

Development of Minimum Cost, Incentive Based Plan for the Implementation of a Technology Standard for Coffee Processing in Honduras

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Robert Hearne, *North Dakota State University*

Bruno Barbier, *CIRAD*

Jose Manuel Gonzalez, *Turrialba, Costa Rica*

Coffee Production In Honduras

- Honduras' Most Important Export Crop
 - ◆ 250,000 hectares cultivated
 - ◆ 85,000 separate plots
 - ◆ 92% small-scale producers < 7 ha.
 - ◆ hillside terrain between 700 and 1500 masl.
 - ◆ 85% with shade trees

Coffee Production In Honduras

- Shade Grown Coffee
 - ◆ considered to be environmentally
 - ★ less chemical inputs
 - ★ soil erosion
 - ★ bird habitat
 - ★ fruits, firewood, and lumber
 - ★ carbon sequestration
 - ◆ can capture premium price
- (Kotchen et al. 2000)

Coffee Processing In Honduras

- de-pulping and drying by farmer
 - water intensive
 - highly polluting
- decentralized processing reduces
 - quality
 - quality control, and
 - prices

Coffee Processing and Water Quality

- Consumes 40 liters of water/ kilo of processed coffee
 - ◆ during dry season
 - ◆ during harvest with migrant workers
- Waste Products
 - ◆ over 272,000 metric tons of pulp
 - ◆ over 136,000 metric tons of mucilage
 - ◆ dumped into upper waterways
 - ◆ without control or treatment

Coffee Processing and Water Quality

Causes

eutrofication

strong odors

loss of plant and fish life

increased mosquitoes and flies

Coffee Processing and Water Quality

■ Table 1: Quality of Water from Different Sources

– Source SERNA 1995

Parameter	Potable Water	Untreated Wastewater	Coffee Processing Discharges
pH	7	6.5	3.7
ChOD mg/lt	2	500	15000
BOD mg/lt	2	250	9000
Soluble Solids mg/lt	0	500	3600
Total Solids mg/lt	500	800	12000

Coffee Processing and Product Quality

- Wet processing consists of separating pulp and mucilage from the bean, with water.
- Wet processing produces a mild-tasting *arabica* coffee.
- In Honduras, small-scale processing implies inadequate fermentation and washing. This implies poor quality, non-existent quality control, and reduced prices.
- Because of quality and quality control, Honduran coffee receives a \$12.00 discount/penalty in international prices.

Objective of Research

In this research a minimum-cost system of centralized coffee processing plants is proposed in order to:

1. Reduce water use and improve water quality;
2. Improve quality of processed coffee; and
3. Improve export prices.

Furthermore the price premium required to make centralized coffee processing pareto superior to *status quo* will be estimated.

Linear Programming Model

■ **Min**
$$\sum_{i,f,p,r} (cf_i + cv_i + \sum_{p,f} ctw \text{ dist}_{f,p,r} + \sum_{p,e} ctd \text{ dist}_{p,e,r}) X_{i,p,r}$$

■ **With**

cf_i = Fixed cost for each plant of type i ;

ctw = Transport cost per km per quintal of wet bean;

ctd = Transport cost per quintal per kilometer of dry bean;

cv_i = Variable cost for each type of plant;

$dist_{f,p,r}$ = Distance from the field to the plant in kilometers; y

$dist_{p,e,r}$ = Distance from the plant to the buyer in kilometer.

Subject to the following restrictions:

$$\sum_f prod_{f,r} \leq \sum_{i,p} pros_i X_{i,p,r}$$

in each river section the sum of coffee produced during the peak period is less than the processing capacity of the river segment

$$\sum dist_{f,p} X_{i,p,r} \leq 25$$

The distance between each coffee field and its corresponding plant is less than 25 kilometers.

$$\sum_{i,p} wat_i X_{i,p,r} < WATER_r$$

Total water consumed by the processing plants in each river segment is less than water available in each segment

$$\sum_{i,p,r} inv_i X_{i,p,r} \leq Inv$$

Total investment is less than a predetermined maximum (in some simulations)

$$\sum_{i,p} cont_i X_{i,p,r} \leq Contm WATER_r$$

The sum of effluents rejected by all plants is less than a predetermined maximum per cubic meter of water (in some simulations)

Data and Estimation Parameters

IHCAFE has excellent data for this study.

- Producer census, with location and output
- Analyses of coffee processing
- Crop Budget and Expected Returns

A recent study in Rio Frío watershed presents

- Stream flow
- Water Quality

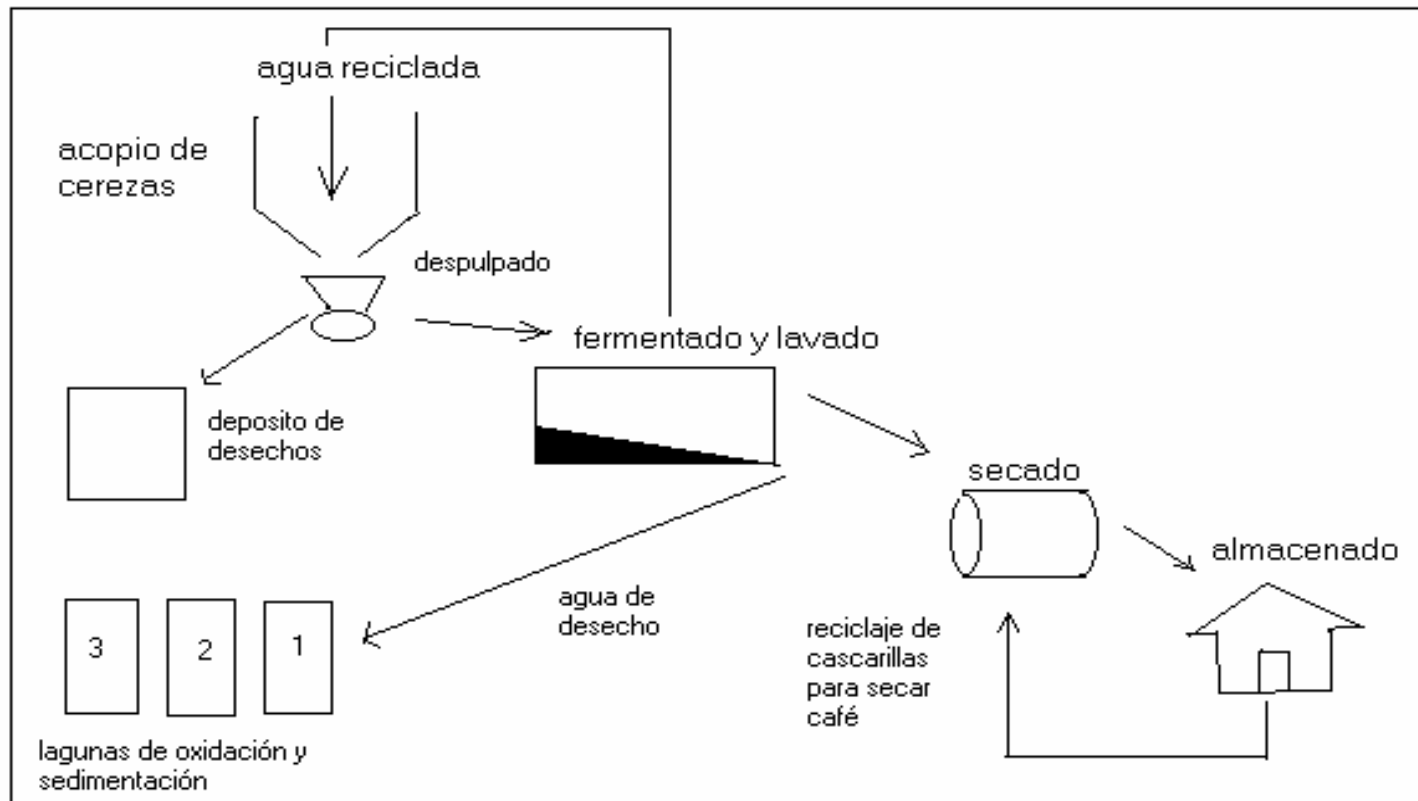
Digitalized maps were available for distances

Primary data consisted mainly of validating distances and updating prices

Environmental Regulation Through Technology and Environment Standards

- The Honduran Coffee Institute, (IHCAFE) has proposed five alternative technologies for coffee processing
- Technology standards are a common form of environmental regulation
- In the USA technology based emissions standards are often employed, i.e. catalytic converters
- Environment standards regulate total effluent in each river section

- Figure 1: Process of Clean Coffee Processing



- Table 2: Description of Processing Plants Proposed by IHCAFE

Plant Model	Fixed Cost \$/sack <small>10 year loan 28%</small>	Effluents kg/sack/year	Variable Cost \$/46Kg sack	Capacity in 46 Kilo sacks	Water use, lt/sack
1	21.88	171	3.18	25	507
2	12.31	171	3.18	100	501
3	10.94	171	2.34	500	300
4	12.31	151	0.99	1000	300
5	14.23	151	0.62	5000	300

Table3: Production, Processing, and Transport Costs

Activity \ model	M1	M2	M3	M4	M5
Harvest	11.49	11.49	11.49	11.49	11.49
Within Farm Transport/ km	0.62	0.62	0.62	0.62	0.62
Transport to Plant/km	0.05	0.05	0.05	0.05	0.05
Transport to Exporter/Km	0.04	0.04	0.04	0.04	0.04
De-pulping	0.20	0.23	0.13	0.23	0.15
Washing	0.79	0.79	0.58	0	0
Recycling	0	0	0.84	0.17	0.03
Drying	0.90	0.82	0.78	0.58	0.43
Sub total for Processing	3.18	3.18	2.34	0.99	0.62

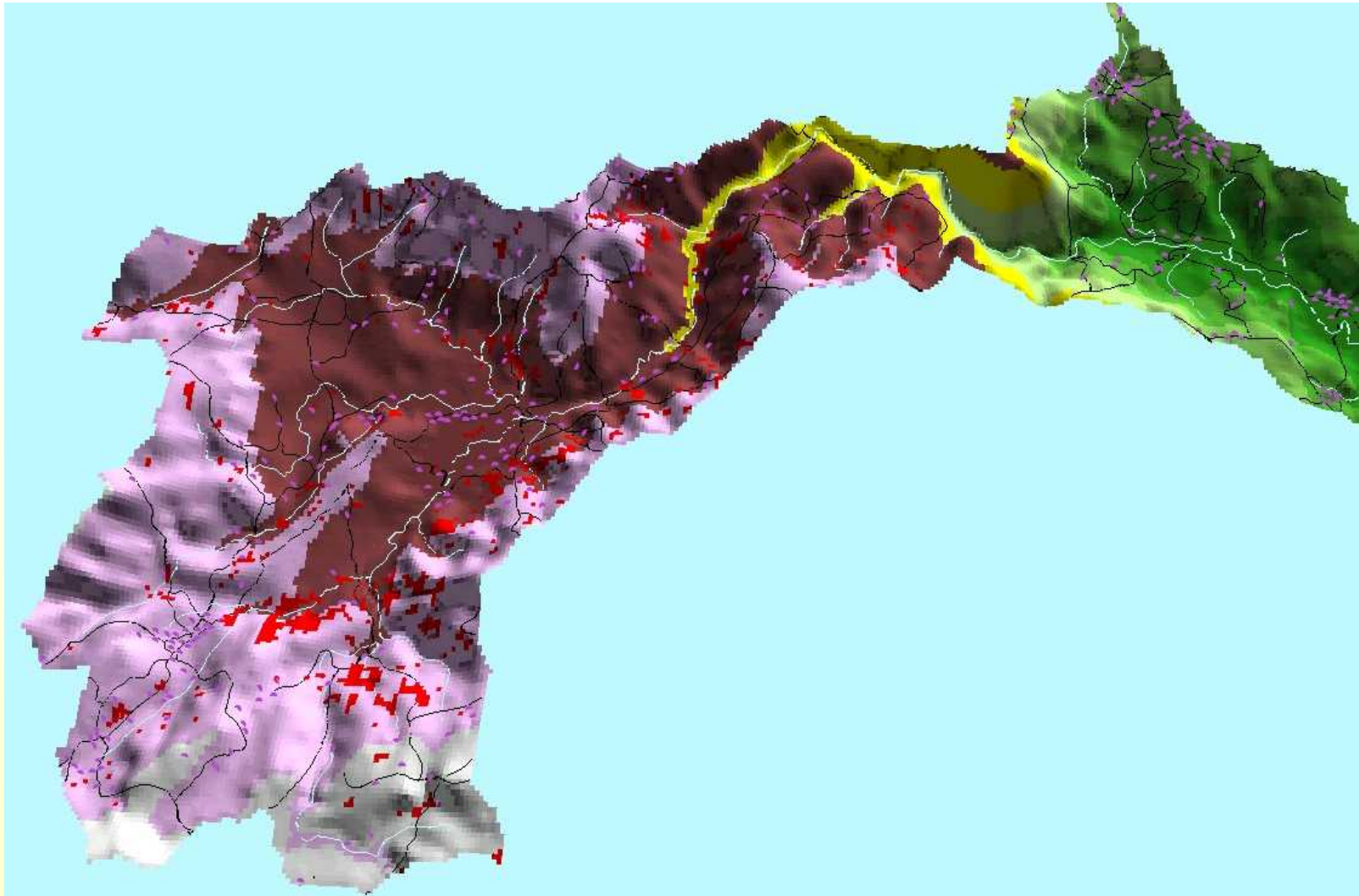
Study Area

The *Río Frio* watershed

in mountainous western Honduras
covers an area of 86 Km² between 550 and 1600 masl
annual rainfall between 2300 a 2700 mm
an average of 120 a 160 days of rainfall
topography is mountainous with slopes of 40 to 50%
these are good conditions for coffee production

Coffee represents the main activity of the watershed
around 1137 families produce coffee
569 families reside all year round
coffee area is 2527 hectares

Figure 2: A digitalized map of the watershed



Estimation of Capacity Requirements

Coffee processing needs to begin within five hours of harvest.

For this reason there is a 25 kilometer maximum distance between field and plant.

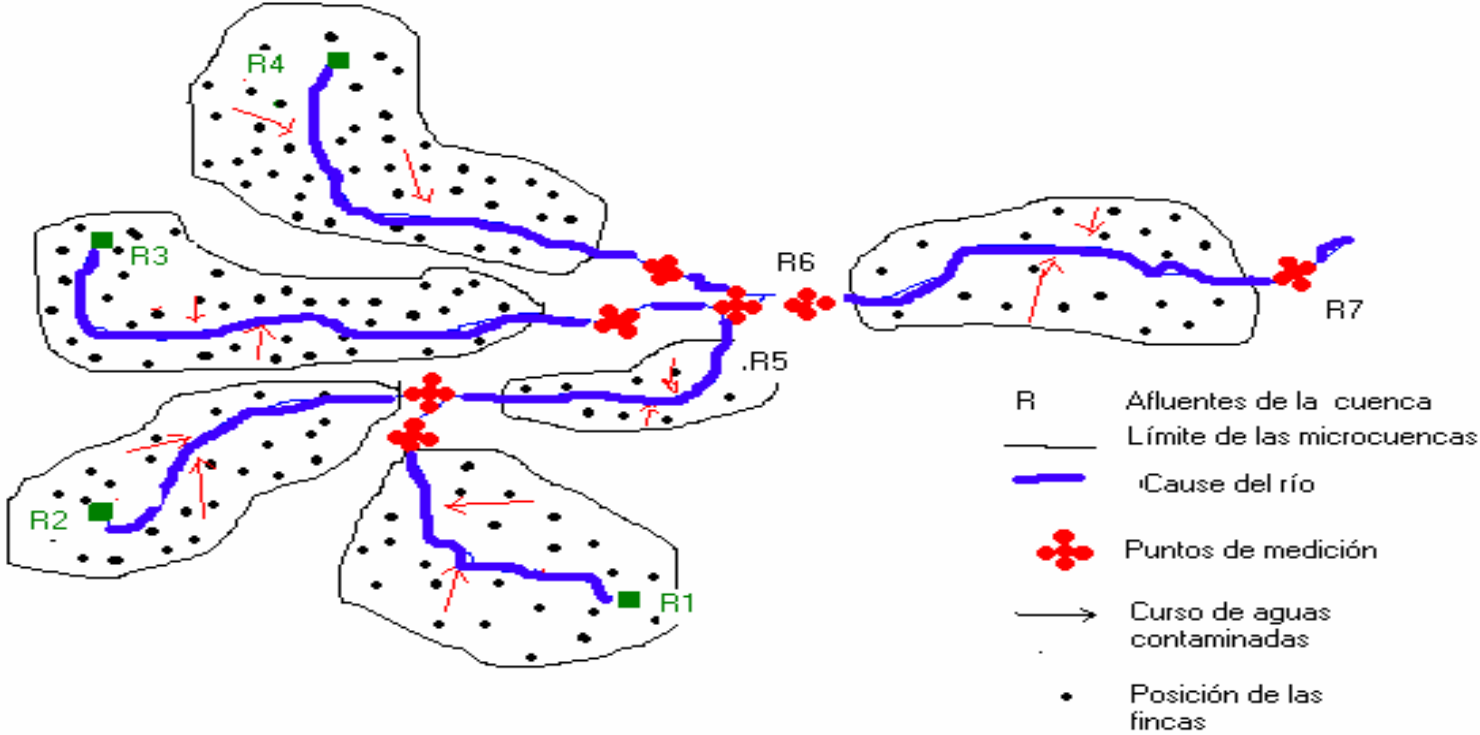
Also processing capacity needs to meet the harvest of the peak harvest day.

Currently in this zone 70% of harvest occurs within a 30 day period.

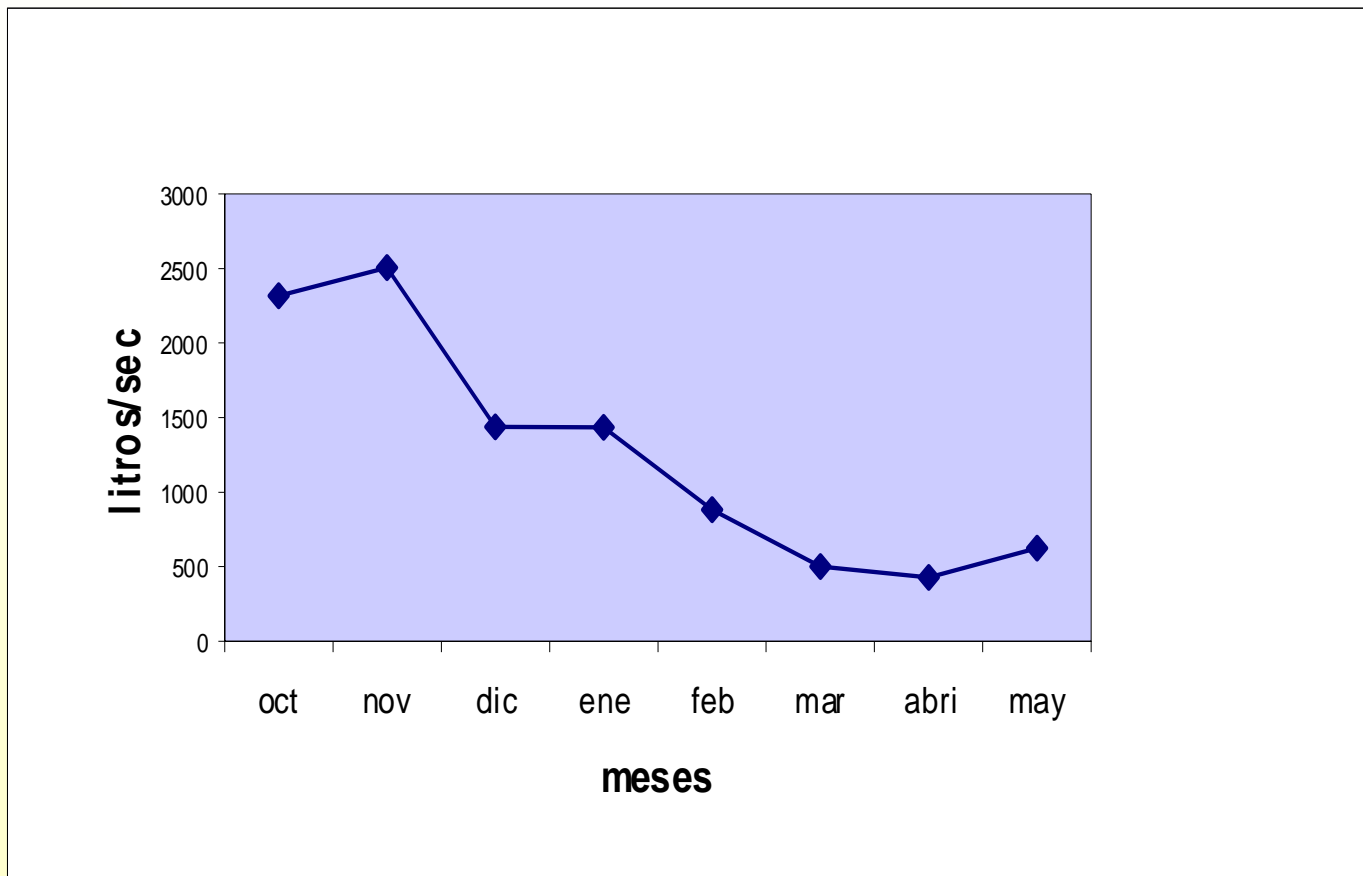
During this period migrant labor is available.

All harvest inputs are fully employed during this period.

Figure 3: Analysis do Water Flows



**Figure 4: Daily water availability in the Río Frío
from October 1997 to May 1998.**



Data Analysis with GAMS

```
$Title A Transportation Problem  
$Offupper
```

```
$Ontext
```

This problem finds a least cost shipping schedule that meets
este problema trata de minimizar el costo de transporte de cafe
a fin de suplir a los beneficios de cafe la demanda de cafe cereza
para procesarlo
requirements at markets and supplies at factories

References:

Dantzig, G B., Linear Programming and Extensions
Princeton University Press, Princeton, New Jersey, 1963,
Chapter 3-3.

This formulation is described in detail in Chapter 2
(by Richard E. Rosenthal) of GAMS: A Users' Guide.
(A Brooke, D Kendrick and A Meeraus, The Scientific Press,
Redwood City, California, 1988.)

The line numbers will not match those in the book because of
these comments.

```
$Offtext
```

```
option NLP = conopt ;
```

```
Sets
```

```
f  fincas de aldeas / f1 * f17 /
```

```
b  beneficio      / b1 * b7 /
```

```
m  modelo de beneficio / m1, m2, m3, m4, m5 /
```

```
r  rios / r1 * r7 /
```

```
Parameters
```

```
invest(m) inversion total por modelo fkdsfjdk
```

```
/ m1 0.008
```

```
m2 0.016
```

```
m3 0.180
```

Figure 5: Proposed Processing Plants

After consulting with local growers and IHCAFE extortionists, plant locations selected for consideration due to availability of water and transport

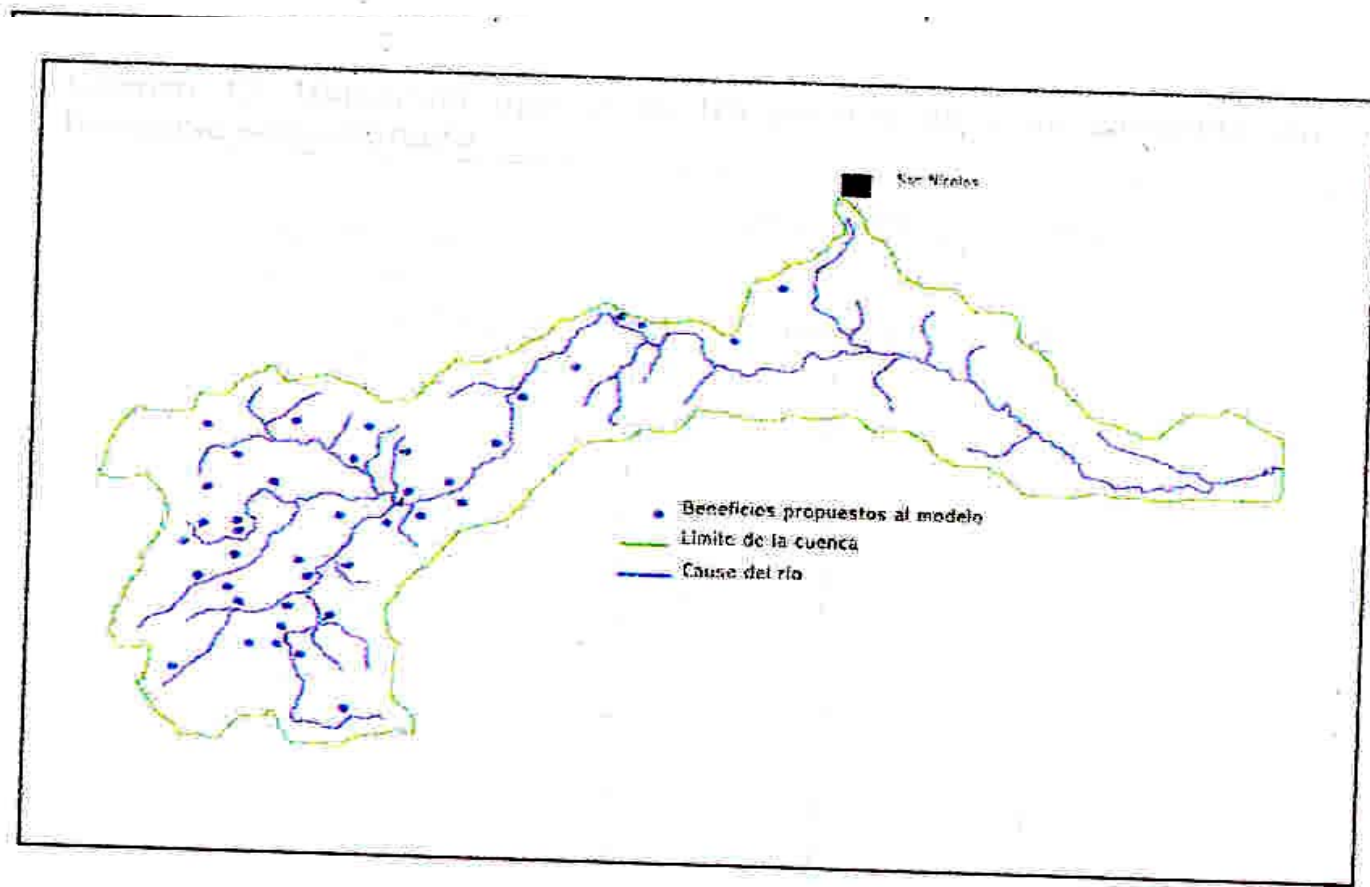


Figure 6: Optimal Number, Size, and Location of Processing Plants

Type 2 Plants	7	Total capacity	40,700 sacks
Type 5 Plants	8	Total Investment	\$667,000
		Effluent Reduction	70%

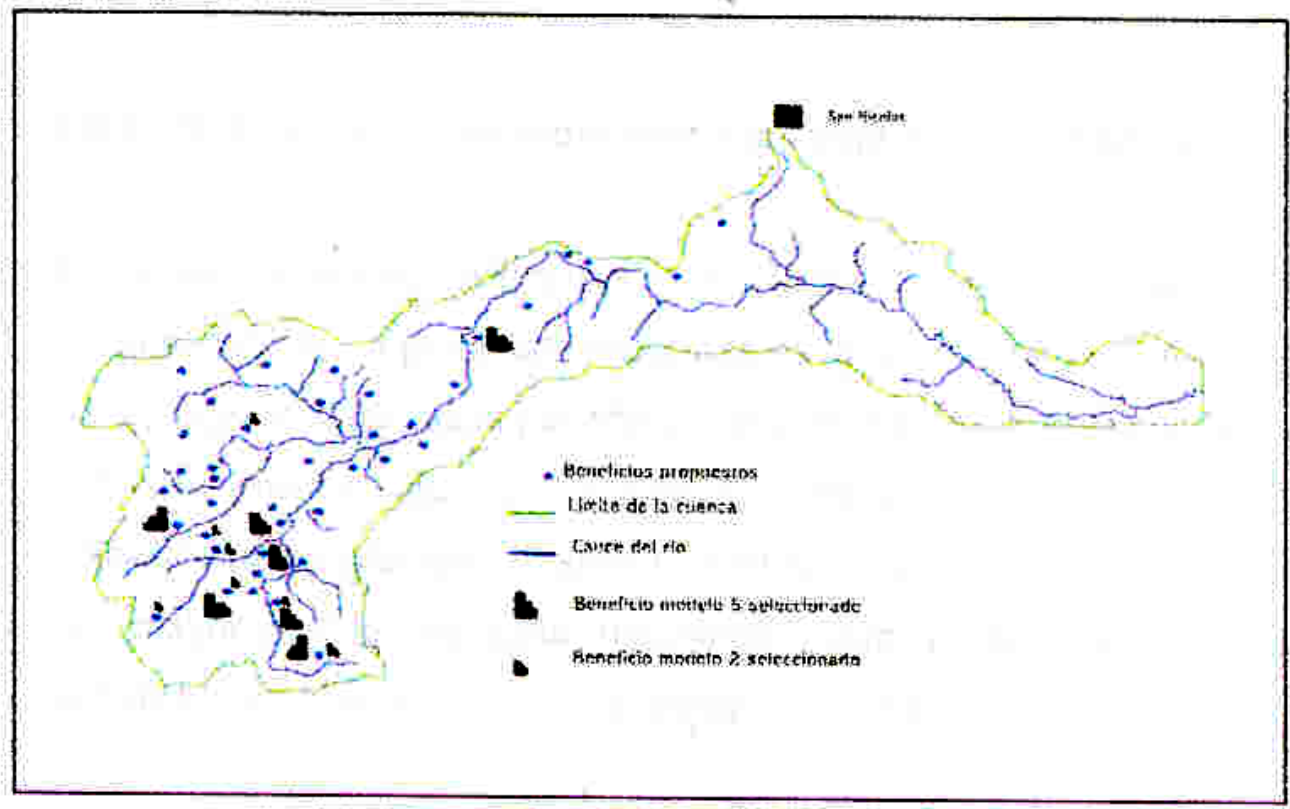


Figure 7: Optimal Number, Size, and Location of Processing Plants with Reduced Initial Investment

Type 2 Plants	26	Total capacity	32,600 sacks
Type 5 Plants	6	Total Investment	\$534,000
		Effluent Reduction	50%

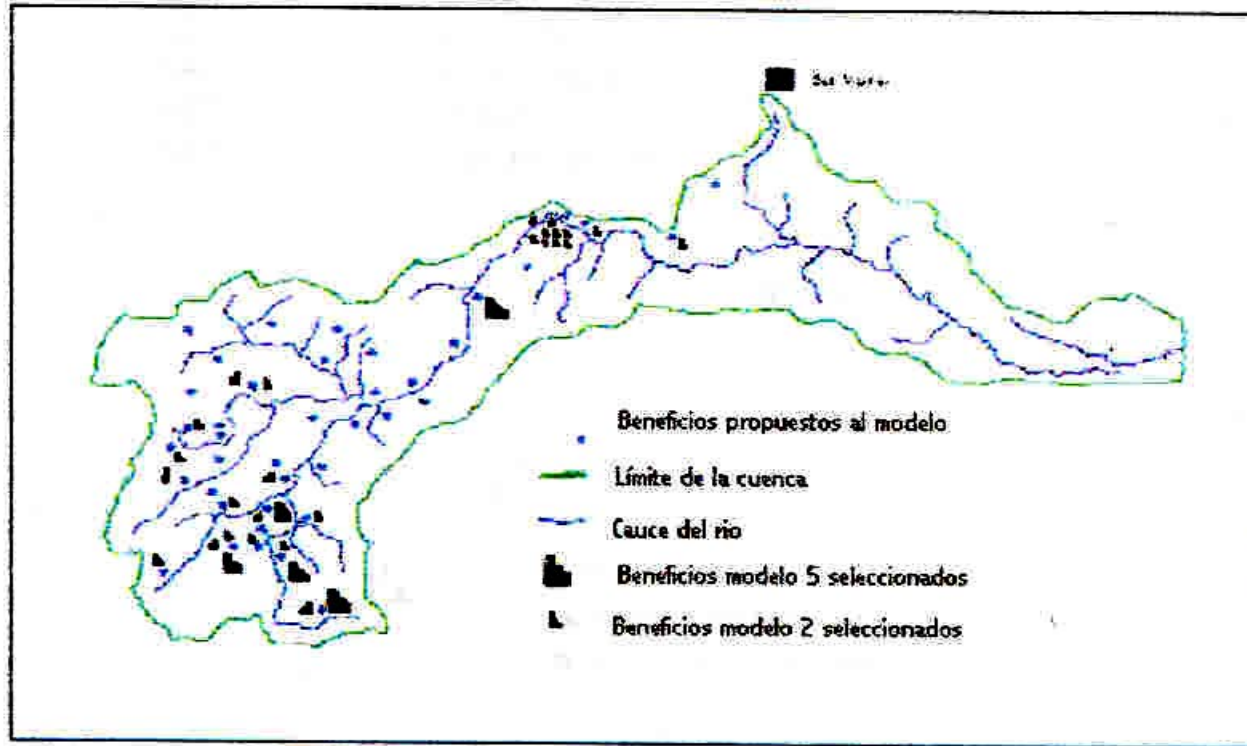
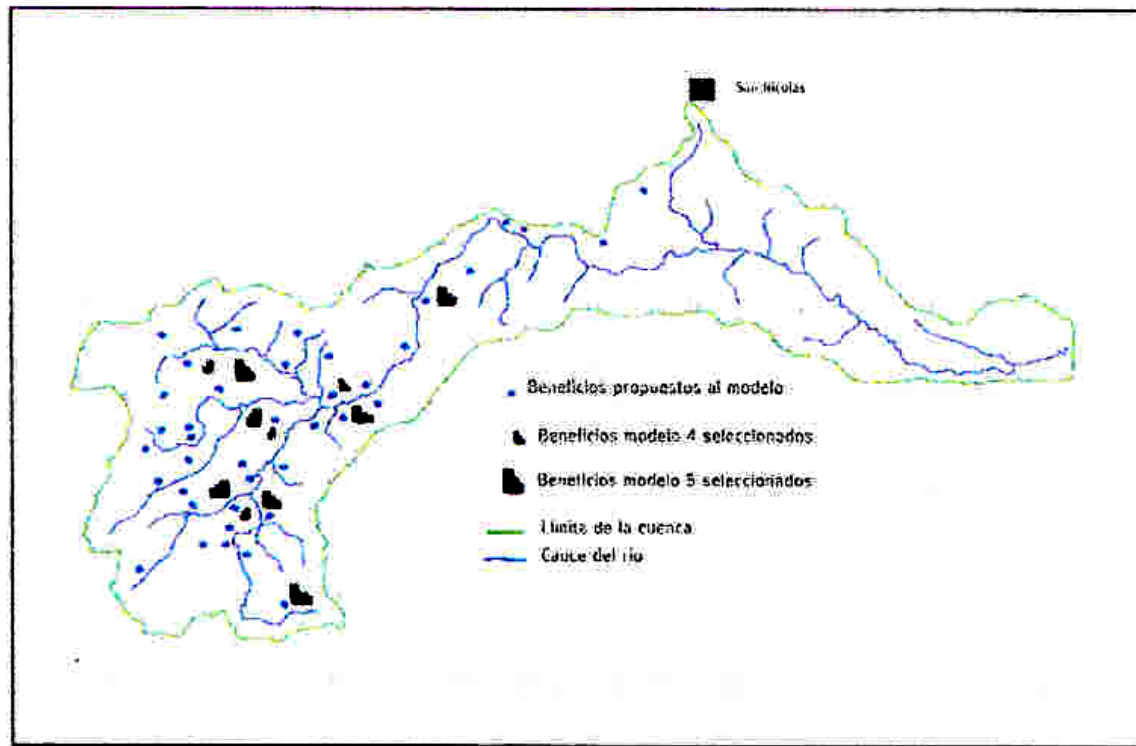


Figure 8: Optimal Number, Size, and Location of Processing Plants with Reduced Water

Type 4 Plants	4	Total capacity	44,000 sacks
Type 5 Plants	8	Effluent Reduction	70%



Financial Analysis of Costs and Necessary Incentives

$$-cv_i Q^\phi = P_f^\gamma Q^\gamma - P_f^\phi Q^\phi$$

In order to ensure the participation of the producer, the farm price of unprocessed beans should be greater than the farm price of processed beans less the variable processing costs.

With

Q^ϕ = 46 Kg sacks of processed coffee;

Q^γ = 46 Kg sacks of unprocessed coffee.

Financial Analysis of Costs and Necessary Incentives

$$P_B^\phi \geq \frac{P_f^\gamma Q^\gamma + CT_{fB}^\gamma + CT_{BD}^\phi + cv_i Q^\phi + cf_i}{Q^\phi} \quad \forall_B \forall_i$$

The price that the exporter/processor receives should be greater or equal to the price paid at the plantation level plus the total transport cost, plus the total cost of processing by type of plant.

■ With

CT_{fB}^γ = Transport cost of unprocessed beans from farm to plants;

CT_{BD}^ϕ = Transport cost of processed beans from plants to depot;

	Item	Formula	\$
a	Current Variable Processing Costs Plant Type 1		16.67
b	Current Harvest Costs		12.11
c	Current International Price		75.00
d	Current Penalty to Honduran Exports		12.00
e	Current Intermediary Cost	c-d-f	6.33
f	Current Farm Price for Processed Beans		56.67
g	Current Returns to Plant and Management	f-a-b	27.89
h	Necessary Farm Price for Unprocessed Beans	g+b	40.00
i	Transport Cost for Unprocessed Beans 25 km		1.25
j	Transport Cost for Processed Beans to Depot		2.80
k	Fixed Cost of Processing Plant Type 2		12.31
l	Variable Cost of Processing Plant Type 2		3.18
m	Necessary Depot Price for Exporter-Processor	h+i+j+k+l	59.54
n	Necessary Export Price	m+e	65.87
o	Necessary Incentive if \$12.00 Penalty Remains	-(c-d-n)	2.87
p	Financial Gain to Sector if Penalty is Avoided	c-n	9.13

Results of Financial Analysis

A Pareto Superior solution was sought and is feasible if penalty is removed.

All farmers maintain their margin, and all processors cover their costs.

If the penalty is not removed a \$2.87/sack incentive is required to improve river water quality, and maintain all current producers.

If penalty is removed, a \$9.13 benefit to the coffee sector is provided through improved quality and quality control.

Conclusions

A new centralized coffee processing system, with environmental controls, is feasible and can be Pareto Superior to current system.

With improved quality control and reduced pollution new plants could achieve financial and environmental improvements.

To minimize the cost of transport and processing within the watershed it would require an investment of \$667,000.

Only Plant Types 2, 4, and 5 are included in the three solutions presented.

Honduras can achieve these results without undermining the current small-farm production.

Observations and Recommendations

This research was conducted under request by IHCAFE.

IHCAFE is interested in establishing centralized processing plants throughout Honduras.

The way centralized processing should be organized has to be determined.

If plant locations are to be determined by a consensus between farmers' organizations and the private sector this optimization tool would assist in making informed decisions.

Further participatory research is needed on the adoption of centralized processing.

Postscript

With greatly expanded production in Vietnam, world coffee prices have plummeted.

International coffee prices are below \$50.00/sack.

In many areas coffee will not be harvested, and processing is not necessary.

IHCAFE has been privatized, and staff have been reduced.

Thank You