for cane	39.60/ton
Return	$b 25.40/ton
Pre-harvest interest costs	1.20
Net return per ton	$b 24.20
Percentage of price paid at mill returned to the producer for the 3rd year = 37.2%	
4th Year	
Average yield = 45 tons/ha.	
Two weedings @ $b150 each	$b 300.
Harvesting @ $b16/ton, 45 tons/ha.	720.
Transporting @ $b13/ton	585.
Total 4th Year Expenses	$b1,605.
Expenses for 4th Year	$b1,605.
Social Benefits for Workers	200.
Pro-rated fixed investment	230.
Total Investment	$b2,035.

Table D1.. Continued

For 45 tons @ $b65/ton	$b2,925.
Total Cost	$b2,035.
Return	$b 890.
Cost Per Ton	
Weeding	$b 300.
Pro-rated fixed investment	230.
Total Investment	$b 530.
$\frac{\$b530}{45/ton}$ = $b11.78/ton ready to be harvested	
Cane ready to be harvested	$b 11.78/ton
Harvesting and transporting	29.00/ton
Total Cost at Mill	$b 40.78/ton
Average price paid at mill	$b 65.00/ton
Less costs for cane	40.78/ton
Return	$b 24.22/ton
Pre-harvest interest costs	1.20
Net return per ton	$b 23.02
Percentage of price paid at mill returned to the producer for the 4th year = 35.41%	
5th Year	
Average yield = 40 tons/ha.	
Two weedings @ $b150 each	$b 300.
Harvesting @ $b16/ton, 40 tons/ha.	640.
Transporting @ $b13/ton	520.
Total 5th Year Expenses	$b1,460.
Expenses for 5th Year	$b1,460.
Social Benefits for Workers	200.
Pro-rated fixed investment	230.
Total Investment	$b1,890.

Table D1. Continued

For 40 tons @ $b65/ton	$b2,600.
Total Cost	$b1,890.
Return	$b 710.
Cost Per Ton	
Two weedings	$b 300.
Pro-rated fixed investment	230.
Total Investment	$b 530.
$\frac{\$b530}{40 \text{ tons/ha}}$ = $b13.25/ton ready to be harvested	
Cane ready to be harvested	$b 13.25/ton
Harvesting and transporting	29.00/ton
Total Cost at Mill	$b 42.25/ton
Average price paid at mill	$b 65.00/ton
Less costs for cane	42.25/ton
Return	$b 22.75/ton
Pre-harvest interest costs	1.20
Net return per ton	$b 21.55
Percentage of price paid at mill returned to the producer for the 5th year = 33.15%	

Source: Guabira', Cane Office, February, 1971.

Summary of Table D1, Appendix D

Annual cost per hectare delivered at the mill

$b	Yield Tons/Ha.
1 - $b 2,470.	1 - 60
2 - 2,470.	2 - 60
3 - 2,130.	3 - 50
4 - 2,035.	4 - 45
5 - 1,890.	5 - 40
$b11,045. Total	255 Total
Average = $b2,209.	Average = 5/tons/ha.

Gross Return/Ha. $b	Net Return/Ha. $b
1 - $b 3,900.	1 - $b1,430.
2 - 3,900.	2 - 1,430.
3 - 3,250.	3 - 1,070.
4 - 2,925.	4 - 890.
5 - 2,600.	5 - 710.
$b16,575 Total	$b5,530. Total
Average = $b3,315.	Average = $b1,106./ha.

Average deliverd at the mill cost per ton = $b43.31

Average yield per hectare = 51 tons

Average net return per ton = $b21.68

Average price paid at mill = $b65/ton

Average return to investment per ton = 33.35%

Source: Carlos Castro, Cane Manager. Guabira' Mill, 1971.

Table D2. Evaluation of One Hectare of Forested Land, Within a 15 Kilometer Radius of the Guabira' Mill

The value of 1 hectare of land in this zone is $b1,500.

The investment required for 1 hectare of sugar cane grown on plowed land.

1st Stage

Forest removal with D7 tractor	= 12 hrs. @ $b300/hr.	$b3,600.
Plowing	= 4 hrs. @ $b 60/hr.	240.
Harrowing	= 2 hrs. @ $b 60/hr.	120.
Pre-seeding land preparation	= 1 1/2 hrs. @ $b60/hr.	90.
Seed	= 7 tons @ $b 60/ton	420.
Hand Seeding		90.
Seed-covering by machine		30.
Total Investment for 5 years (pro-rated)		$b4,590.

2nd Stage

1 machine cultivation	= 2 hrs. @ $b60/hr.	$b 120.
2 manual weedings between furrows	@ $b60/hr.	120.
Average harvesting cost	= $b16/ton @ 70 ton/ha	1,120.
Transportation cost	= $b13/ton @ 70 ton/ha	910.
Total 1st Year Expenses		$b2,270.

1st Year

Expenses of the 1st Year	$b2,270.
Social Benefits for Workers	50.
Pro-rated fixed investment	918.
Total Investment	$b3,238.
70 tons/ha. @ $b65/ton	$b4,550.
Total Investment	3,238
Net Return	$b1,312/ha.

NOTE: The costs for the 1st and 2nd Year will be the same because the yields are equal.

Table D2. Continued

Cost Per Ton

Cultivating and weeding	$b 240.
Pro-rated expense	918.
Total	$b1,158.

$$\frac{\$b1,142}{70\ ton/ha.} = \$b16.54/ton \text{ ready to be harvested}$$

Cane ready to be harvested	$b 16.54/ton
Harvesting and transporting	29.00/ton
Total Cost at the Mill	$b 45.54/ton
Average price paid for cane at the mill	$b 65.00/ton
Less costs for cane	45.54/ton
Return	$b 19.46/ton
Interest on pre-harvest loans	1.20
Net return per ton	$b 18.26

Percentage of price paid at mill returned to producer for 1st and 2nd year = 28.1%

3rd Year

Average production = 55 tons/ha.

1 machine cultivation	= 2 hrs. @ $b60/hr.	$b 120.
2 manual weedings between furrows @ $b60/ha.		120.
Harvesting	= $b16/ton @ 55 ton/ha.	880.
Transporting	@ $b13/ton	715.
Total 3rd Year Expenses		$b1,835.
Expenses of the 3rd Year		$b1,835.
Social Benefits for Workers		50.
Pro-rated Fixed Investment		918.
Total Investment		$b2,803.

Cost Per Ton

Cultivating and Weeding	$b 240.
Pro-rated expense	918.
Total	$b1,158

Table D2. Continued

$$\frac{\$b1,158}{55\ tons} = \$b21.05/ton \text{ ready to be harvested}$$

Cane ready to be harvested	$b 21.05/ton
Harvesting and transporting	29.00/ton
Total Cost at the Mill	$b 50.05/ton
Average price paid for cane at the mill	$b 65.00/ton
Less costs for cane	50.05/ton
Return	$b 14.95/ton
Interest on pre-harvest loans	1.20
Net return per ton	$b 13.75

Percentage of price paid at mill returned to producer for 3rd Year = 21.15%

4th Year

Average production = 45 tons/ha.

1 machine cultivation	= 2 hrs. @ $b60/hr.	$b 120.
2 manual weedings between furrows @ $b60/ha.		120.
Harvesting	= $b16/ton @ 45 tons/ha.	720.
Transporting	@ $b13/ton	585.
Total 4th Year Expenses		$b1,545.

Expenses of the 4th Year	$b1,545.
Social Benefits for Workers	50.
Pro-rated fixed investment	918.
Total Investment	$b2,513.

Cost Per Ton

Cultivating and Weeding	$b 240.
Pro-rated expenses	918.
Total	$b1,158.

$$\frac{\$b1,158}{45\ tons} = \$b25.73/ton \text{ ready to be harvested}$$

Table D2 . Continued

Cane ready to be harvested	$b	25.73/ton
Harvesting and transporting		29.00/ton
Total Cost at Mill	$b	54.73/ton
Average price paid for cane at mill	$b	65.00/ton
Less costs for cane		54.73/ton
Return	$b	10.27/ton
Interest on pre-harvest loans		1.20
Net return per ton	$b	9.07

Percentage of price paid at mill returned to producer for 4th Year = 13.95%

5th Year

Average production = 40 tons/ha.

1 machine cultivation	= 2hrs. @ $b60/hr.	$b 120.
2 manual weedings between furrows	@ $b60/hr.	120.
Harvesting	@ $b16/ton, 40 ton/ha.	640.
Transporting	@ $b13/ton	520.
Total 5th Year Expenses		$b1,400.

Expenses of the 5th Year	$b1,400.
Social Benefits for Workers	50.
Pro-rated fixed investment	918.
Total Investment	$b2,368.

Cost Per Ton

Cultivating and Weeding	$b 240.
Pro-rated expenses	918.
Total	$b1,158.

$$\frac{\$b1,158}{40 \text{ tons}} = \$b28.95/\text{ton ready to be harvested}$$

Cane ready to be harvested	$b	28.95/ton
Harvesting and transporting		29.00/ton
Total Cost at Mill	$b	57.95/ton

Table D2 . Continued

Average price paid for cane at mill	$b	65.00/ton
Less Costs for cane		57.95/ton
Return	$b	7.05/ton
Interest on pre-harvest loans		1.20
Net return per ton	$b	5.85

Percentage of price paid at mill returned to the producer for the 5th Year = 9.00%

Source: Ingenio Guabira', February, 1971.

Summary of Table D2, Appendix D

Annual cost per hectare delivered at the mill

$b	Yield/Ha. Tons
1 - $b 3,222.	1 - 70
2 - 3,222.	2 - 70
3 - 2,787.	3 - 55
4 - 2,497.	4 - 45
5 - 2,352.	5 - 40
$b14,080. Total Average = $b2,816.	280 Total Average = 56 tons/ha.

Gross Return/Ha. $b	Net Return/Ha. $b
1 - $b 4,550.	1 - $b1,328.
2 - 4,550.	2 - 1,328.
3 - 3,575.	3 - 788.
4 - 2,925.	4 - 428.
5 - 2,600.	5 - 248.
$b18,200. Total Average = $b3,640.	$b4,120. Total Average = $b824.

Average delivered at the mill cost per ton = $b50.29.

Average yield per hectare = 56 tons.

Average net return per ton = $b14.71

Average price paid at mill = $b65./ton.

Average net return to investment per ton = 22.63%

Source: Carlos Castro, Cane Manager, Guabira' Mill, 1971.