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ECONOMIC FEASIBILITY OF EXPANDING  
PERMANENT TREE CROPS ON HILLSIDES

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**ECONOMIC FEASIBILITY OF EXPANDING  
PERMANENT TREE CROPS ON HILLSIDES**

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The views expressed in signed articles are those of the author  
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## ECONOMIC FEASIBILITY OF EXPANDING PERMANENT TREE CROPS ON HILLSIDES

### I. Introduction

Usually, farmers do not have a written farm plan. They do however have a farm plan, but in their minds. For the most part the farmer is guided by what has worked in the past and makes small continuous adjustments in the plan from one season to the other. With this process, farmers allocate their resources -labour, land and capital- given the technology available, their goals and risk considerations.

The typical farm operation has labour, capital and land which can be allocated in many ways to the production of different crops and livestock activities. How farmers decide what to plant and how much is a complicated process, but in general, one is to assume they are rational in their decision making process and efficient in the allocation of their scarce resources.

A farm model was developed to better understand this decision making process. Its first application was used to address and analyze the economic feasibility of small farmers investing in tree crops on the hillsides . The model is a simplified representation of a typical farm in a region.

The first step in developing the farm model was to attempt to reproduce what the farmers do. The model tries to represent the complex manner in which prices, yields and farmers' resources interact to determine the best combination of production activities.

In the development of the farm model one attempts to capture the relationships that prevail among production, investment, borrowing, hiring, buying and selling activities. In a small family farm operation, household consumption needs and decisions affect allocation of resources and production activities. This relation needs to be represented in the model if one tries to analyze small farmers resource allocations rationale.

Reasonable correspondence of the simulated outcome to what actually occurs provides an excellent foundation to structure a model which looks into the future. The model can then be used to analyze different production, price, technology and resource availability situations to provide insight into a variety of relationships. The reliability of the model for projecting different farm scenarios, rests upon how well it does represent reality.

## II. The model

A multi-period 4 year farm model was developed to simulate the path to be followed to move a farming operation from its present situation to a desired one of expanding the area planted with permanent tree crops.

The model represents production activities which supply cash at harvest time, and it demands cash for purchase of inputs and for household cash needs. Production and family consumption requirements compete for available cash. The model includes a constraint that requires that the cash generated by the farm operation, needs to satisfy the basic family cash expenditures first. A fairly safe assumption to be made.

The multi-period model allows transfers of cash between periods representing cash flows closer to the real farm situation. Any surplus of cash in one year is transferred to the next year.

The multi-period model requires that all the production, investment and consumption activities considered in the analysis ought to be included in the model each year. The problem is that the size of the model increases substantially. The analysis was restricted to four years due to the limitation imposed by the computer software available at the moment.

The model was developed and processed using linear programming method. Linear programming is a mathematical optimization technique that with the use of computers have made practical to simulate farm operations under different assumptions.

The method allows to detect the complex manner in which prices, yields, limiting resources and constraints to production interact during critical periods. The solution provides the best combination of activities that can be obtained given the limitations of the resources available. The method allows in a short period of time to test a large number of production alternatives with reference to changing or applying: a) different technologies; b) prices; c) yields; and d) production constraints.

## III. Information used in the model

The model delineates a representative farm for the Districts of Golden Grove, Troja and Riversdale in the Rio Cobre watershed in Saint Catherine. Baseline survey information on 190 farms was used to select the representative farm size and production activities to include in the model.

Figure 1 in the Annex , illustrates the typical land use for the three Districts. Tree crops occupy about 50 percent of the land. Figure 2, shows land tenure in the region, 86 percent of the land is family and owned land. Rented land is about 14 percent. Figure 3, presents information on farm size, 47 percent of the farms have 3 acres of land or less. Figure 4, shows the proportion of farmers farming one parcel or more. Forty three percent of the farmers farm more than one parcel.

The information and assumptions used in the preparation of the model are presented below.

### 1. Production activities

The activities considered in the analysis are:

- a) maintenance and marketing activities of permanent tree crops; and
- b) production and marketing of annual crops common in the region.

There are major distinctions in terms of resource use and income between the two groups (permanent and annual). Maintenance of permanent trees demands less of farmers management time (supervision), labour and working capital; they are not so demanding in terms of correct timing of cultural practices. Income, although not as high as with annual crops, is more stable. Yield and short run price variations are lower and therefore income from tree crops provides a more regular source of cash flow.

The crops included in the model are the following:

#### Permanent

- a) coffee and cocoa inter-planted with bananas and plantain
- b) citrus
- c) sugar cane

#### Annuals

- d) root crops
- e) vegetables

The production activities represent the technology used by the farmers. No pattern of crop rotation seems to



exist in the region, therefore activities showing crop rotation were not included in the model.

One of the assumptions of the model is that cacao and coffee do not compete for the same type of land with citrus, sugar cane and annual crops. The model assumes that annual and permanent crops compete for farmers' labour during the year. Certain farm operations need to be performed at a specific period of time and annual and permanent crops may compete for the available labour during that critical period of time.

Annual crops depend more on the availability of moisture for land preparation and planting. The model assigns a limited period of time for land preparation to plant annual crops twice a year. Labour use for weed control and other cultural practices for permanent and annual crops presents more flexibility.

## 2. The production coefficients

Production coefficients correspond to the crop yields, labour and working capital requirements per acre. Differences in demand for labour and working capital between permanent and annual crops are reflected in the size of the coefficients.

The model assumes a production per acre of 8 boxes each for inter-planted cocoa and coffee and a production of 100 stems for bananas and 50 for plantain.

## 3. Product and input prices

The farm model developed represents early 1991 prices. The level of prices has increased since then, but the assumption is that relative prices remain the same.

Having all prices too high or too low will distort the income estimate of the optimum plan, but if prices are in line one with another then the optimum crop plan and the analysis conducted is still valid.

## 4. Resources

Resources include land, labour and working capital. The model represents a farm with 4 acres of land and assumes that 1 acre is suitable for citrus, sugar cane and annual crops and 3 acres only for tree crops.

The model assumes a total farmer's labour supply of 253 man-days per year available in 4 periods (April, 23 man-days; May-July, 63; August-November, 83; and December-March, 84). The rest of the farmers and family labour is used in livestock and other activities of the farm operation.

In the construction of the model it is assumed that farmers have an initial working capital for the beginning of the first year. This represents cash generated by the production activities of the previous year. Working capital for the rest of the periods included in the analysis is generated within the model by the selling of farm production.

#### IV. Results

A first step in developing the model was to attempt to reproduce what the farmers do in the region. Once the model was processed, the results were checked to see how close the model reflects reality.

Figure 5, presents survey data showing actual land use and main production activities for owned farms. The crop mix corresponds to farms with 3 to 5 acres of land in one parcel.

Farm model results show that given the alternatives included in the analysis the crop combination that maximizes income subject to farm resources constraints includes 50 percent of the land (2 acres) with a combination of cocoa and coffee inter-planted with banana and plantain, 20 percent (8 squares) with vegetables and 5 percent (2 squares of root crops).

There is approximately 25 percent of unused land. Part of this land may be used in livestock activities that were not included in the analysis.

Labour supply was limiting during land preparation for annual crops in April and during the period August-November. The model shows that reductions in labour supply in April and during the August-November period will result in reductions of income of \$180 and \$260 per man-day. There is a surplus of labour in the other periods.

This has important implications for the introduction of new activities that demand labour during the periods that labour is limiting. The farmers will expect substantially higher returns to labour before they adopt the new activities.

Working capital is not a limiting factor in the implementation of the farm plan. Production activities generate enough cash to satisfy basic household and farm operational needs. Given the actual crop mix, technology and level of activity, the farm generates enough cash to maintain that level of production without external financing. The actual production mix and the levels of technology used may be one of the factors that could explain the low demand for credit by small farmers.

The optimization method also provides information on the reduction in income that will occur if one unit of production activity not in the optimum farm plan is included in the farm plan. Citrus and sugar are not included in the optimum plan. This means, that if resources actually allocated to the production of vegetables, root crops and other permanent crops are allocated to the production of citrus and sugar cane, this will result in a loss of income of about \$ 6,000. The decrease in production will result mainly in the production of annual crops.

For the purpose of the analysis on hand, it is considered that the model is a good representation of the farm situation in the region. The results of the analysis show more that the farmers, in general, allocate resources efficiently given the opportunities open to them.

The next step is to simulate what could be the reaction of farmers to the introduction of new production alternatives. Will the new alternatives be attractive enough for the small farmer to adopt them?.

#### Analysis of production alternatives

Assuming that production conditions remain the same in the future, no adjustments in relative price relationships are made to analyze the impact of new production activities introduced in the model.

Two permanent crops activities are included in the analysis:

- a) establishment of cocoa inter-planted with coconut and banana
- b) establishment of low land coffee under natural shade

The model assumes that banana production starts during the second year, cocoa in the third year and coconuts during the fourth year. Production during the fourth year is 12 boxes for cocoa, 400 nuts for coconuts and 240 stems for banana. Coffee production during the fourth year is 70 boxes per acre.

### First alternative

The model assumes that the permanent trees will be planted on the unused land. Labour requirements and working capital required for the establishment and maintenance of the tree crops are included in the model.

### Results

The optimum solution shows that it is not economically feasible to increase the area with permanent tree crops under the conditions presented in the model. Farmers' income will be higher if they continue with the same crop mix and level of activities.

There are no economic incentives to change and the farmers' subsistence level of income would be reduced during the first three to four years. Working capital and labour used in the production of vegetables and root crops and maintenance of permanent tree crops will need to be allocated to the establishment and rehabilitation of permanent tree crops.

The model estimates the reduction of income in the first year to be \$12,000 per acre of land planted with this tree crop alternative. This value decreases in year two as bananas start producing but continues at a negative value in years three and four.

### Second alternative

The model was processed again, but this time it was assumed that inputs and labour required during the first two years were financed by outside sources and that the farmer only provided the land in years 1 and 2. The model assumes that the farmer provides labour and working capital in years 3 and 4.

### Solution

Again, the optimum solution shows that the optimum farm plan remains the same as before. Even with outside financing during the first two years it is not economically feasible to increase the area with permanent tree crops considered with this alternative. The use of farmers' labour to maintain the additional acreage with cacao and coffee in year three and four results in a reduction of income for the farmer. It will not be surprising to see 3 year old cocoa and coffee plantations where weed control and cultural practices are not implemented.

Labour seems to be the most limiting factor and it seems that the farmer cannot afford to behave differently. Certain cultural practices will not be carried out not because the farmers do not know of the benefits, but because they cannot afford the time to do it.

### Third alternative

Labour hiring activities were introduced in the model to release the labour constraint for the period August–November and explore changes in the optimum farm plan. Labour was hired at \$ 50 per man-day.

### Result

The optimum solution shows that labour is hired until labour productivity is equal to the salary paid. The additional labour was allocated to the production of vegetables. The area under vegetables was expanded from 0.8 to 1 acre during the period August–November and root crops were dropped from the optimum plan. It is interesting to notice that it took no more than 15 additional man-days to decrease to \$50 the value added by the last unit of labour.

This needs further analysis but it may indicate a low demand for labour given the actual production alternatives available to the farmer. This may help to understand why farmers complain about the cost of labour.

### Conclusion

The main conclusion of this preliminary analysis is that actual farm size, technology and production alternatives have a very important impact in the feasibility of small farmers expanding the area with tree crops. In the model runs, the expansion of tree crops on the hillsides by small farmers seems to be uneconomical.

In the short term, outside financing for rehabilitation and establishment of permanent tree crops appears as a feasible alternative. It appears that the period requiring outside financing will have to be at least two years or more.

Outside financing should include hired labour during critical periods. The opportunity cost of farmers labour is higher than current wage rates. Indeed, farmers will tend to use some of the additional financial resources provided for more profitable alternative uses on the farm.

In the medium term, the problem needs to be addressed by way of exploring the feasibility of other high value tree crops; establishment and rehabilitation of tree crops associated with high value annual crops; increase the productivity of annual crops. A strong research program to test sustainable economically feasible production alternatives addressed to the limiting factors faced by the farmers is a must. Also, there is a need to understand the interrelationships between household and farm operation to understand why farmers act as they do and what kind of incentives they need to manage their environments in a more sustainable manner. Finally, an economic evaluation of the damage to the watersheds environment is necessary, so that appropriate policies and projects can be devised.

The costs to society in reference to the deterioration of natural resources, damage to the environment and infrastructure, merits to invest resources in the analysis of these and other options for the improvement of agriculture on the hillsides.

The problem is serious, the exploration of alternative solutions challenging. It is hoped that this presentation stirs some thoughts into the problem and promotes some discussion for the benefit of the small farmer and Jamaica's society in general.

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FIGURE 1.

# LAND USE

Riversdale-Troja-Golden Grove Districts

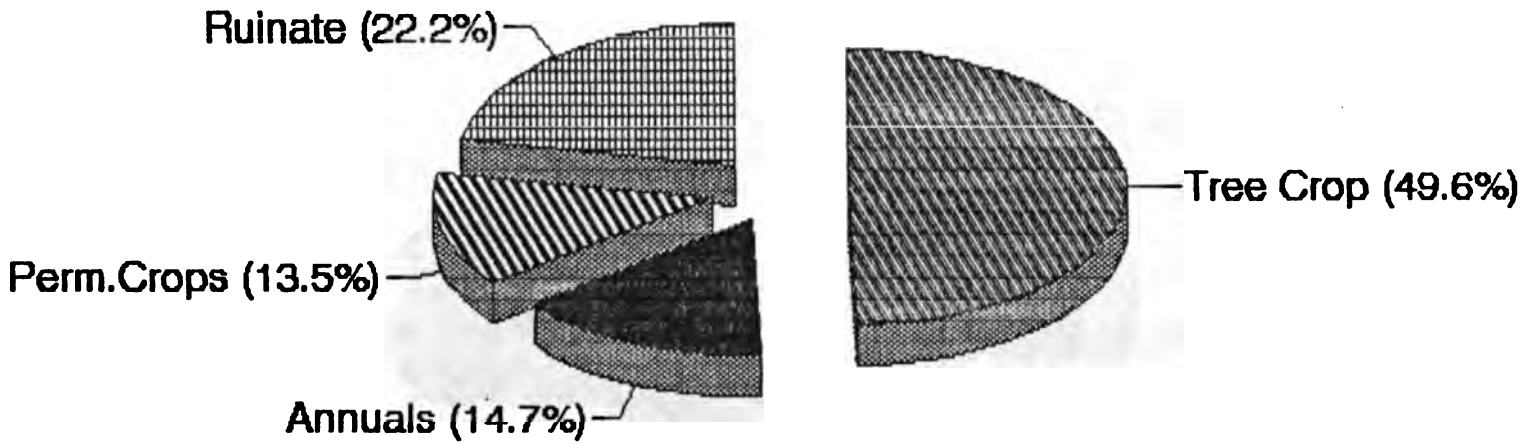


FIGURE 2.

# LAND TENURE

Riversdale-Troja-Golden Grove Districts

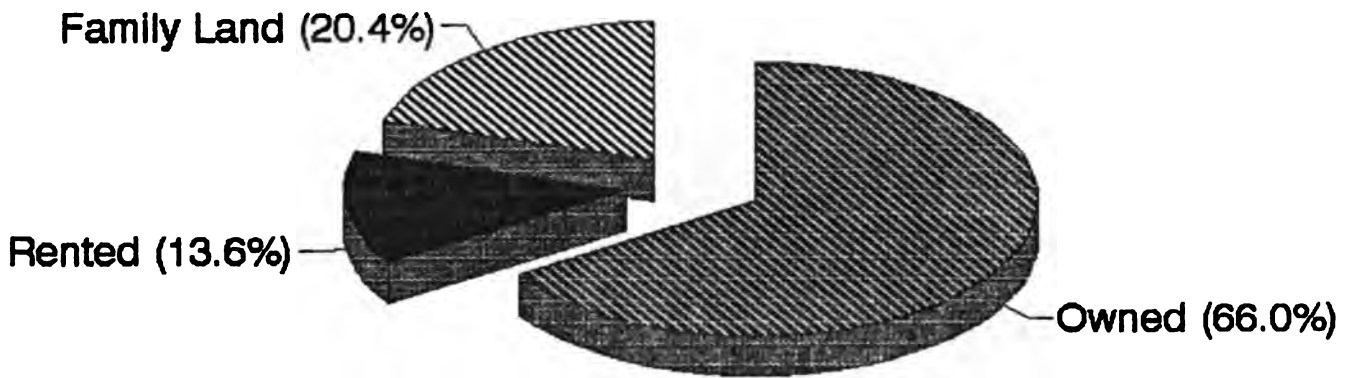


FIGURE 3.

# FARM SIZE

Riversdale-Troja-Golden Grove Districts

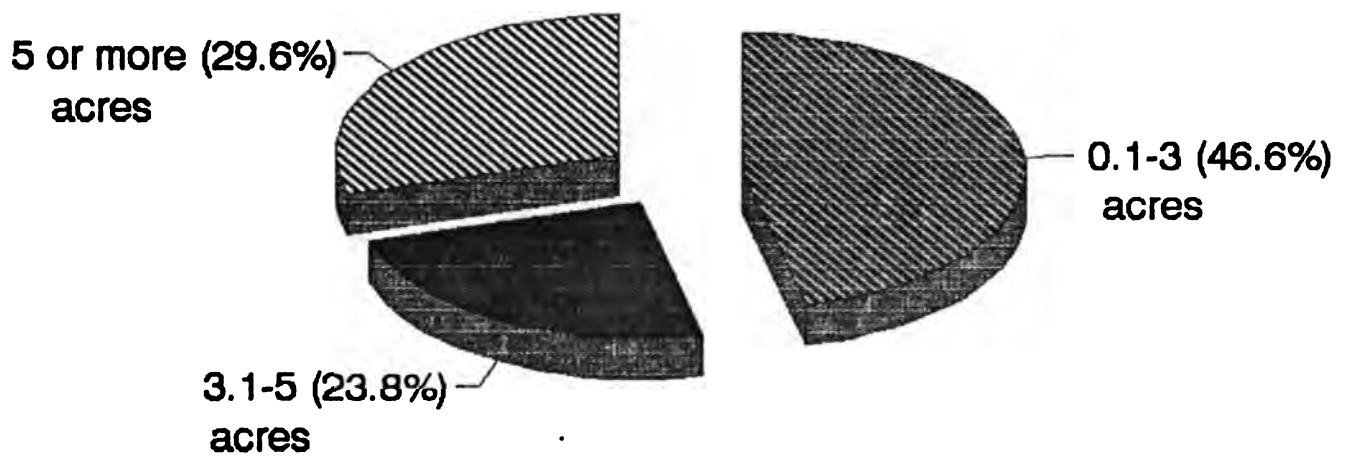


FIGURE 4.

## Number of Parcels per Farm Riversdale-Troja-Golden Grove Districts

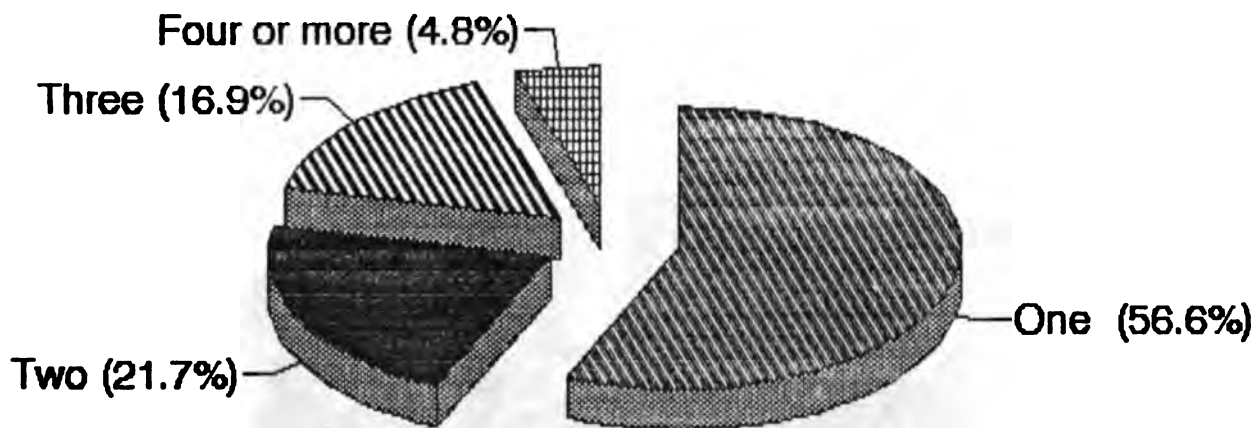


FIGURE 5.

# CROP MIX FOR 3-5 ACRES FARM

Riversdale-Troja-Golden Grove Districts

( Privately Owned)

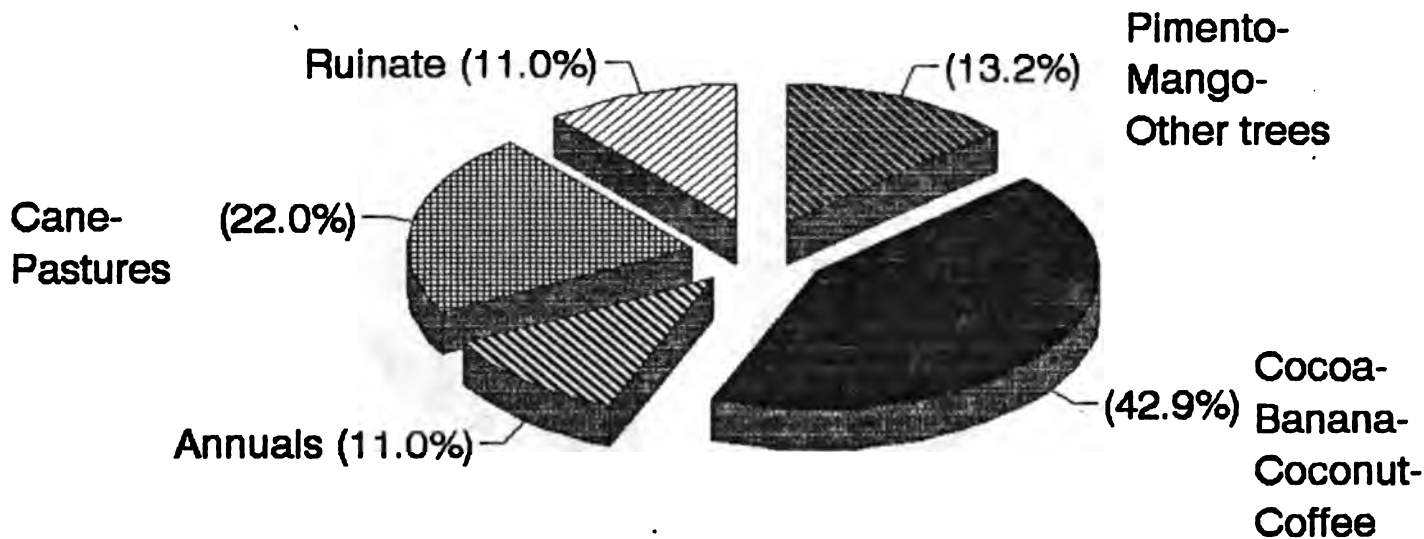
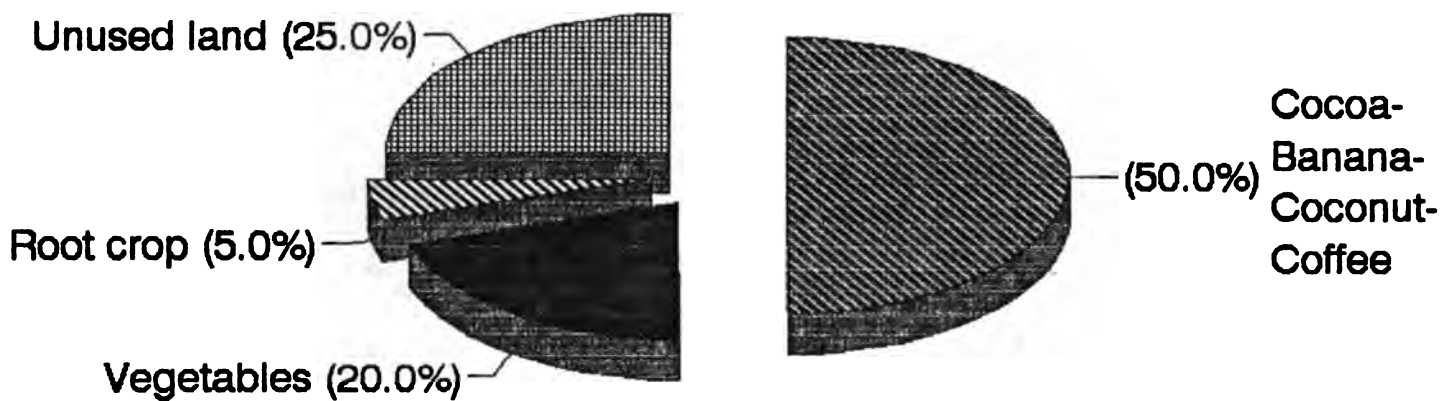


FIGURE 6.

# FARM MODEL CROP MIX

Riversdale-Troja-Golden Grove Districts

( 4 acres )





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