RATES OF RETURN TO PRIVATE AGRICULTURAL EXTENSION: EVIDENCE FROM TWO FARM MANAGEMENT CENTERS IN EL SALVADOR

Abstract: This paper evaluates the economic and the financial viability of implementing private farm management centers (FMC) in El Salvador. In doing so, an *ex ante* cost-benefit analysis is performed. The results of this analysis suggest that a combination of better farm prices (paid and received), reallocation of resources, and crop diversification that would be promoted by a FMC can lead to an increase in farm level profits that is sufficient to cover the operation of the center and to still generate net gains in household income.

Keywords: Private Agricultural Extension; Farm Management Centers; Cost-Benefit Analysis; Developing Country; El Salvador.

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**Rates of Return to Private Agricultural Extension:
Evidence From Two Farm Management Centers in El Salvador**

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1. Introduction

The privatization of agricultural services began as a response to a decline in public expenditures worldwide. Dinar (1996) shows that, in real terms, public expenditures on extension have been declining since the mid-1980s. Beynon (1995) provides two explanations for these reductions. The first involves fiscal budget restrictions that have been imposed in order to reduce state activity in those areas where the private sector may be willing to invest. The second is the need to raise the cost-effectiveness of a deteriorating system of public research and extension in many developing countries.

The current experience with private agricultural extension ranges from complete privatization to cost-recovery approaches. Complete privatization has been shown to be effective among larger-scale commercial farmers and for high-value cash crops and livestock (Kidd *et al*, 2000). Conversely, co-financing and cost-recovery alternatives have been introduced as a way to stimulate private sector participation in rural development programs (Dinar and Keynan, 2001; Olomola, 2001). Regardless of the approach followed, the leading force behind the privatization process is that farmers and their organizations should have the opportunity to obtain the advice and information they require from those most prepared and willing to offer it (GTZ, 1998, Hall *et al*, 1999). Moreover, Bindlish and Evenson (1997) argue that, in developing countries, agricultural development programs should be specially focused in helping farmers to become better managers.

Although systematic extension programs have been going on for at least 50 years, studies of rates of returns to private agricultural extension are rare. In addition, the available studies have been carried out at the national (aggregate) level, and the effects of extension programs are frequently mixed in with research efforts (Alston *et al*, 2000; Alston and Pardey, 2001). Kidd *et al* (2000) claim that it seems premature to consider any of these private extension models as feasible alternatives. Furthermore, Rivera (1996; 1991) cautions that the promotion of different privatization extension models without a formal analysis is likely to lead to the repetition of the mistakes made by many extension systems in the past.

Two main reasons have motivated the privatization of agricultural extension in El Salvador. On the one hand, the public expenditures on agricultural research and extension in this country have been dramatically reduced since 1980 (Solís, 2002). On the other hand, some international development agencies have imposed self-financing or self-supporting mechanisms as a condition to finance agricultural extension projects (Beynon, 1998). Therefore, there exist an increasing interest in this country for private strategies that compensate the reduction of the state investment in agricultural extension and that fulfill the conditions imposed by the development agencies.

This paper intends to contribute to the existing literature by providing an empirical analysis of the economic and financial benefits of a specific private agricultural extension strategy in El Salvador. The results obtained in the analysis are used to develop several recommendations for private agricultural extension programs in this country.

2. Data and methodology

This study analyzes the feasibility of two private farm management centers (FMCs) established recently in El Salvador. These FMCs are part of a group of centers which were initiated by a USAID funded rural development project called *ROCA*. The main purpose of this project is to improve the competitiveness of small-scale farms by encouraging and facilitating their progressive integration into the market economy. The two FMCs included in this analysis are Usulután II and Funsalprodese. These FMCs were selected because they have the most complete and reliable data among the five centers established by *ROCA*. Moreover, Usulután II was chosen because of the diversity in the beneficiaries' production systems which include agricultural and shrimp producers.

The data used in this evaluation were obtained from a variety of sources. The socio-economic characteristics of the farmers come from a survey administered to farmers randomly selected from cooperatives associated with the FMCs. This survey also contains individual enterprise budgets for different crops cultivated in each farm during the 2001-2002 agricultural year. The financial, accounting and marketing information was obtained from records collected by the FMCs. Secondary sources are also used to compare, expand and improve the data available.

To evaluate *ex ante* the viability of the FMCs the following methodology is implemented. A classification process is used to create a set of representative farms. Then, enterprise and whole-farm budgeting techniques are used to calculate the observed net benefits. The benefits of the FMCs are projected assuming that alternative services are provided. These alternatives are developed to simulate farm improvements that are expected from the services provided by the FMCs. To compute the benefits of the FMC as a whole, the incremental net benefit of each representative farm is extrapolated to the population that they represent. The viability of the FMC is examined using the financial and economic net present value (NPV) and internal rate of return (IRR). Lastly, to assess the inherent risk of the project, a sensitivity analysis is conducted. The main steps of this evaluation are discussed in the following subsections.

2.1. Representative farm selection and description

Due to the diversity in the agricultural production systems among the farmers working with the project it is necessary to classify them in order to create representative farms. The agglomerative hierarchical clustering analysis is used to provide the framework for constructing uniform groups of farms within each FMC. In doing so, the Ward method is selected as the sorting strategy for the formation of the clusters and the square Euclidean distance is chosen to measure the similarity among the cases (Norušis, 2002; Aldenderfer and Blashfield, 1984). The variables used for the classification process are selected based on empirical studies conducted on peasant economies (Cisse, 2001; Coydan, 1999; and Escobar and Berdegué, 1990), and the data available. The variables included are: farm size, measured in Manzanas (Mz); farm income, calculated in dollars; farmer age; farmer agricultural experience, measured in years of agricultural work; and cropping orientation, which represents the main crop or group of crops cultivated in the farm. To determine the optimal number of clusters to be included in the analysis the hierarchical agglomerative graphical approach is used (Aldenderfer and Blashfield, 1984). This technique reveals that the optimal number of clusters for each FMC is four.

A representative farm is defined as the average farm within its particular cluster. By calculating the average for every production factor inside its cluster, each representative farm displays the average farm size, cropping pattern and input allocation of their cluster fellow members.

To describe the production system of the representative farms and to establish their profitability, enterprise and whole-farm budgeting techniques are used. Seventeen enterprise budgets and eight whole-farm budgets are constructed considering prevalent practices and conditions of the farms included in the study. These budgets are created mainly using data extracted from the survey. However, this survey does not provide the amount of labor that the farmers utilize for each crop. Thus, the labor requirements per enterprise was obtained from three studies performed in rural El Salvador: Reyes (2001); Solís *et al* (2001); and MAG (2000). Moreover, the survey also lacks information related to the farm's fixed cost. Therefore, this analysis is based on the farm's gross margin. A brief summary of the whole-farm analysis is presented in Table 1.

2.2. Cost-Benefit analysis

The cost-benefit analysis performed in this study has been developed from a financial and an economic perspective. The main differences between these two approaches are related to the following issues: cost of family labor; discount rate; financial cost; and funding.

From a financial standpoint, the family labor cost is calculated by using the average wage rate for unskilled agricultural workers in the areas under analysis. In contrast, Gittinger (1982) suggests that in crowded developing countries, like El Salvador, the marginal product of an unskilled agricultural worker is zero. Consequently, the cost of family labor is assumed to be zero in the economic analysis, but this assumption is modified in the sensitivity analysis.

Regarding the opportunity cost of capital, the average bank interest rate for agricultural projects in El Salvador (13.5%) is used in the financial analysis. By contrast, the most commonly adopted rate by international agencies of 12% is used as the opportunity cost of capital in the economic analysis.

The financial cost, which is defined as operating costs times the interest rate, is considered as a cash outflow in the financial analysis. By contrast, in the economic analysis this cost is considered a transfer payment from the farmers in the project to the rest of society; thus, it is excluded (Alston *et al*, 1995).

Lastly, the funding for this project was provided by the United States Agency for International Development (USAID) as a grant, and for this reason, this funding is assumed to have zero opportunity cost for the country in the economic analysis. However, in order to refine the analysis, the amount of the grant is also treated as coming from a national fund, and thus considered as a cash outflow. In the financial analysis, the grant is considered as a positive cash inflow regardless of where the funds come from.

2.3. Project benefits

The benefits of the project are projected using the representative farms as the unit of analysis. In doing so, the following three alternatives regarding services provided by the FMCs are analyzed: marketing; business management; and technology transfer. The marketing service assumes that by buying inputs and selling outputs in bulk the FMC should generate better prices for farmers (pecuniary economies of size). The price advantage is the difference between farm level prices and wholesale prices in the areas where the FMCs are active.

The rationale behind the business management service is that farmers with better management skills have the tools to develop more profitable farm-plans. This service relies on a multiperiod linear programming (MLP) model to incorporate a farm-planning service. The MLP models optimize the resource allocation in the farm in order to generate an optimum (profit maximizing) cropping pattern.

The technology transfer service is incorporated into the MLP model by adding new crop activities, which are expected to generate higher profits to farmers. The crops selected for this analysis were chosen based on recommendations made by specialists of the FMCs. The specific crops introduced on basic grain oriented farms are sesame (*Sesamum indicum*), and beans (*Phaseolus vulgaris*). The crops introduced on horticultural farms are green peppers (*Capsicum annuum*), papaya (*Carica papaya*), and winter squash (*Cucurbita maxima*).

2.4. Multiperiod linear programming model

Following Glen and Tipper (2001) and Hazell and Norton (1986) the MLP models use in this study can be expressed as follows. First, the farm profit function in period *t* is defined as:

$$(1) \qquad \pi_t = \sum_{j=0}^{J}(P_j * X_j) - \sum_{j=0}^{J}(C_j * X_j)$$

where: π_t : farm profit (gross margin) in period *t*;
P_j : product price for growing activity *j*;
X_j : level of activity *j*; and
C_k : is the variable cost of activity *j*;

The objective function of this model is to maximize the net present value (NPV) of the flow of future net income, $\pi_{t,}$ discounted at a rate *r*, subject to the restrictions imposed by the resources available. Accordingly, the objective function and the constrains can be written as:

(2) Max NPV = $\sum_{t=0}^{T} \frac{\pi_t}{(1+r)^t}$

subject to

(3) $\sum_{t=0}^{T} (\mathrm{A}_{\mathrm{jit}} * \mathrm{X}_{\mathrm{jt}}) \leq \mathrm{B}_{\mathrm{it}}$

where: A_{jit} : amount of resource *i* consumed by each unit of activity *j* in period *t*;
X_{jt} : level of activity *j* in period *t*; and
B_{it} : amount of resource *i* available in period *t*.

In this MLP model, the farm's gross margin is calculated each year through a series of accounting activities and balance rows. These activities collect the annual gross margin into the objective function (Schrage, 1997). To facilitate the incorporation of these results into the cost-benefit analysis, all these values are discounted to year zero.

The constraints included in this analysis have been selected based on Jimenez *et al* (2000), and Hazell and Norton (1986). More specifically, the constraints under discussion are as follows:

- Farm Resources: because of the lack of information related to farm resources only land has been included in the analysis. Other farm resources (e.g. labor, machinery, etc.) will be treated as fully available by hiring or purchasing them.

- Capital: Reyes (2001) has estimated that, on average, a small farm in El Salvador has between ¢4,370 and ¢6,125 ($500 and $700) in available short up capital per Mz. This capital allows farmers to purchase inputs and hire some labor.

- Rotation: to avoid soil-borne pests and diseases, crop rotations have been included in each of the MLP models. The rotation requirements are: basic grains are rotated every 3 years; beans and vegetables are rotated every 4 years; and green pepper is rotated every 5 years. Maize (*Zea mayz*) has no rotation restriction.

- Fruit Crops: the model implemented in this study allows for planting fruit crops in each of the 10 years included in the analysis. The economic lifetime used for each of the fruit crops is as follows: Banana (*Musa paradisiacal*) 10 years; Papaya 3 years; and coffee (*Coffea arabica*) 15 yeas.

A simplified sample tableau of the MLP model implemented in this study is presented in Table 2. The activities incorporated in this example include 3 fruit crops, 3 cereal crops and 4 vegetable crops. To incorporate the fruit crops, it is necessary to enter the income and resource coefficients in each year during the crops' lifetime. For instance, papaya planted in year 1 has data entries for year 2 and 3, since the lifetime of this fruit crop is 3 years. The cereal and the vegetable crops included can also be grown every year in the model. However, because these are annual crops, coefficients only appear in the columns for the year in which the crops are grown.

The total gross margin is calculated using balance rows and accounting activities. The balance rows calculate each year the annual gross margin. In contrast, the accounting activities discount those values to year 0 and collect them into the objective function. Lastly, this model also incorporates resource availability and some technical and financial constraints. For example, the maximum quantity of land available is 2.01 Mz; the total operating capital for year 1 is $1,256; and, due to rotation constraints, sorghum should not exceed one third of the cultivated area.

3. Empirical results

3.1. Agricultural Farm Benefits

Based on the alternative services described in Section 2.3, four different scenarios are developed to measure the benefit to farmers associated with the FMCs. Scenario 1 describes the farm benefits without the assistance of the FMCs (Baseline). Scenario 2 presents the situation where extra profit are earned due to expected changes in product prices and input costs due to pecuniary economies of size (marketing service). Scenario 3 portrays the situation as in Scenario 2 but incorporates a farm-planning service (business management service). Finally, Scenario 4 represents the same situation as in Scenario 3, but new crops are included in the model (technology transfer service).

To measure farm benefits through time, the evaluation is projected over a 10-year period. A 10-year horizon was chosen because it is an average period used in agricultural cost-benefit analysis performed by international agencies (World Bank, 2000), and it coincides with the length of life of one of the fruit crops selected for the analysis (i.e., banana). The discounted benefits for all the representative farms and for the production of shrimp are presented in Tables 3 and 4. These tables present the financial and economic analysis for each scenario, respectively.

The main results of this analysis can be summarized as follows. The economic analysis of the Baseline presents higher discounted benefits than the financial analysis. In fact, the returns for agricultural producers are between 49% and 121% higher in the economic analysis than in the financial analysis. The differences between the financial and the economic analyzes are due to the treatment of family labor cost, the financial cost and the discount rate.

The marketing service (Scenario 2) evaluates the effect of pecuniary economies of size on farm benefits. The farm level prices used in this model are extracted from the survey. However, the wholesale prices for outputs and inputs come from data collected in the areas under analysis by the FMCs and from a bulletin published by the Ministry of Agriculture of El Salvador (MAG, 2001). On average, wholesale prices for outputs are 40% higher than farm level prices. In addition, wholesale input prices are, on average, 21% lower than farm prices. By including the marketing service into the analysis, the discounted benefits increase between $700 and $3,000 per farm, approximately. The biggest increments are realized by the largest and most diversified farms. The positive effect of this service is consistent with survey results, which reveal that farmers tend to buy their inputs in local retail stores at high prices and sell their production to intermediaries (*coyotes*) at low prices.

The incorporation of the business management service (Scenario 3) is especially beneficial for the more diversified farms. For instance, farms with five or more crops increase their discounted benefits by 56% on average. In general, this model reduces the production of low profitable crops and increases the area cultivated with the most lucrative ones. However, monocultural farms show little improvement or no improvement with this service.

The results of Scenario 4 are particularly beneficial for horticultural farms. The introduction of papaya and green pepper increases their gross margins by more than 700%. However, farm U-003, which has an orientation towards basic grains, does not show any improvements between Scenario 3 and 4. This farm is highly specialized in the production of maize and reaches large returns on its production. Thus, in this specific case, the new crops introduced to this farm (sesame and beans) are less profitable than corn.

To assess the overall benefits of the FMC on its agricultural producers, the aggregate benefits of the representative farms are computed. The aggregate benefits are calculated using the current number of beneficiaries in each FMC. In doing so, the benefit of each representative farm is extrapolated to the population that they represent using an expansion factor computed in the cluster analysis (Solís, 2002).

3.2. Shrimp production

The production of shrimp has been implemented among cooperative members of Usulután II as an alternative to converting old salt production facilities into a more profitable activity. To evaluate the effect of the FMC on the production of shrimp, enterprise budgets are developed to describe the situation *with* and *without* the assistance of the FMC. These budgets have been constructed by the FMC's shrimp specialist, and have been adapted using the data extracted from the survey.

The main difference between the traditional and the new production systems is the technology level. Overall, the traditional system presents a low use of inputs. For instance, this system's expenses in feed are one third of what the modern system uses. This difference is explained by the fact that the traditional system uses a natural feeding method, which relies on organisms present in the water to feed the shrimp' larvae. Furthermore, the traditional system uses a generic variety of larvae.

In contrast, the production system implemented by the FMC has been designed and implemented by a shrimp specialist. This specialist is also in charge of the feeding strategy, the technical assistance, and the harvesting schedule. Moreover, in order to reach the best results, a high quality variety of pink shrimp has been chosen, and an oxygenation system is utilized to give the shrimp the best environment to develop.

The new technology increases the variable costs by 100%. The indirect costs also rise due to an increment in administrative costs. However, the positive effects of the new production system are not only reflected in the yield, but also in the size and the number of harvests per year. The modern production system reaches a higher and more uniform yield, and most of the production is in the middle size range, which is the size that commands the highest price. Furthermore, the modern production system achieves two more harvests per year than the traditional system. Thus, the net returns per year for the production of shrimp increases from $137.0 to $1,906.4 per Manzana.

3.3. Economic and Financial Viability of the FMCs

To estimate the economic and financial viability of each FMC, the incremental net benefits of all farmers associated with the project are calculated. The incremental net benefits measure the contribution that each FMC makes to its members. This contribution is computed by calculating the benefits reached by all farm members stemming from the different services provided by FMCs, minus the aggregate farm benefits expected without an FMC (Baseline).

The economic and financial NPV and IRR are calculated based on the current number of beneficiaries of each FMC using the aggregate net benefits developed above. These indicators are computed using the investment and operating cost of each FMC. This analysis does not include the costs of the project's management unit (MU). However, section. 3.4 will present a sensitivity analysis which modifies this and other assumptions undertaken.

The analysis of the Usulután II FMC includes agricultural activities as well as shrimp production. The aggregate incremental net benefits for shrimp production are measured as follows. First, the difference between the traditional and the modern production system is computed. Then this result is extrapolated to the total area available for the production of shrimp in the Usulután II FMC (43 Mz). As shown in Table 5, the financial analysis of the Usulután II FMC presents positive returns in all of the models analyzed. Scenario 2 shows the lowest returns with a NPV equal to $181,300 and an IRR of 16.9%. Scenario 3 presents an increment of approximately 70% with respect to Scenario 2. Furthermore, Scenario 4 displays a dramatic improvement on the returns of the project. In fact, the IRR increased from 28.1% in Scenario 3 to 56.2% in Scenario 4.

Economic analysis A, which treats the funding of the project as a grant, follows the same pattern described for the financial analysis. However, this analysis shows higher returns than the financial analysis. These variations are a consequence of the differences between both approaches on the valuation of the family labor cost, the financial cost and the discount rate. Scenario 3 shows a NPV equal to $1,101,800 and an IRR of 42.5%. Moreover, Scenario 4 presents a major increment with a NPV equal to $4,107,400 and an IRR of 63.2%.

Economic analysis B examines the effect of considering the funding of the project as a cash outflow. In this analysis the NPV of Scenario 2 became a negative $98,300. In contrast, the analysis for Scenario 3 and 4 show positive returns. These scenarios display NPVs equal to $815,000 and $3.8 million, and IRRs of 31.3% and 60.2% for Scenarios 3 and 4, respectively.

The Funsalprodese FMC shows negative returns for Scenario 2 in both the financial and the economic analysis. The worst result was for Economic Analysis B followed by the financial and the Economic Model A. The NPVs for these analyses are -$381,300; -$89,300 and -$76,600, respectively. On the contrary, Scenarios 3 and 4 display positive outcomes in all of the analyses. Scenario 3 shows a NPV between $267,500 and $561,500 and IRRs in the range of 19.6% and 35.7%. As in the Usulután II FMC, the introduction of new crops in Service 4 generates a large improvement in the return of the project. For instance, the NPV in the financial analysis increases by more than 200% with respect to Scenario 3. The economic analysis also shows large improvements. Indeed, the IRRs for Economic Analyses A and B increased from 35.7% and 19.6%, in Scenario 3, to 81.5% and 77.3% in Scenario 4, respectively.

3.4. Sensitivity analysis

The sensitivity analysis first explores the effect of incorporating the investment and operating costs of the project's MU in the evaluation process. The result of this analysis is summarized in Table 6. As shown in this table, the financial analysis for both FMCs displays negative returns for Scenarios 2 and 3. However, Scenario 4 presents NPVs equal to $3.4 and $6.1 million for Usulután II and Funsalprodese, respectively.

In contrast, the economic analysis presents some differences between both FMCs. In the Usulután II FMC the Economic Analysis A and B, for the marketing service, present negative NPVs, while Scenarios 3 and 4 display positive outcomes. In Funsalprodese, Scenario 2 also displays negative returns. However, Scenario 3 shows a positive NPV and IRR, when the funding of the project is treated as a grant (Economic A), and it presents negative returns, when the funding is considered a cash outflow (Economic B). The results for Scenario 4 are also positive in Funsalprodese.

Finally, the sensitivity analysis also looks at the consequences of modifying the assumptions regarding the family labor cost on the economic analysis (Economic C). Up to now, the economic cost of family labor has been set equal zero. In the Economic C scenario the average market price for unskilled agricultural workers is used as the opportunity cost for family labor. The result of this analysis shows negative returns in Scenarios 2 and 3. In contrast, Scenario 4 shows positive returns with IRRs equal to 39.7% and 55.6%, and NPVs of $3.3 and $5.7 million for Usulután II and Funsalprodese, respectively.

4. Conclusions and policy implications

The cost-benefit analysis performed in this study was developed from a financial and an economic perspective. Generally speaking, the financial analysis revealed that the implementation of FMCs in El Salvador is an attractive prospect for the private sector to pursue. In addition, the economic analysis showed that this project also generates benefits for society.

Those results suggest that the government should take action to encourage farmers and their associations to adopt the FMC model.

The results obtained in this study suggest several recommendations for private agricultural extension programs in El Salvador. First, the analysis of the marketing service reveals that there is a significant gap between the prices actually paid (inputs) and received (outputs) by individual farmers and what they might be able to realize by working together. Available data shows that individual producers buy their inputs in local supply stores at high prices and sell their production to intermediaries at low prices. In general, the marketing service did not generate enough benefits to cover all the cost of the FMC. However, farmers' gross margins increased drastically. Consequently, a way to improve farm profits is to facilitate and encourage cooperation among peasants with the aim of selling their products and purchasing their inputs in bulk.

Second, the differences in prices also suggest the presence of a market failure in rural El Salvador; namely, farmers lack market information. Extension programs could address this situation by generating and distributing pricing and marketing reports that can be readily used by farmers and their organizations. Furthermore, educating farmers in basic financial tools will help them to develop better market alternatives and strategies.

Third, the results show that there is a substantial difference between observed and profit maximizing cropping patterns. Although a divergence between observed and optimal plans is expected, such differences can be reduced. These differences could be a consequence of several factors. For example, farmers might simply prefer to cultivate traditional crops primary for home consumption. However, the farmers' survey suggested that peasants do not keep records of their farm's costs and returns. Moreover, the lack of information on the economics of alternative crops makes it very difficult for these producers to evaluate the expected profitability of different cropping plans. Therefore, the implementation of a service which collects and analyzes enterprises' costs and returns would help farmers to develop more profitable farm-plans. Furthermore, extension services should assist their beneficiaries in the formulation of cropping patterns using optimization techniques. In doing so, not only an optimum farm-rotation would be developed but farmers would also have a better understanding of the potential and the limitations of their business.

The findings of the study also indicate that farm profits could increase significantly by incorporating new enterprises. The technology transfer service revealed that in some cases the introduction of new crops increases farm's gross margins by more than 100%. Therefore, extension programs must take advantage of the favorable effect of nontraditional crops by providing and supporting technology transfer programs that promote crop diversification. It should be emphasized that support to improve the production side of the business needs to be coupled with assistance in marketing of both inputs and outputs.

In sum, the analysis suggest that a combination of better farm prices (paid and received), reallocation of resources, and crop diversification that would be promoted by a farm management center can lead to an increase in farm level profits that is sufficient to cover the operation of the farm management center and to still generate net gains in household income.

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Table 1. Whole Farm Analysis for Representative Farms Based on Observed Cropping Patterns

Usulután II FMC		Funsalprodese FMC	
Farm U-001	**($)**	**Farm F-001**	**($)**
Gross Revenue	421.1	Gross Revenue	656.1
Total Variable Cost	388.9	Total Variable Cost	570.2
Total Gross Margin	32.3	Total Gross Margin	85.9
Total Manzanas (Mz)	1.23	Total Manzanas	1.99
Gross Margin / Mz	26.2	Gross Margin / Mz	43.1
Farm U-002	**($)**	**Farm F-002**	**($)**
Gross Revenue	332.7	Gross Revenue	242.0
Total Variable Cost	325.6	Total Variable Cost	274.5
Total Gross Margin	7.1	Total Gross Margin	-32.5
Total Manzanas	1.03	Total Manzanas	1.33
Gross Margin / Mz	6.9	Gross Margin / Mz	-24.5
Farm U-003	**($)**	**Farm F-003**	**($)**
Gross Revenue	2,947.7	Gross Revenue	188.0
Total Variable Cost	2,075.2	Total Variable Cost	210.1
Total Gross Margin	872.5	Total Gross Margin	-22.1
Total Manzanas	4.88	Total Manzanas	1.00
Gross Margin / Mz	178.8	Gross Margin / Mz	-22.1
Farm U-004	**($)**	**Farm F-004**	**($)**
Gross Revenue	637.1	Gross Revenue	942.3
Total Variable Cost	614.1	Total Variable Cost	613.7
Total Gross Margin	23.1	Total Gross Margin	328.6
Total Manzanas	2.01	Total Manzanas	1.43
Gross Margin / Mz	11.5	Gross Margin / Mz	229.8

Table 2. Simplified Sample Tableau of the Multiperiod Linear Programming Model: Representative Farm U-004 (Economic Analysis – Scenario 4)

		Year 1				Year 2				Year 3				…	Year 10				Counting Activities by year						
		So1	…	Pa1	Ba1	So2	…	Pa2	Ba2	So3	…	Pa3	Ba3	…	So10	…	Pa10	Ba10	1	2	3	…	10		
Obj Func			…				…				…			…		…			i^1	i^2	i^3	…	i^4		Max
Year 1	**G M**	320	…	-7960	-1960		…				…			…		…			-1			…		=	0
	Land	1	…	1	1		…				…			…		…						…		<=	2.01
	Capit	140	…	7960	1960		…				…			…		…						…		<=	1256
	Rot 1	1	…				…				…			…		…						…		<=	0.67
	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	.	⋮	.	⋮	⋮	⋮	⋮	⋮	.	⋮	⋮	⋮
Year 2	**G M**		…	57470	-230	320	…	-7960	-1960		…									-1		…		=	0
	Land		…	1	1	1	…	1	1		…			…		…						…		<=	2.01
	Capit		…			120	…	1,290	140		…			…		…						…		<=	1121
	Rot 1		…			1	…				…			…		…						…		<=	0.67
	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	.	⋮	.	⋮	⋮	⋮	⋮	⋮	.	⋮	⋮	⋮
Year 3	**G M**		…	85470	530		…	57470	-230	320	…	-7960	-1960								-1	…		=	0
	Land		…	1	1		…	1	1	1	…	1	1	…		…						…		<=	2.01
	Capit		…				…			100	…	1020	120	…		…						…		<=	500
	Rot 1		…				…			1	…			…		…						…		<=	0.67
	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	.	⋮	.	⋮	⋮	⋮	⋮	⋮	.	⋮	⋮	⋮
⋮	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	⋮	.	⋮	⋮	.	⋮	.	⋮	⋮	⋮	⋮	⋮	.	⋮	⋮	⋮
Year 10	**G M**		…		850		…		850		…		900	…	320	…	-7960	-1960				…	-1	=	0
	Land		…		1		…		1		…		1	…	1	…	1	1				…		<=	2.01
	Capit		…				…				…			…	50	…	460	60				…		<=	453
	Rot 1		…				…				…			…	1	…						…		<=	0.67
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	.	⋮	⋮	⋮

So: Sorghum (Mz); **Pa:** Papaya (Mz); **Ba:** Banana (Mz); **Obj. Function:** Discounted Gross Margin; **G M:** Product Gross Margin ($);**Capt:** Operating Capital ($); **Rot1:** Rotation Restriction for Sorghum. The extended tableau for this model encompasses a matrix of 100 activities and 90 restrictions, over 10-years planning horizon.

Table 3. Discounted Benefits by Representative Farm and Farm Service: Financial Analysis (Values in $)

Representative Farm	Scenario 1	Scenario 2	Scenario 3	Scenario 4
U-001	171.7	881.4	881.4	1,017.0
U-002	37.6	694.4	694.4	821.1
U-003	4,641.4	7,709.3	7,872.9	7,872.9
U-004	122.8	1,608.5	2,559.7	28,674.6
Shrimp Production	728.8	10,141.3	10,141.3	10,141.3
F-001	456.7	1,881.8	3,257.1	25,530.1
F-002	-173.0	673.1	680.6	945.4
F-003	-117.7	563.5	592.9	744.7
F-004	1,748.1	2,970.3	4,071.8	21,570.3

Table 4. Discounted Benefits by Representative Farm and Farm Service: Economic Analysis (Values in $)

Representative Farm	Scenario 1	Scenario 2	Scenario 3	Scenario 4
U-001	1,407.26	2,161.2	2,161.2	2,189.7
U-002	1,065.65	1,763.3	1,763.3	1,802.6
U-003	9,963.89	13,222.5	13,476.1	13,476.1
U-004	2,128.85	3,706.9	10,605.2	33,392.9
Shrimp Production	774.14	10,771.8	10,771.8	10,771.8
F-001	2,213.01	3,726.7	5,720.4	32,783.1
F-002	814.92	1,713.6	1,736.1	1,967.9
F-003	633.07	1,356.6	1,392.2	1,535.7
F-004	3,417.02	4,715.2	6,989.1	26,127.8

Table 5. Project Financial and Economic Returns by Farm Model and FMC (Values in Thousands of $)

FMC	Models	Financial		Economic (A) [1]		Economic (B) [2]	
		NPV	IRR (%)	NPV	IRR (%)	NPV	IRR (%)
Usulután II	Scenario 2	181.3	16.9	188.5	16.9	-98.3	--
	Scenario 3	311.2	28.1	1,101.8	42.5	815.0	31.3
	Scenario 4	3,800.3	56.2	4,107.4	63.2	3,820.9	60.2
Funsalprodese	Scenario 2	-89.3	--	-76.6	--	-381.3	--
	Scenario 3	302.4	23.1	561.5	35.7	267.5	19.6
	Scenario 4	6,537.5	74.3	7,828.3	81.5	7,536.1	77.3

[1] The funding of the *ROCA* project is treated as a grant.
[2] The funding of the *ROCA* project is treated as a cash outflow.

Table 6. Project Financial and Economic Returns: Sensitivity Analysis (Values in Thousands of $)

FMC	Models	Financial		Economic (A) [1]		Economic (B) [2]		Economic (C) [3]	
		NPV	IRR (%)	NPV	IRR (%)	NPV	IRR (%)	NPV	IRR (%)
Usulután II	Scenario 2	-237.5	--	-230.3	--	-517.1	--	-527.1	--
	Scenario 3	-107.6	--	683.0	24.3	396.2	20.1	-379.1	--
	Scenario 4	3,381.5	40.1	3,688.6	45.2	3,401.8	43.3	3,326.9	39.7
Funsalprodese	Scenario 2	-495.4	--	-508.1	--	-571.9	--	-574.7	--
	Scenario 3	-107.5	--	142.7	17.8	-149.3	--	-388.0	--
	Scenario 4	6,118.7	58.3	7,409.5	67.6	7,117.5	65.5	5,796.1	55.6

[1] The funding of the *ROCA* project is treated as a grant.
[2] The funding of the *ROCA* project is treated as a cash outflow.
[3] The funding of the *ROCA* project is treated as a cash outflow, and labor cost equals market price.