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HILLSIDE AGRICULTURE SUB-PROJECT (HASP)

Economic Viability of Perennial Inter-Cropping
Utilizing HASP Technology

A. Shaun-Marie Grant
Jamaica, W.I.

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ECONOMIC VIABILITY OF PERENNIAL INTERCROPPING UTILIZING HASP TECHNOLOGY

1. Introduction

Given the benefits of improved cash flows and risk diversification, the system of intercropping is the best approach that HASP has chosen to introduce small, resource-poor farmers on the hillsides to more profitable tree-based farming systems.

As such, the purpose of this report is to provide information to extension officers, researchers, project implementors and policy-makers on the economic viability of mixed cropping systems. In so doing, it will list the more profitable crop combinations that can be recommended to small farmers.

1.1 Justification

Since the main objective of the Hillside Agriculture Sub-Project is to increase the socio-economic well-being of resource-poor farmers of the watershed areas in the Northern Rio Cobre, the emphasis has been on developing strategies in increasing on-farm income while at the same time conserving the soil on the hillsides.

The selection of this approach has been confirmed by the findings of both the Informal Survey 1989; (Grant, 1990) and the HASP Baseline Survey (Bockarie,1993), in which the main problems faced by small farmers in the area, are of inadequate cash flow, low prices, limited resources of labour and credit as well as inadequate transportation.

Although there is a definite need to expand tree crop acreage on their hillsides, the farmers face high production costs for establishment. They also face the risks of low prices and uncertain markets. Studies have argued that tree crop expansion is influenced by market prices.

Consequently, farmers adopt a risk minimization strategy of minimum maintenance of existing crop acreages. While farmers tend to neglect their fields in the face of low prices, this does not necessarily mean that they will rehabilitate their fields in more prosperous times.

Studies have shown that farmers would rather expand their crop acreages as a response to better market prices, than attempt to rehabilitate their old fields, (Graham, 1990). Although this study was carried out for Cocoa, similiar conditions exist for other tree crops.

The implication here is that farmers are willing to increase their tree crop cultivation, whenever there are high market prices. Hence, they need different stimuli for maintaining the necessary crop care regime in less favourable circumstances.

As such, perennial intercropping satisfies the needs for short term cash flows, as well as assist in compensating the farmer for the market risks encountered in establishing tree crop orchards. This conclusion is borne out by HASP Baseline survey findings where a third of the sample, have off-farm income sources.

In terms of crop care regime, tree crops receive greater attention and care in an intercropping system, than when planted as a pure stand cultivation.

1.2 Target group and resource environment

As mentioned beforehand, these intercropping packages have been developed for resource-poor farmers on the hillsides. As such, the technology is geared toward overcoming the constraints faced by farmers in their farming system. These constraints of land, labour and capital are faced by farmers with different farm sizes but who have similiar cropping systems.

Specifically, the packages are targeted mainly at the farming systems, which are either mixed cropping systems or are cocoa based. Farming systems have been defined based on the proportion of the farm in ruinate, pasture, cocoa, citrus, banana, pineapple, coffee, sugarcane and annuals (Bockarie, 1993).

However, there are indications that the technology would be more easily assimilated by tiny (0 > 2 ac.) and small farmers (2- 5 ac.) as well as women farmers for they usually devote more of their acreages to annuals on their farms.

It should be noted that these farmers already have mixed cropping systems. The differences with the HASP technology, are namely : improved planting stock, greater reliance on fertilizers and farm chemicals, greater insistence on recommended spacing, as well as an intensified crop care programme.

In many cases, the technological package has been desegregated and refined. This approach has been taken as farmers tend to adopt technology in a step-wise fashion.

1.3 Tree Cropping systems

Previous studies (Mulleady, 1991) indicate profitability is not the only incentive to small farmers in increasing tree crop acreages. Based on constraints of labour, especially during the critical periods of the year, farmers are more concerned with the returns to labour.

There is a definite seasonality of demand for labour on the farm . Small farmers tend to rely on hired labour for specialized tasks such as land clearing and preparation as well as planting activities which tend to take place before the rainy months.

1.4 Intercropping systems

Intercropping can be defined as the practice whereby 2 or more crops are grown in the same field, whether in sequence, combination or both. It is also known as mixed cropping systems and also as polyculture. This method of crop establishment is not restricted to solely to annuals but also to perennials, such as cocoa intercropped with coconut, or coffee with banana.

There are many benefits associated with intercropping as listed below :

- increased crop yields
- less variable yields
- minimized risks
- less weeding
- increased soil fertility
- greater maximization of environmental resources (such as soil nutrients)
- greater food supply for family and market needs

On the other hand, the disadvantages associated with intercropping, are :

- certain operations such as weeding cannot be mechanized
- greater care must be taken during harvesting in order to avoid damaging the companion crops
- insufficient number of herbicides that can be used in mixed cropping systems
- more labour-intensive

Despite these apparent disadvantages, the benefits will outweigh these concerns. The fact that many small farmers already have mixed cropping systems, should verify this conclusion.

1.5 Packages under HASP

As a strategy to preserve the hillsides, mixed cropping systems, even in a modified form have been advocated (McKenzie, 1993). The technology is fairly land and labour intensive, especially so within the first few years, therefore, the returns to labour and capital must be high to justify their adoption.

However, any proposed intercropping package must be sufficiently diversified in the scope of crops grown, in order to minimize the risks faced by the farmers. Survey findings (Bockarie, 1993) confirm that many farmers experience many problems in marketing their produce, such as low price, low market demand and lack of transportation. These problems tend to vary by crop; for instance, problems of low price affects crops such as banana, plantain and tomato, while lack of transportation affects cocoa, yam, and pineapple.

In addition to these concerns, other factors that should be considered, should include agronomic compatibility, farmer's experience with the crop, security of market and future market demand. As a result, the following packages, that have been developed and promoted by HASP are :

- Ackee/Scotch Bonnet Pepper/Cow Peas/Cow Peas/Pumpkin

- Cocoa/Coconut/Plantain/ Pumpkin/Cucumber

- Coffee/Coconut/Plantain/ Peanut/Red Peas

- Coffee/Coconut/Plantain/ Tomato/Sweet Pepper

- Cocoa/Coconut/Plantain/Yam/Cow Peas

- Coffee/Coconut/Plantain/ Tomato/Cabbage

Data for the analysis has been obtained from case studies on a small group of farmers who participated in the project's Intercropping programme. It should be noted that farmers were responsible for selecting the cash crops used in the intercropping programme.

Although farmers in the project area are not traditional vegetable growers, popular choices were tomato, cucumber, sweet pepper and cabbage. These choices came about as a result of their involvement in the monthly Farmers' Market Fair, which was first spearheaded by the project.

2. The Model

The feasibility of the intercropping packages can be shown by the construction of multi-period optimization models, via Linear Programming exercises, which analyze production activities over a four year period. It then analyzes and recommends the best combination of activities giving a high level of income.

The rationale here is that modelling takes into account the constraints of land, labour and capital, faced by the farmer, the various production alternatives as well consumption and marketing activities found in the typical farming system.

2.1 Data sources

Data on production coefficients as well as product and input prices were collected from the farmers' fields, also known as HASP observation plots. Information for the various activities, ranging from land clearing and preparation, nursery bed preparation, planting, moulding, fertilizing, weeding to harvesting, were also recorded and used in the analysis.

2.2 Characteristics

(a) Transfer of resources over multiple time periods

As this is a multi-period model that spans four years, there is a transfer of resources and production from one year to the other. This is especially so in the case of the intercropping, in which the income from the cash crops is transferred to the next planting season or year, for use as working capital. This characteristic is very true of many farming systems, where the revenue coming in from the sale of crops such as cocoa, would be used to pay labourers and purchase inputs.

(b) Family expense allocation

Another characteristic of the model is the allocation of funds for family use. Consequently, J$70,000 per year, have been allocated to family expenses. It is assumed that half of the cash needed for family expenditure is required in every half-yearly growing period.

(c) Focus on crop enterprises

Although the livestock component forms a part of the typical farming system in the project area, it has not been included in the analysis. The reason is that we want to see the full impact of the changes in tree crop technology on the system. Hence, the exclusion of the livestock component, would facilitate the examination of these changes.

2.3 Production activities

Each intercropping package has been analyzed in a separate crop optimization model. The package is always evaluated against popular production alternatives, such as annuals. Hence, tomato, yam and cabbage have been included as profitable production alternatives for the farmer.

(a) Intercropping systems

Within the structure of each model, the intercropping activity in year 1, has been defined as the establishment and maintenance of the tree crops (main crop and permanent shade) as well as the growing, harvesting and selling of the short-term intercrops (that is, the annuals).

The activity in years 2, 3 and 4, will be defined as the maintenance of tree crops as well as the cultivation and harvesting of any cash crop.

(b) Growing of annuals

This is in contrast to the definition for the annuals (in the model) in which the activity involves the growing, harvesting, production and selling of the crop in one growing season. However, there are crop combinations in which one cash crop is grown in the first growing period and followed by the planting of another crop in the second period.

(c) Procurement of additional resources

There are two other main production activities in the model, namely : labour hiring and loan borrowing. They have been introduced later in the model, in order to assess their impact on farm management decisions.

(i) Labour-hiring

The labour restraint will be relaxed and the farmer now has the choice of hiring additional labour in those critical periods for planting. Baseline Survey findings indicated that male farmers used an average of nine farmers per year, but this number is reduced for farmers with smaller acreages. For instance, farmers with tiny (less than 2 ac.) or small (2 - 5 ac.) used only five laborers per year.

Other studies on small farmers (Blustain, 1980) indicate that hired labour is used mostly for land clearing and preparation as well as planting, while family labour is used mostly for less strenuous activities such as weeding and reaping. However, interviews with farmers in the project area, indicate that hired labour is also used for weeding.

These studies all confirm the hypothesis that small farmers hire outside labour for certain activities on the farm, and do not rely solely on family labour. Therefore, the decision to introduce the labour hiring activity into model during critical periods of the year, appears to be realistic.

The daily wage rate in the model is J$100.00 (excluding the provision of lunch), which is based on information coming out of recent interviews with farmers in the area.

Although farmers report that they hire their labourers on a job work basis, the assumption here is that farmers are hired on a daily basis in order to simplify computations.

(ii) Securing credit

In terms of securing loans, it is assumed that the farmer has some need for credit. This hypothesis is verified by the findings of the Informal and Baseline Surveys, both which report that most farmers report a shortage of funds to run their farms as one of their biggest problems in utilizing the farm's resources to their fullest capacity.

Baseline Survey findings indicated that the amount of money earned from the farm for a typical six month period, is approximately J$2,000 (Lewis, 1991). This substantiates the complaint of farmers regarding the shortage of funds. As the cropping system of the project area is tree-based, there are implications of tight funds over the short-term.

Although the Baseline Survey's report indicated that only 19% of the farmers borrowed funds form agricultural credit agencies (Bockarie, 1993), it also reported that farmers with larger acreages would be more inclined to seek outside financing. As the farm size used in this model is 4 acres, it could be implied that the model's assumption is in keeping with this reported tendency of loan procurement.

An interesting point to note is that some farmers tend to seek outside financing for their farm, mainly for buying seedlings and for employing labourers (Lewis, 1991).

Hence, the model has been constructed with the assumption that borrowed funds would be used to supplement the supply of funds required for working capital.

For the analysis, the interest rate has been set at 34%, which is the rate that has been stipulated by the Jamaican Government for loans offered by the traditional agricultural lending agencies to small farmers.

2.4 Product and input prices

The model uses 1993 prices, and in particular, those of the second quarter, for incorporating product and input prices into the analyses. This is as a result of the inflationary situation of the Jamaican economy, which has been further aggravated by recent changes in the Jamaica/US$ exchange rate, These exchange rate movements have affected input prices and consequently, the costs of production and net prices (that is, the difference between total gross income and total variable costs). However, price relationships have been left undisturbed.

2.5 Production coefficients

The technical coefficients relate both to input and output. In the case of output, they are for crop yields such as those for the produce from the intercropping systems as well as the annuals, On the input side, they relate to the quantities associated with restraints for land, labour and capital. It should be noted that each production activity has a different set of technical coefficients for resources.

2.6 Resources

The resources available to the farmer as defined in the model are namely : land, labour and cash (cash for working capital needs). As the technology that is being developed and promoted by HASP, is primarily for resource-poor farmers particularly those on the hillsides, all these resources have been introduced as restraints into the model.

(i) Land

In terms of land, there are two distinct growing periods for its utilization per year. Each growing period is six months in duration. The first starts in a traditional rainy month, April and ends in September, while the second starts in another traditional rainy month, October and ends in the following March. This means that the land can be tied up for at least six months at a time, such as in the case of annuals but for perennials, this arrangement continues over many years.

The model also provides for the transfer of land resources between growing seasons, or in the case of perennials on a yearly basis. As the intercropping ties up the same land for four years, this provision must be made.

(ii) Labour

As mentioned above, there are also restraints for labour. These restraints are associated with the critical periods for labour. In the model, there are two periods in the year,

, namely : April/May and October/November.It is at these times that the farmer could experience a shortage of man days in completing vital farm activities, such as planting, before the onset of the traditional rainy seasons .

(iii) Working capital

As in the case of land, the restraints for working capital correspond to the two main growing seasons. The rationale here is that funds are tied up during the months of crop growth and development.

The farmer is only able to recover his investment after harvesting , which usually occurs at the end of a growing period. In the case of tree crops, this continues beyond the typical growing season and it takes years before the farmer can break even and realize any profit.

3. Results

3.1 Ackee/Scotch Bonnet Pepper/Cow Pea/Cow Pea/Pumpkin

In terms of resources, the labour for all farm activities will be supplied by the farmer and his family. He will also be responsible for providing the necessary working capital, that is, funds for running the farm. Finally, the farmer's holding consists of one four acre parcel of land which is owned and operated by him.

With regards to the intercropping under review, the crop combination of ackee, scotch bonnet pepper, cow peas and pumpkin, facilitates the transfer of funds (for working capital purposes) over the multiple time periods.

Ackee and scotch bonnet pepper are established in the first growing period, April-September of year 1. Sales from the pepper (reaped in the second period) will provide income in both the first and second years.

Two crops of cow peas will be grown in the second year, with one crop in each of the six monthly periods. As a result, revenues will be spread throughout the year as well as financing the planting of pumpkin in the third year.

Pumpkin sales will enable the funding of maintenance activities of ackee in the fourth year.

There are other production activities, in addition to the ackee based intercropping that are available to the farmer, which include :

- <u>Growing of Annuals</u> :

o Tomato/Sweet Pepper

Tomato will be planted in the first growing period, April-September and sweet pepper in the second, October-March.

o Cucumber/String bean

Cucumber will be planted in the first growing period, April-September and string bean in the second, October-March.

- <u>Other cash crops</u> :

o Plantain

o Yellow Yam

Both crops will tie up the land for at least one year, in terms of establishment, growing and production.

Results

<u>Alternative 1 : Family labour and capital</u>

The full 4 acres will be utilized in the first year, but reduces to 3.7 acres in the following year. The maximum of 4 acres will be used in the third and fourth years.

There will be full labour usage in every first critical period, April/May over the four years. This will be followed by a reduction in labour use in every second critical period.

There will be a depletion of working capital funds in the second growing period, October -March for the first and third years. Nonetheless, there will be excess funds in all the other growing periods of the model.

In the solution, the recommended crop mix will include approximately 3 acres of the ackee-based intercropping grown over the four-year period on the farm. The choice of cash crops will differ each year, as well as the proportion of land devoted to their cultivation.

The other crops that should be grown in the first year, includes 0.6 ac. of yellow yam as well as 0.3 ac. of the tomato/sweet pepper mix. Yellow yam (1.2 ac.) would also been planted in the third year. However, the only other crop planted, will be plantain in the second and fourth years. Its acreage planted will vary from 0.7 ac. and 2 ac. over the two years of planting.

In terms of income, the crop mix over the four year period should give a total income of $305,039.91 for the farmer.

Alternative 2 : loan borrowing

With the introduction of credit into the model, the farmer's total income is $305,478.59 over the four-year period. There is a reduction of acreage planted in ackee and more yam would be grown but there is very little change in resource utilization.

Alternative 3 : Hired labour

With the introduction of hired labour in the model, the farm income is $724,896. There is maximum use of land and labour but excess capital in every growing period over the 4 years. However, the farmer would devote a larger acreage to the cultivation of vegetables, particularly the tomato/sweet pepper mix, at the expense of the ackee intercropping.

Alternative 4 : Hired labour and loan borrowing

In this case, there is a relaxation of the main restraints of labour and working capital, with the inclusion of labour-hiring and loan borrowing activities.

In the optimal solution , credit has no effect on land use, farm management decisions or income. In fact, the recommended crop combinations and total farm income remains unchanged from those stipulated in alternative 3 : hired labour. Therefore, it can be concluded that the typical farming system , as depicted by the optimization model, is more responsive to changes in labour supply, particularly that of seasonal hired labour (that is labour in the critical periods of the year).

3.2Coffee/cocoonut/plantain/tomato/cabbage

In this case, the farmer is faced with a choice of many production alternatives over the four year period, namely :

oCoffee/coconut/plantain/tomato/cabbage

The two vegetables will be grown in the first year. Tomato will be planted in the first growing period, April-November and cabbage in the second, October-March. Plantain will be established also in the very first growing period while the other crops, coconut and coffee will planted in the second period of the first year, October-March.

Hence, the farmer will reap his tomato and its revenue help to defray costs of establishing all the other crops in the second growing period. Cabbage sales will help to defray costs of maintenance in the second year. Income from Plantain sales (over years 2 and 3) will provide additional funds for working capital in third and fourth years .

Coffee will be reaped in the third and fourth years and coconut, will start its early bearing in the fourth year.

o Yellow Yam

This crop will tie up the land for one year with its establishment, growing and production.

o Cucumber/String Bean

Cucumber will be planted in the first growing period, April-September and string bean in the second, October-March.

o Pumpkin/Peas

Pumpkin will be planted in the first growing period, April-September and gungo peas in the second, October-March.

o Sugar Cane

This will be grown for the local parochial and curbside markets. This crop will tie up land resources for one year.

<u>Alternative 1 : Family inputs</u>

As mentioned earlier, the farmer and his family supplies inputs, namely : land, labour and working capital. As such, the farmer will provide $5000 in the first growing period of the first year and $2000 in the corresponding period of year 2.

It is indicated in the optimal solution that approximately 2 acres of land will be utilized in the first year. The entire farm land, that is, 4 acres will be fully utilized in the second, third and fourth years.

Labour will be fully utilized in the two critical periods, April/May and October/November of the first year. In the subsequent years, years 2-4, labor will be fully utilized only in first period, April/May. This quantity will be reduced to 40% in the second critical period, October /November in years, 2-4.

In every first growing period,April-September, there will be excess capital in each of the four years. However, in every second growing season of each year, October-March, for the four years, the working capital funds will be completely utilized.

Results

In the solution, approximately 1.5 acre will be devoted to the coffee-based intercropping mix over the four-year period. The proportion of farmland devoted to yam production will vary over the four years, from 0.6 acre in year 1, to 0.9 acre in years 2, 3 and 4.

As the cash component of the coffee-based intercrop mix is phased out, other short-term crops will be grown on other areas of the farm. As such, sugar cane will be planted in years 2-4. The acreage of sugar cane cultivation will remain constant at 1.6 ac. per year.

Based on this overall crop mix for the four year period, the farmer should earn a total revenue of $373,912 from this intensive use of his farm.

Alternative 2 : loan borrowing

The restraint for working capital has been relaxed in this case. The farmer can borrow additional funds at an interest rate of 34% per annum.

Results

The pattern of utilization of land and labour resources as well as working capital remains unchanged.

The acreage devoted to the coffee-based intercrop mix also remains unchanged. The acreage planted for yellow yam and sugar cane remains the same.

In spite of the availability of credit, the farmer's total income remains the same as under alternative 1 : family inputs, at $373,912.94 over the four year period.

Alternative 3 : labour-hiring

In this case, only the restraint for labour has been relaxed. The farmer is now able to hire outside labour during the critical periods of the year at a daily wage rate of $100.

Results

There is full utilization of land resources in every growing period over the 4 years. There is also full labour utilization in the every first growing period followed by excess labour in every second period over the 4 years. Labour would be hired for every day of the two critical periods in every year.

There is also excess working capital funds in every first growing period, which is followed by a depletion of funds in every second growing season.

In this case, the farmer would only grow yellow yam. Consequently, the farmer's total income would increase to $640,000 over the 4 year period.

Alternative 4 : Loan borrowing and labour-hiring

The pattern of resource utilization, crop combinations as well as total income would be same as under alternative 3 : labour-hiring only.

3.3Coffee/plantain/coconut/tomato/sweet pepper

In this case, the farmer is faced with a choice of many production alternatives over the four year period, namely :

- oCoffee/plantain/ coconut/tomato/sweet pepper

The two vegetables will be grown in the first year. Tomato will be planted in the first growing period, April-November and sweet pepper in the second, October-March.

Plantain will be established also in the very first growing period while the other crops, coconut and coffee will planted in the second period of the first year, October-March.

Hence, the farmer will reap his tomato and its revenue help to defray costs of establishing all the other crops in the second growing season. Sweet pepper's sales will help to defray costs of maintenance in the second year. Income from Plantain sales from years 2 and 3, will provide additional funds for working capital in third and fourth years .

Coffee will be reaped in the third and fourth years and coconut, will start its early bearing in the fourth year.

- o Yellow Yam

This crop will tie up the land for one year with its establishment, growing and production.

- o Cucumber/String Bean

Cucumber will be planted in the first growing period, April-September and string bean in the second, October-March.

- o Pumpkin/Peas

Pumpkin will be planted in the first growing period, April-September and gungo peas in the second, October-March.

- o Sugar Cane

This will be grown for the local parochial and curbside markets. This crop will tie up land resources for one year.

Alternative 1 : family inputs

As mentioned earlier, the farmer and his family supplies inputs, namely : land, labour and working capital. As such, the farmer will provide $5000 in the first growing period of the first year and $2000 in the corresponding period of year 2.

Results

From the solution generated from the model, there will be a heavy utilization of land resources over the 4 years. In the first year, approximately 2 acres will be used in the first year. From years 2-4, the full 4 acres will be utilized in all the growing periods.

There will be a full utilization of labour during the first critical period for labour which occurs in the April/May period for each of the four years .

In the second critical period for labour, October/November of year 1, this will fall to 38 days. The proportion of labour utilized in every second critical period is also lower for the subsequent years, that is, 10% of the previous amount, in years 2, 3 and 4.

However, there will be excess funds for working capital in all of the growing periods for the 4 years.

Approximately 2 acres of land will be devoted to the coffee-based intercropping mix over the 4 year period. Yellow Yam which is a popular choice among project area farmers, will be grown in every year of the 4 year model.

Nevertheless, the acreage planted of yellow yam will vary from 0.4 ac. in year 1 to 1 ac. in years 2, 3 and 4.

In order to compensate for the declining cash flow resulting from the phasing out of the cash crops in coffee-based intercropping mix, sugar cane will be grown from years 2 to year 4. Acreage planted will remain constant at 1 acre in the third and fourth years.

Based on these crop combinations over the four year period, the farmer should earn a total revenue of $436,697.79 from the utilization of his 4 acre farm.

<u>Alternative 2 : loan borrowing</u>

The restraint for working capital has been relaxed in this case. The farmer can borrow additional funds at an interest rate of 34% per annum.

Results

Consequently, an additional acre of land will be utilized in the first year but the maximum of 4 acres will be used in years 2-4.

The same amount of labour will be used in the first year as under alternative 1 : family inputs This trend will continue into the first growing period of the second year. However, more labour will be used in the second growing period of year 2. A similiar pattern of labour usage will occur in years 3 and 4.

There will be excess working capital funds in every growing period over the 4 years. Based on the model, the farmer would borrow $10,091 in the first year.

The same amount of land would be devoted to the coffee-based intercrop mix as under alternative 1. However, more land would be devoted to sugar cane therefore market cane will be grown for 4 years.There will be no yellow yam planted in the fourth year.

With the introduction of credit, total income increase slightly to $446,169.63 over the 4 year period.

Alternative 3 : labour-hiring

In this case, only the restraint for labour has been relaxed. The farmer is now able to hire outside labour during the critical periods of the year at a daily wage rate of $100.

Results

There is full utilization of land in every year. There is also excess working capital in every first growing period which is followed by a depletion of funds in every second growing period over the 4 years.

There is full labour usage in every first critical period but a surplus in every second critical period. Labour would be hired for every day of the two critical periods of each year.

The farmer would only plant yam over the period under review. Total income would be $640,000 over the period under review.

Alternative 4 : Loan borrowing and labour-hiring

The pattern of resource utilization, crop combination as well as total income would be the same as under alternative 3 : labour-hiring.

3.4Coffee/coconut/plantain/ peanut/red peas

The farmer is faced with a choice of many production alternatives over the 4 year period, which are namely :

o Coffee/coconut/plantain/ peanut/red peas

The two cash crops, peanut and red peas will be grown in the first year only. Peanut will be grown in the first growing period, April-September. Red peas will be planted and harvested during the second growing period, October-March of the same year.

Income from the sale of the peanut, will be used to supplement the farmer's funds for working capital in the second growing period, October-March during the first year, and as such, help to defray establishment costs of the other crops in the intercrop mix.

Additionally, income from the red pea sales should help to defray maintenance costs in the second year. Sales from Plantain (reaped in years 2 and 3) will provide working capital funds needed in the third and fourth years of the model.

Coffee will be reaped in the third and fourth years while coconut will start its early bearing in year 4.

o Yellow Yam

This crop will tie up the land for one year with its establishment, growing and production.

o Cucumber/String Bean

Cucumber will be planted in the first growing period, April-September and string bean in the second, October-March.

o Pumpkin/Peas

Pumpkin will be planted in the first growing period, April-September and Gungo Peas in the second, October-March.

o Sugar Cane

This will be grown for the local parochial and curbside markets. This crop will tie up land resources for one year.

o Tomato/sweet pepper

Tomato will be planted in the first growing period, April-September and sweet pepper in the second period, October-March.

Results

Alternative 1 : family inputs

As indicated from the model, there is a heavy utilization of resources on the farm over the four-year period, particularly of land and labour.

In terms of land, about 1.7 acre has been used up in the first year. This later increased to the maximum of 4 acres in years 2, 3, and 4.

On the other hand, the labour supply has been exhausted in both critical periods for labour, April/May and October/November within the first year. The trend of complete utilization of labour continues in the first critical period in year 2. This later drops from the maximum of 40 days to 23 in the second critical labour period of the second year.

This pattern of maximum labour utilization of 40 days in the first critical period followed by a 45% reduction in the second critical period also occurs in the third and fourth years.

There are excess funds of working capital in every year of the four-year model. Hence, the initial amounts of $5000 in the April-September period in the first year as well as a further $2000 in the corresponding period of year 2, have been supplemented from income from crop sales. It should be noted that in every second growing period, October-March of each year, the amount of surplus working capital is less than that of the preceding growing period.

In the optimal solution, there is only one (1) acre devoted to coffee-based intercropping mix over the four years. As the cash crops, peanut and red peas are phased out, other production alternatives are included in the model in order to compensate for the shortfall in cash flow before the stage of economic bearing from the coffee and coconut.

As such, there is the planting of yellow yam in each of the four years and sugar cane in the years 2,3 and 4. The acreage planted of yellow yam remains constant at 0.7 ac. per year. Sugar cane, also remains constant at 2.27 acres for the last three years.

Based on the crop combinations generated by the model, the farmer should earn a total income of $343,557.85 from his farm over the four years.

Alternative 2 : loan borrowing

The restraint for working capital has been relaxed in this case. The farmer can borrow additional funds at an interest rate of 34% per annum.

Results

The patten of resource utilization and crop combinations remain unchanged from alternative 1 : family inputs. The total income thus remains the same at $343,557.

Alternative 3 : labour-hiring

In this case, only the restraint for labour has been relaxed. The farmer is now able to hire outside labour during the critical periods of the year at a daily wage rate of $100.

Results

There is maximum utilization of land and labour resources over the four year period. There is also excess working capital in every growing period for each year.

Although labour is hired in every critical period in each year, yellow yam is the only crop planted. The farmer should earn a total income of $724,896 over the four-year period.

Alternative 4 : Loan borrowing and labour-hiring

The pattern of resource utilization, crop combination as well as total income would be the same as under alternative 3 : labour-hiring.

3.5Cocoa/coconut/plantain/pumpkin/cucumber

The farmer is faced with a choice of many production alternatives over the 4 year period, which are namely :

- Cocoa/coconut/plantain/pumpkin/cucumber

The two cash vegetables, pumpkin and cucumber will be grown in the first year. Pumpkin will be grown in the first growing period, April-September. Cucumber will be planted and harvested during the second growing period, October-March of the same year.

Income from the sale of the pumpkin, will be used to supplement the farmer's funds for working capital in the second growing period, October-March during the first year, and as such, help to defray establishment costs for the other crops in the intercrop mix.

Additionally, income from pumpkin's sales should help to defray maintenance costs in the second year.Sales from Plantain (reaped in years 2 and 3) will provide working capital funds needed in the third and fourth years of the model.

Cocoa would be reaped in the third and fourth years while coconut will start its early bearing in year 4.

o Yellow Yam

This crop will tie up the land for one year with its establishment, growing and production.

o Cucumber/String Bean

Cucumber will be planted in the first growing period, April-September and string bean in the second, October-March.

o Pumpkin/Peas

Pumpkin will be planted in the first growing period, April-September and gungo peas in the second, October-March.

o Sugar Cane

This will be grown for the local parochial and curbside markets. This crop will tie up land resources for one year.

Results

Alternative 1: Family inputs/ 'Class A' land

There is full utilization of land and labour resources under this four-year model. As such, the maximum of 4 acres of land has been used in every growing period per year.

Also, the maximum limit has been reached for labour usage in every first critical period and is followed by a 10% reduction in every second critical period.

Nonetheless, there is excess working capital in every growing period. The yearly pattern is a greater surplus in every first growing period, April-September of each year

The optimal solution has been obtained for the case where the farmer has used prime agricultural land, termed for this analysis, 'class a' land. In this case, the only crops that would be grown over the four years, would be yellow yam and sugar cane. in each year, 0.4 ac. would be devoted to yellow yam production and 3.6 ac. to sugar cane.

Based on this crop combination, the farmer should earn a total income of $322,909.09 over the 4 year period from his farm.

Alternative 2 : Multiple land restraints

In this case, the 4 acre farm is comprised of land resources with varying levels of suitability. Hence there are two classes of land on the farm, "class A" and "class B". "Class A" can be regarded as the prime agricultural land on the farm while "Class B" is assumed to be marginal land, representing the steeper parts of the farm.

It is also assumed that the farmer would grow cash crops on the "Class A" land but tree crops on "Class B" land. In terms of "class B", there is a provision in the model for land resources to be transferred from year to the other in keeping with the long-term nature of tree crops.

Results

In terms of "Class A" land, there would be heavy utilization of the land resources. The amount of land cultivated would increase from 1.5 acres in the first year and increase to the maximum of 2 acres. This land would be cultivated by yellow yam and sugar cane over the four years.

The acreage under both crops would vary over the period under review. Acreage planted of yellow yam would be 0.05 ac. in the first year and increase to 1 acre in years 2, 3 and 4. On the other hand, acreage planted of sugar cane would be 1.5 ac. in year 1, and decline to 0.9 ac. in the following 3 years.

The maximum of 2 acres of "Class B' land would be used over the 4 year period. It would be devoted to the cocoa-based intercrop mix.

There would be maximum labour usage in every first critical period, April/May of each year. The amount of labour utilized, would decline in every second critical period.

There would be excess working capital funds in all the growing periods for the 4 years.

Based on this crop mix, the farmer should earn a total income of $304,187.89 over the 4 year period.

3.6 Cocoa/coconut/plantain/ yellow yam/cow peas

The farmer is faced with a choice of many production alternatives over the 4 year period, which are namely :

- Cocoa/coconut/plantain/ yellow yam/cow peas

The two cash crops, yellow yam and cow peas will be grown in the first year. Yellow yam will be planted in the first growing period, April-September but will not be harvested until 9-12 months after planting.

Cow peas will be planted and harvested during the first growing period, October-March of the same year.

Hence, income from the cow pea sales should also help to defray establishment costs in the first year.

Income from the sale of the Yellow yam, will be used to supplement the farmer's funds for working capital in the second year, and as such, help to defray maintenance costs for the other crops in the intercrop mix.

Sales from Plantain (reaped in years 2 and 3) will provide working capital funds needed in the third and fourth years of the model.

Cocoa would be reaped in the third and fourth years while coconut will start its early bearing in year 4.

o Yellow Yam

This crop will tie up the land for one year with its establishment, growing and production.

o Cucumber/String Bean

Cucumber will be planted in the first growing period, April-September and string bean in the second, October-March.

o Pumpkin/Peas

Pumpkin will be planted in the first growing period, April-September and gungo peas in the second, October-March.

o Sugar Cane

This will be grown for the local parochial and curbside markets. This crop will tie up land resources for one year.

o Tomato/sweet pepper

Tomato will be planted in the first growing period, April-September and sweet pepper in the second, October-March.

<u>Alternative 1: Family inputs/ 'Class A' land</u>

As was the case with the previous cocoa-based intercrop mix, there has been a full utilization of land resources but only for the first three years. In the fourth year only 1.3 acres would be used.

There will be a maximum usage of labour in every first critical period, April/May over the four years. This will be followed by a 10% reduction in every second critical period, with the exception occurring in the last period in the fourth year when no labour has been utilized.

Similarly, there is excess funds for working capital in those first three years, with the higher amounts in the first growing period, April-September of each year.

The solution was generated for the case of 'Class A' land. Like the previous cocoa-based intercrop mix, sugar cane and yellow would be the only two crops grown. Hence, 0.4 ac. of yellow yam and 3.6 ac. of sugar cane would be planted annually over the first three years. In the fourth year, yellow yam would be the only crop grown.

Based on the crop mix, the farmer would earn a total on-farm income of $298,181.82 over the four-year period.

<u>Alternative 2 : Multiple land restraints</u>

In this case, the 4 acre farm is comprised of land resources with varying levels of suitability. Hence there are two classes of land on the farm, "class A" and "class B". "Class A" can be regarded as the prime agricultural land on the farm while "Class B" is assumed to be marginal land, representing the steeper parts of the farm.

It is also assumed that the farmer would grow cash crops on the "Class A" land but tree crops on "Class B" land. In terms of "class B", there is a provision in the model for land resources to be transferred from year to the other in keeping with the long-term nature of tree crops.

Results

The maximum of 2 acres of "Class A" land would be used during the first three years. However, only 1.3 ac. would be cultivated in the fourth year.

In terms of "Class B', the maximum of 2 acres would be devoted to the cocoa-based intercrop mix.

In terms of labour resources, the maximum number of man days would be utilized in every first critical period over the four years. This would be followed by a reduction in labour usage in every second critical period .

There would be excess working capital funds in every growing period over the four year period.

Consequently, yellow yam and sugar cane would be cultivated on the "Class A" land. However, the acreage under these crops varies over the years. The acreage planted of yellow yam would range from 0.2 acre in year 1 and increase to 1 acre in years 2 and 3, and to 1.3 acre in year 4.

Approximately 1.8 ac. of sugar cane would be planted in the first year but would decrease to 0.9 ac. in years 2 and 3. There would be no sugar cane planted in the fourth year.

Based on the crop mix, the farmer would earn a total income of $282,806.30 over the 4 year period.

3.7 Summary

The results of the four-year crop optimization models have been summarized in the table below :

Table 1
Total farm income under the various production alternatives for a 4 year period

Crop Name	Alternative	Total Income
		$
Ackee/pepper/pea/ pumpkin	Family inputs	305,039.91
	Loan-borrowing	305,478.59
	Labour-hiring	724,896.00
	Loans & Labour-hiring	724,896.00
Cocoa/pumpkin/cocnut cucumber/plantain/	Family inputs/"Class A" land	298,181.82
	"Class B" land	282,806.30
Cocoa/Yam/plantain/cow peas/plantain/coconut	Family inputs/Class 'A' land	322,909.09
	Class 'B' land	304,187.90
Coffee/sweet pepper/ tomato/plantain/c'nut	Family inputs	436,697.79
	Loan-borrowing	446,169.63
	Labour-hiring	640,000.00
	Loans & labour-hiring	640,000.00
Coffee/peanut/red peas/plantain/coconut	Family inputs	343,557.85
	Loan-borrowing	343,557.85
	Labour-hiring	724,896.00
	Loans & Labour-hiring	724,896.00
Coffee/tomato/cabbage/ plantain/coconut	Family inputs	373,912.94
	Loan-borrowing	373,912.94
	Labour-hiring	640,000.00
	Loans & labour-hiring	640,000.00

3.8 Conclusions

As an outcome of the HASP intercropping programme, economic analysis had been carried out for ackee-based, cocoa-based and coffee-based mixed cropping systems. Hence, crop optimization models were developed for six tree-based intercrop mixes, which were earlier established in the project area.

The main aim of this study was to investigate the economic feasibility of these mixes for resource-poor farmers in hillside areas, particularly those of the Rio Cobre watershed in North-eastern St. Catherine.

Additionally, another aim was to examine the effects of changes in resource usage from any increased availability of credit and labour and assess this impact on cropping decisions.

Based on the results of Linear Programming exercises, several conclusions were made.Firstly, the coffee-based intercrop mix would give the highest income of all the tree-based mixes in the case where the farmer supplies all his own resources of land, labour and capital.

Secondly, the availability of credit has little or in some cases, no effect on farm management decisions. In the case of the ackee based and coffee-based systems (with the exception of the coffee/ coconut/plantain/tomato/sweet pepper mix) the income remains the same.

Thirdly, the farmer would plant more cash crops, particularly yellow yam and sugar cane, in the case where the desired amount of labour could be hired. However, the acreage under tree crops would remain the same. Total income would tend in most cases to double than if he used only family labour. Therefore, the farming system is more responsive to changes in the labour supply than in credit.

However, if the farmer used his prime agricultural land, he would plant between 1-2 acre of tree crops, particularly, ackee and coffee.

In the case of cocoa, he would plant it on marginal land or "Class B" land. A possible explanation could be the low price per unit for cocoa.

One may argue that this model only spans 4 years but tree crops are long-term investments. Nevertheless, farmers are motivated by both short and long-term considerations.

Baseline Survey findings has shown that inadequate cash flow are among their foremost concerns. Hence, a 4 year model could be useful in examining strategies to improve those flows.

The economic analysis confirms the view that tree-crop intercropping systems are profitable, viable and feasible alternatives to resource-poor farmers on the hillsides. The adoption of this strategy is strongly recommended.

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