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PILOT PLANT FOR INDUSTRIALIZATION AND PYRETHRUM PRODUCTION

DP/RWA/66/503

RWANDA

Technical report:
STUDY ON THE ESTABLISHMENT OF A PYRETHRUM (PALE) EXTRACT REFINERY

Prepared for the Government of Rwanda by the United Nations Industrial Development Organization, executing agency for the United Nations Development Programme

United Nations Industrial Development Organization

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Vienna, 1977

Explanatory notes

References to dollars ($) are to United States dollars.

The monetary unit in Rwanda is the Rwandese franc (RF). Except where otherwise indicated, the exchange rate used to convert Rwandese francs into dollars is $US 1 = RF 93.77.

Unless otherwise stated pyrethrum extract prices refer to extract with a 25% pyrethrin content by AOAC analysis.

A slash between dates (1974/75) indicates a crop year or financial year.

Use of a hyphen between dates (1972-1975) indicates the full period involved, including the beginning and end years.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millons, except in tables.

References to "tons" are to metric tons.

The following forms have been used in tables:

A dash (-) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

A minus sign before a figure (-2) denotes a deficit or decrease, except as indicated.

Parentheses around a figure indicate that it does not contribute directly to the total of the row or column in which it appears.

Totals may not add precisely because of rounding.

The following abbreviations of organizations and company names have been used in this report:

AOAC	Association of Official Agricultural Chemists
ASPY	Association des planteurs de pyréthre
FED (EDF)	European Development Fund
ISAR	Institut des sciences agronomiques du Rwanda
OCIR	Office des cultives industrielles du Rwanda
Paysannat	Peasant Co-operative
USINEX	Usine d'extraction de pyréthrine

ABSTRACT

The study on the establishment of a pyrethrum pale extract refinery, was prepared by the United Nations Industrial Development Organization (UNIDO) as part of a United Nations Development Programme (UNDP) project for a pilot plant for industrialization and pyrethrum production (DP/RWA/66/503). Its purpose is to enable prospective investors to decide on the investment potential of the project. The study outlines the history of the pyrethrum industry in Rwanda to show that it has a natural advantage over other pyrethrum growing countries (high pyrethrin content of the flowers and high yield of flowers/hectare). The Government of Rwanda has repeatedly stated its determination to continue its support for pyrethrum flower production so that it reaches 3,000 tons of dry flowers a year as soon as possible. The supply of pyrethrum flower is therefore taken as assured.

A study of the market confirms that the marketing of the country's output of pyrethrum in the form of pale extract would not upset the world market, and the producers would be able to obtain a higher price. The selection of the appropriate technology will not pose any serious problems, because processing units in different parts of the world operate satisfactorily. The national staff of the country's crude-extract plant will be a great asset for the proposed refinery. Very conservative figures are used in assessing the fixed and working capital requirements of the project. A financial analysis shows that capital required would be about $US 1.6 million, internal profitability would be 17%, and the farmers' price of flower should increase by about 30% in three years. From the third year onwards, the return on investment would be at least 6%, and the refinery would contribute to the extended operation of existing extraction facilities. An economic analysis shows that the project is highly profitable and explains the great importance the Rwandese Government attaches to this foreign currency earning industry, which also generates important rural employment opportunities. A number of actions by the Government would be required. The study refers to these in the appropriate chapters.

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INTRODUCTION

Pyrethrum flowers grown in the northern part of Rwanda are processed in a plant at Ruhengeri by USINEX to produce a partially dewaxed pyrethrin extract.

The pyrethrum crude extract plant was built in 1972 as a pilot plant with United Nations Development Programme (UNDP) funds. The United Nations Industrial Development Organization (UNIDO) was the executing agency. Although the plant was designed to treat 3,000 tons of flowers a year, it has never processed more than 1,696 tons, because of a shortage of flowers. The soils and climate of Rwanda are ideally suited for the cultivation of pyrethrum flowers, and Rwandese flowers have the highest content of pyrethrins in the world (about 1.5%). The European Development Fund helped to organize flower cultivation initially. Because of the shortage of flowers and the difficulty of selling partially dewaxed extract, USINEX, which is in charge of the operation, had financial and other difficulties. These were compounded by the arrival of synthetic pyrethrins on the market and demand by users in Europe and the United States for a refined pale extract.

UNDP and UNIDO have been trying for the last few years to help Rwanda build a pale extract refinery, and various feasibility studies have been made. Unfortunately, the $1.6 million required to finance the refinery could not be found. The present study was prepared, at the suggestion of UNDP, with a view to finding finance for the project through the UNDP Capital Development Fund or other financial organs.

In accordance with UNDP's suggestion, which was fully endorsed by the Government, the present study brings together in a single report information that will enable the financing or investment organizations (primarily UNDP) to evaluate the soundness of this project and consequently secure the financing required.

The refinery is only one of the steps being taken to improve the profitability of the pyrethrum industry: the first and most important step is the agricultural production.

This importance of flower production is shown by the large number of rural families (about 10,000) who earn their livelihood by the cultivation of pyrethrum flowers. The fate of these families is tied to the marketing of their product, which is why the refinery is also an important move towards improving the agricultural production of pyrethrum.

I. THE PYRETHRUM INDUSTRY IN RWANDA

A. Geographical location and historical development of the industry

Pyrethrum cultivation was introduced in Rwanda in 1936 with a view to producing an insecticide powder locally. Since then, pyrethrum has become the export crop of high-lying volcanic areas where coffee cannot be grown.

Pyrethrum cultivation requires the following conditions:

(a) Adequately drained, rich soils, especially volcanic soils;

(b) An altitude of between 2,000 and 2,700 m;

(c) Annual rainfall of around 1,500 mm.

The pyrethrum-cultivation area of Rwanda is located in the three prefectures where these conditions exist - Byumba, Ruhengeri and Gisenyi (see figure I) - and is at the moment concentrated in the latter two prefectures.

From 1936 to 1967 production of pyrethrum flowers was handled mainly by foreign growers. Annual production varied considerably, although yield per hectare was satisfactory, averaging 606 kg of dried flowers for the period 1953-1959. The high point was reached in 1955, with a production of 1,207 tons.

Some of the pyrethrum flowers were used domestically as an insecticide powder and some were exported in the raw state. The Government began to think of establishing a pyrethrin-extraction plant in the early 1960s. An extraction plant at Goma, Zaire, had stopped functioning and in 1963 Kenya prohibited the processing of Rwandan pyrethrum flowers in its two plants. Therefore only dry flowers could be exported, which was not economic for a number of reasons. Before industrial processing of pyrethrum could begin, however, agricultural production had to be stimulated, and this was accomplished through a project for the development of pyrethrum cultivation.

The project began in October 1967 with financial assistance from the European Development Fund (EDF). Its objective was to improve Rwanda's position in the world pyrethrum market by reducing dependency on neighbouring countries for both the processing and transporting of pyrethrum flowers. In line with this goal, the Government decided to extend the pyrethrum Paysannats (rural cooperatives) that had been started in 1961 in Ruhengeri and Gisenyi.

The project envisaged planting about 4,700 ha with pyrethrum, involving 10,000 families inside and outside the Paysannat; yield was to be 3,000 tons of dried flowers a year. Consequently, roads were built, social services instituted, the equipment required for drying the flowers was acquired, and at the beginning of 1969 a co-operative including all those benefitting from the project was established. It was called the Association of Pyrethrum Planters (ASPY).

Thus, by 1971 pyrethrum cultivation was almost entirely in the hands of the Rwandese. Moreover, in 1972 the pyrethrum selection station of the Rwandese Institute of Agronomic Sciences (ISAR) was established at Tamira to do research into the production of selected plants.

Pyrethrum production increased slowly between 1967 and 1971. The dried flowers were sold unprocessed to Kenya and the United Republic of Tanzania. Nevertheless, production did not regain its 1955 level until the extraction plant began operation in 1972.

The project to set up the plant, "Pilot plant for pyrethrum extraction and the stimulation of industrialization" (RWA/66/503), was financed by the United Nations Development Programme (UNDP) and executed by UNIDO. The plant was constructed by a consulting firm (Messrs. Rosedowns and Thomson) between 1969 and 1972, and in February 1972 Presidential Decree No. 72/10 established the pyrethrum extraction plant USINEX as a public enterprise.

Since then, the plant has been processing all the dried pyrethrum flowers produced in Rwanda. Although equipped to process 3,000 tons of dried flowers a year to crude extract, it has been able to operate at no more than half this capacity, as shown below:

	Tons
1972	1 174
1973	1 427
1974	1 301
1975	1 753
1976	1 575

The main reason for this deficiency is that USINEX has found it difficult to sell crude extract on the world market. Moreover, since the FMC refinery in Baltimore, closed in 1972, USINEX has had only one buyer, MGK of Minneapolis.

The Government is keenly interested in establishing a refinery as an extension of USINEX's existing facilities, so as to enable Rwanda to take advantage of the added value and larger markets that would result from exporting pyrethrum in pale-extract form. Several studies have been made of this possibility and all concluded that it would be advantageous to construct a new unit

Growers may buy into the co-operative by purchasing shares of RF 300 per person, which is reimbursable when they leave the co-operative. They receive the usual services of advice, supervision and assistance (insecticides, seeds for food products and selected pyrethrum clones are distributed). Within the Paysannat, each grower is expected to grow a minimum of 72 ares of pyrethrum in return for the plot assigned to him (1.8-2 ha or 180-200 ares), the rest of the land being reserved for food crops.

The co-operative buys the pyrethrum flowers from growers inside and outside the Paysannat and resells them after drying to USINEX.

	Before 1975	After 1975
Purchase price of 1 kg of fresh flowers	RF 9	RF 12
Sales price of 1 kg of dried flowers (base=1.5% pyrethrin)	RF 75	RF 84

Each delivery of fresh flowers by the grower to the reception centres or to the drying plants is recorded, after weighing, on the grower's name card.

At the end of each three-month period the weights of the deliveries are totalled for payment. As a result, however, of financial problems at ASPY (which aggravate USINEX's own difficulties), the growers have not always been paid on the agreed date. It was the growers themselves who requested the co-operative to make payments every three months, since this forced them to save. But any delay in payments poses a hardship for them, and they then tend to neglect pyrethrum in favour of other crops.

Flower production follows a seasonal cycle. It is reasonable to estimate that roughly 50% of the annual production is delivered by the growers in three months (October, November and December), which provides a basis for calculating the size of the cash reserves ASPY needs to meet its obligations to the growers at the agreed time.

Furthermore, since ASPY is paid by USINEX according to the pyrethrin content of the flowers, it should in turn pay the growers according to the quality of the flowers (percentage content of pyrethrin) and not, as it does, according to the volume of flowers delivered. Nevertheless, the negligible weight of the individual batches makes it impossible to carry out batch-by-batch analyses, and the varieties that have a high pyrethrin content often weigh less than the common ones.

Drying-plant equipment and operation

The drying plants were initially designed to operate with wood, but later, because of lack of wood, they were equipped to run on kerosene. In view of the rise in petroleum prices and the high consumption rate (about 600 litres of fuel for every 1,000 kg of dried flowers), the pyrethrum driers were converted in 1975 to peat operation. The rate of consumption is 2 tons of peat for every 1 ton of dried flowers; the cost price to the drying plant is RF 1.25 for 1 kg of peat. According to a 1975 study, the investment required for working the peat (bog work, drier conversion and the erection of storage shelters) has been put at RF 8,204,000. The same study estimated the savings in operating expenses resulting from the substitution of peat for kerosene at RF 11,550 per ton of dried flowers, making it possible to recover the investment by the end of the first year. The ratio of fresh flowers to dry flowers is close to 5:1 (in March 1977 for Ruhengeri it was 4.88:1, and for Gisenyi 5.13:1). The moisture content of the dried flowers ranges between 9 and 12%.

Financial results

	RF
1971/72	+ 3,335,957
1972/73	+ 3,672,483
1973/74	-12,791,880
1974/75 (11 months)	-22,186,915

Sources: for 1971-1973 - Mortensen Report, April 1975; for 1973-1975 - Klooss report.

Although no data seem to be available for the period 1975/76 and for the year 1976, the figures for the period 1974/75 can be broken down and the results extrapolated to the current period.

Breakdown of figures for 1974/75

	For 1,541 kg of dried flowers (RF)	For 1 kg of dried flowers (RF)
Variable costs (drying fuel RF 21,109,976 or RF 13.70/kg)	32,464,149	21.06
Fixed costs	24,348,775	15.80
Exceptional costs	5,920,000	3.84
Total	62,733,010	40.70

C. USINEX and the processing of pyrethrum flowers

This section does not deal with the technical process developed by USINEX to recover pyrethrin from dried flowers in the form of a crude extract, or with technical performance since operations began. These matters are covered in the chapter on technology.

Operation

The principal instruments governing the operation of USINEX are:

(a) The Presidential Decree of 29 February 1972 establishing USINEX;

(b) Executive Decree No. 39/75 of 7 November 1975 on Public Establishments;

(c) Presidential Decree No. 227/01 of 20 December 1976 on the staff regulations of Public Establishments.

USINEX is one of the fourteen public establishments covered by the Executive Decree of November 1975; among the others are the Agency for the Development of the Bugesera-Mayaga Natural Region (OBM), the Industrial Crop Board of Rwanda (OCIR), the Office for the Pastoral and Agricultural Development of Mutara (OVAPAM), and the National Board for the Development and Marketing of Food and Animal Products (OPROVIA).

USINEX is a public establishment invested with legal status and organic administrative and financial autonomy. It is required to employ the usual methods of double-entry bookkeeping. Its staff is governed by the Presidential Decree of December 1976, which defines the categories, grades and classes and the corresponding salary levels.

The total staff of USINEX has developed as follows:

31 August 1972	62
31 August 1973	74
31 August 1974	89
31 December 1975	109
31 December 1976	117

The 1976 staff is regarded by USINEX as the maximum required to operate the extraction installation at full capacity and to provide the general services shared by the extraction operation and the refinery. The USINEX Board of Directors has four members.

Financial supervision of the plant is the responsibility of two auditors appointed by the President of the Republic on the recommendation of the Ministry of Finance.

Marketing

Marketing figures are given in table 2.

Comparison of the figures for 1975 and 1976 seems to indicate that the prices obtainable vary inversely with the quantities sold.

Since 1975 USINEX has had only a single buyer.

Sales during the period 1974-1975 correspond to an average f.o.b. price of $10.41/lb (25% pyrethrin concentration), while sales made during 1976 correspond to an average price of $8.95/lb (25%). It appears that at the beginning of 1977, USINEX will be selling at the more remunerative price of $10.25/lb (25%).

Financial results

The cumulative results for 58 months of operation appear as follows (see also table 3):

At	Operations	Period
31 August 1972	- 2,235,477	- 2,583,216
31 August 1973	+ 4,090,763	+ 3,496,122
31 August 1974	+33,344,041	+31,791,314
31 December 1975	+22,042,755	+19,625,279
31 December 1976	+ 843,990	+ 1,722,030

Comparison of the two tables "Marketing" and "Financial results" indicates that the latter are directly affected by the price and volume of sales. The period 1974-1975 closed with a stock of crude extract amounting to 45,415 kg, which represents a value of RF 90,948,987 chargeable under the single heading of variable costs. Since the fixed costs must be borne exclusively from receipts from quantities sold, the effect on the financial result is all the greater.

Determination of break-even point
(for figures see table 4)

The break-even point determined in kg of crude extract that USINEX could have sold is proportional to the length of the accounting period (1972 - 6 months; 1974-1975 - 16 months), which means that for the 1972 accounting period (12 months) the quantity of crude extract to be sold in order to break even would have been 60,132 kg; for 1974-1975 it would have been 51,037 kg.

Table 3. USINEX - financial results (RF)

	1/3/72 to 31/8/72	1/9/72 to 31/8/73	1/9/73 to 31/8/74	1/9/74 to 31/12/75	1/1/76 to 31/12/76
Total sales	45,068,652	151,990,682	193,856,929	141,662,891	177,327,490
Crude extract	45,058,652	151,870,432	193,718,129	141,658,991	177,231,722
Fixed costs for the report period	9,819,102	21,885,647	25,931,347	46,166,145	39,528,637
Depreciation	6,608,943	13,449,822	13,350,444	19,129,218	15,162,733
Wages	1,690,862	4,503,287	7,580,647	16,958,915	13,262,056
Others	1,519,197	3,932,538	5,000,256	10,078,012	11,103,848
Variable costs	44,085,027	130,127,775	129,198,721	195,570,902	134,906,226
Dried flowers	38,082,940	115,911,085	116,767,645	175,804,909	112,206,537
Solvents	1,919,550	3,254,663	1,864,578	2,848,561	1,154,339
Energy	1,939,967	3,352,243	4,074,849	8,204,881	6,760,392
Sales expenses	1,666,842	5,225,159	3,638,900	5,135,093	12,036,569
Others	475,728	2,384,625	2,852,749	3,577,458	2,748,389
Movement of stock:					
Initial stock		5,300,720	11,649,700	2,176,117	90,948,987
Final stock	6,600,000	11,649,700	2,176,117	90,948,987	66,857,595
Cost of merchandise sold	47,304,129	145,664,442	164,603,651	152,964,177	198,526,255
Result of operation	- 2,235,477	+ 6,326,240	+ 29,253,278	- 11,301,286	- 21,198,765
Extraordinary loss or profit	- 347,739	- 246,902	- 958,086	- 864,749	+ 3,295,516
Result for the period	- 2,583,216	+ 6,079,338	+ 28,295,192	- 12,166,035	- 17,903,249

The break-even point in terms of the volume of dried flowers has been calculated on an annual basis.

Calculation of the break-even point as a percentage of the theoretical production capacity of USINEX (3,000 tons of dried flowers a year) shows that during the first four accounting periods, taking into account the selling prices that USINEX succeeded in obtaining, the factory broke even with a low rate of production. However, it should be emphasized that in this case the determination of the break-even point is based on the fictitious assumption that the entire quantity produced during the accounting period was actually sold, which is far from being the case, particularly for 1974-1975, when there was a deficit, since only 53% of the output was marketed. For the 1976 financial year, the break-even point is above the maximum capacity of the factory, owing to the low margin left for covering fixed costs out of the selling price.

D. The place of pyrethrum in the Rwandese economy

The importance of pyrethrum to the economy of Rwanda may be illustrated by reference to:

(a) Expenditure already earmarked;

(b) Jobs created;

(c) The place of pyrethrum in export.

Estimate of expenditure earmarked

		Expenditure (RF) Actual		Expenditure (RF) Planned
Paysannat (1)				
EDF agreement No. 215.014.11:	258,236,559	336,115,967	(2)	
EDF agreement No. 211.014.49:	74,175,711			
"Fourth EDF"	3,743,697			
Rwandese Government			(3)	25,478,550
ASPY			(4)	23,976,000
Beneficiaries of the project				110,037,600
USINEX				
Rwandese Government		41,145,035	(5)	
United Nations Special Fund		150,431,902	(6)	
United Nations technical assistance for project RWA/66/503: 393.6 man/months or $1,116,168 x 92		102,687,456	(7)	
Total expenditure (actual and earmarked): RF 789,872,510 or approx.$8.6 million		630,380,360		159,492,150

The place of pyrethrum in exports (RF 1,000,000)

	Exports of pyrethrum		Value of	%
	Statistical data	Corrected date (A)	total exports (B)	(A)/(B)
1966	24.3	24.3	1,174	2.1
1967	29.5	29.5	1,404	2.1
1968	17.4	17.4	1,487	1.2
1969	36.0	36.0	1,424	2.5
1970	29.2	29.2	2,481	1.2
1971	59.7	59.7	2,233	2.7
1972	79.1	101.2 [a]	1,795	5.6
1973	108.7	139.1	2,787	5.0
1974	165.9	212.3	3,459	6.1
1975	78.9	101.0	3,818	2.6
1976	120.6	154.4	7,391	2.1

a/ From 1972, the statistical data on external trade have been adjusted.

The values declared on the pro-forma export invoices and used by the Statistics Office are based on a standard pyrethrin content of 25%. They do not take into account the final payment, which is established on the basis of the actual pyrethrin content (average 32%) of USINEX products.

In 1972, pyrethrum represented 9.5% by value of exports of agricultural products from Rwanda. At the beginning of the decade under consideration, tea had roughly the same place as pyrethrum in exports, in 1976 the value of tea exports was about four times that of exports of pyrethrum; this rapid progress was due solely to the establishment of a sufficient number of tea-processing plants, whenever the need was felt.

(a) Supply ASPY with sufficient funds to alleviate its liquidity problem;

(b) Increase extract sales prices by installing a refinery at USINEX, thus enabling the pale refined extract to be sold to the wider refined-extract market.

On the whole, in spite of the large amount of pyrethrum being planted within the Paysannat, the immediate prospects for increased flower production are not promising given the present financial constraints, and production is likely to remain at the present level.

With the installation of a refinery, which could be done within two years, the level of flower production could be raised considerably, since increased payments could then be made to the Paysannat. The management of ASPY has estimated that flower production could be augmented by 400 tons a year with additional technical assistance and financial incentives. Assuming that the refinery was operational in two years' time, a suggested profile of flower production would be as follows:

	Flowers/tons a year
1976	1,575
1977	1,575
1978	1,600
1979	1,750
1980	2,050
1981	2,500
1982	3,000
1983	3,000

The required flower production of 3,000 tons could thus be achieved approximately four years after the refinery had been installed.

B. Requirements for increasing annual production to 3,000 tons

The rated capacity of the USINEX extraction plant is 3,000 tons of dried flowers a year at 10% moisture. As no factory extension is contemplated at this time, an attempt should be made to expand production to that figure.

The tendency for flower production to peak around November and December could be counteracted by an improved payment system. Because payments are delayed the peasants now usually plant at the same time every year, which accentuates the natural cycle of the crop.

Moreover, the reduction in pyrethrum cultivation and production appears to be continuing, since the USINEX factory received only 506 tons of flowers in the first three months of 1977, compared with 704 tons in the corresponding period of 1976.

Under normal conditions, with a land availability of 5,000 ha, production of approximately 3,000 tons of flowers is possible, but if yields continue to be low, flower production will be only approximately 2,500 tons. Fortunately 850 additional hectares are available at Kengi and Bondi, and they will apparently be cultivated under the auspices of USINEX. Given this additional area, and with sufficient regard for the necessary technical, management and financial inputs, flower production could reach 3,000 tons a year.

Introducing new clonal material

ASPY has limited propagation facilities and ISAR has approximately 8 ha available for a variety of clones. The clonal material distributed to the Paysannat through ASPY is strong, vigorous, nematode-resistant variety with a pyrethrin content of approximately 1.8%. Nevertheless, the amount of clonal material distributed this year will be sufficient for only 20 ha. As the total land estimated to be under cultivation is about 3,000 ha, the overall effect on increased pyrethrin content will be quite small. In fact it is possible that, with the natural decline in the pyrethrin content of old clones, the overall effect may be negligible.

Because of the important financial advantages (per kg of pyrethrum of cultivating high-pyrethrum clones,e.g. lower picking, drying and processing costs, expansion of ISAR activities in pyrethrum cultivation and propagation should be given priority.

Propagation of the new variety could be carried out by the Paysannat itself. Each member could be given a small number of clones, to be supplemented each year by additional material, and allowed to proceed with propagation in the manner that best suits him. A more practical approach, however, might be to have selected Paysannat propagators who supply material to their fellow members. Production of flowers by the propagator would be negligible, but if such a system could be properly organized the area cultivated with new clonal material could increase as follows:

Although the standard ASPY driers are otherwise satisfactory, the poor drying technique causes overdrying and pyrethrin loss. Although the usual drying time is about 16 hours, drying times of as long as 20 hours are often necessary. Furthermore, the generally static bed causes localized hot spots. With flowers that have a moisture content of less than 10%, pyrethrin loss in the drier is calculated at approximately 5-10%. The financial implication of this loss should be sufficient incentive for an appraisal of the driers.

E. The USINEX crude-extract plant

On the whole, the USINEX crude-extract plant supplied by UNIDO and UNDP gives a good impression. Most of the management functions are carried out by Rwandese with the two UNIDO experts now assigned to the project acting in a general advisory capacity. This is a marked change from 1973 when there were five UNIDO experts (project manager, chief chemist, maintenance engineer, mechanical engineer, and chemical engineer) attached to the project.

In 1974 another UNIDO expert had to be recruited to carry out administrative duties. It is gratifying to see how, since then, the Rwandese have taken over the various technical and managerial responsibilities, and it is to be hoped that their efforts will be rewarded by the emergence of an efficient, well-maintained production unit.

The plant is kept tidy and orderly in all departments, though some areas have to be cleaned continuously because of the dusty nature of the operations. The whole factory has an air of quiet efficiency, with excellent working relations between the UNIDO experts and the Rwandese counterparts and workers.

Throughout its five years history, and despite some corrosion problems and minor equipment malfunctioning, the extraction plant has satisfactorily processed all available flowers and has proved itself capable of processing 265 tons of flowers in a month, which is equivalent to a production of just over the designed capacity of 3,000 tons a year. The plant has never been under continual pressure to process flowers and has never been required to operate at much more than half its annual design capacity, except for short periods. In the circumstances it is difficult to assess performance accurately, since it has been possible to carry out essential repairs and preventive maintenance when the plant was shut down because of flower shortages.

Production recovery improved dramatically when the UNIDO experts determined the best grist-particle size and reduced the percolation and steaming-out difficulties in the extractors.

In recent years the vent system, the refrigerated vent condenser system and the steaming-out lines have been modified, and vacuuming during final distillation has been improved. The plant's improved performance may be seen from table 5, which gives production data for 1976 and the first quarter of 1977, summarized below:

	1976	First quarter 1977
Recovery (%)	96.15	98.9
Solvent (litres/ton)	20.39	17.03
Electricity (kWh/ton)	358	313
Fuel oil (litres/ton)	156	153
Antioxidant (kg/ton)	0.25	0.25
Pyrethrin content of flowers (%)	1.49	1.53

Table 5. USINEX production data

(a) 1976

Flowers received	1,569,587.0 kg
Flowers processed	1,364,427.5 kg
Average pyrethrin content of flowers	1.49%
Total pyrethrin in flowers	20,135.45 kg
Crude extract produced	59.590.0 kg
Average pyrethrin content of extract	32.52%
Total pyrethrin in extracts	19,375.70 kg
Average recovery	96.15%
Utility consumption	
Hexane	20.39 litres/ton
Fuel oil	156 litres/ton
Electricity	358 kWh/ton
Extract produced	43.67 kg/ton
Receipts of flowers since 1973	
1973/74	1,563,704.0 kg
1974/75	1,694,292.5 kg
1976	1,569,787.0 kg

The installation of the new equipment should result in far greater process stability.

Other changes in equipment include:

(a) Purchase and installation of a flower feed-belt for the mill so as to obtain a constant feed for optimum mill operation;

(b) Modification of steaming-out filters;

(c) Replacement of steaming-out lime;

(d) Installation of a stand-by vacuum pump on the final still;

(e) Modification of vent lines.

These process changes cost relatively little.

The management of USINEX is aware that further equipment purchases will be necessary, especially of critical items, since the plant has now been operational for five years. The items under consideration are:

(a) A new marc boiler;

(b) A new compressor for the refrigeration unit;

(c) New valves for extractors;

(d) A water-cooling tower to reduce the load on the existing main water-pump.

Another major expenditure will be necessary to seal off the dust-filtration bags in the mill in order to improve conditions for the employees working there. Any other outlays will probably depend on an increase in flower production and on the installation of the refinery.

A major weakness of the project has been the poor maintenance procedures adopted for the plant. This has been partly because too few UNIDO experts were assigned to this function and because preventive maintenance, including for the six critical items of equipment, was not introduced at the plant until recently.

Down time

It is difficult to draw definite conclusions about the improvement in down time because sometimes the plant is not operational owing to flower shortages, and in the early years of operation a number of shut downs were caused by the unavailability of solvent and diesel oil.

The following data give down time as a percentage of the total time available for plant operation, which is determined by flower availability:

H. Workshop

The eight people employed in the workshop, which is managed by a Rwandese, are able to do excellent work with the available equipment. Electric and oxyacetylene welding can be done, but the shop does not have the Argon Arc equipment needed for satisfactory welding of SS plate. The equipment installed in the workshop is given in detail in the UNIDO refinery-installation tender document. Recently two small rolling machines capable of rolling 5 mm MS and 4 mm SS plate were added, so that the workshop can now manufacture 800-litre tanks from plate. This size could be increased considerably if dished ends and rolled plate were imported.

Although the workshop has to buy bearings and shafts it is able to work with 8-in. pipe and to turn suitable "D" flanges. It should therefore be able to do the engineering installation work in the refinery project. Lifting gear and equipment of up to a 20-ton capacity is also available.

As the workshop is the only one in Rwanda with such extensive equipment facilities, it should be important in the country's industrialization.

I. Management and work force

The factory has a traditional management structure under the Director of USINEX, Mr. Mbatyé. There are four main sections (laboratory, production, maintenance and administration), each leaded by a Rwandese who has graduated from university or a similar institution. The sections employ 15, 53, 26 and 9 persons respectively giving a total work force of over 100.

As the factory is overstaffed, some of the personnel required for the refinery could be taken from it, especially at the supervisory level.

The factory is managed as a well-knit, efficient, integrated unit and the installation of a refinery alongside the crude-extraction plant should not pose any major management problems.

Pyrethrum cultivation is highly labour-intensive - approximately 600 man/days per year and hectare. Pyrethrum production will therefore remain the prerogative of countries that have the advantage of cheap agricultural labour.

Quantities produced

Since the 1955/56 crop year, annual production of pyrethrum dried flowers has risen by 6.7%. Table 6 illustrates the general trend.

Considerable fluctuations in the volume of production may lead to price variations that are disadvantageous to producers.

Rwanda must therefore take these fluctuations into account in its marketing strategy and endeavour in the longer term to co-operate with other producer countries in establishing buffer stocks.

Pyrethrum processing

Originally, pyrethrum was refined in the user countries. In the course of normal developments, the pyrethrum industry was relocated in the producer countries; the establishment of a refinery in Rwanda will only confirm this general development.

The present approximate pyrethrum refining capacity throughout the world (25% concentration pale extract) is as follows:

Cooper (United Kingdom)	25 tons
MC (United Kingdom)	90 tons
Prentiss (United States)	15 tons
MGK (United States)	360 tons
PMBK (Kenya)	500 tons
Total	990 tons

Existing refining capacity can process a total output of about 20,000 tons of dried flowers and would not be sufficient to process world pyrethrum output if Kenya did not sell part of its output (3,000-4,000 tons of dried flowers) in the form of powder.

The installation of supplementary capacity in Rwanda for refining 3,000 tons of dried flowers would therefore not lead to under-utilization of existing equipment, even taking into consideration the major pyrethrum refinery project in Tanzania (of the order of 400 tons of 25% pale extract). It is expected that world production of dried flowers will in any case very soon reach 30,000 tons a year, taking into account the production plans of various countries.

The place of pyrethrum in the insecticides market

There are two major categories of insecticides:

(a) Agricultural insecticides (80% of the United States market);

(b) Non-agricultural insecticides (20% of the United States market).

Pyrethrum-based insecticides are in the second category, since they have not yet been able to compete with agricultural insecticides because of their high price and their instability in sunlight.

Non-agricultural insecticides may be either natural (almost exclusively pyrethrum) or synthetic. Their applications include domestic use, use in communal establishments (hospitals, schools etc.), use in commerce (fresh food) and the food industry, and use for medical purposes.

In addition to properties expected of an insecticide - "kill effect", "knock-down effect", "repellent effect" and "flushing-out effect", which it has to a high degree, pyrethrum also has the following advantages:

(a) Unlike certain synthetic products, pyrethrum does not generally create tolerance effects and can be used against a wide range of insects;

(b) It is not toxic;

(c) Above all, it is readily degradable.

Although it is sometimes argued that pyrethrum costs more than synthetic products, its continued use in the face of competition from cheaper substitutes is sufficient proof that intrinsic qualities that the other products lack are attributed to pyrethrum in the market. The great suitability of pyrethrum for association with other products in technically very complex formulations by means of which the final product can be given all the properties peculiar to each of the components is an additional reason for believing that pyrethrum will always retain its position.

Although competing synthetic products can still benefit from economies of scale, their cost will also increase, since it is linked to the incessantly rising costs of products of the chemical industry and energy. Moreover, it must be remembered that the pyrethrum or synthetic product accounts for only about 10% of the total cost of the formulation. In other words, even if a synthetic product intended to replace pyrethrum were to cost only half as much, the final product would be only 5% cheaper and would not have the advantages and properties of a product based on natural pyrethrum.

Development of prices for pale extract

From customs statistics it is possible to determine the average c.i.f. values of pale extract imported into a country, but these statistics are not reliable in view of variations in a number of factors that they do not take into account, notably, the pure pyrethrin content.

Published market lists (in the "Chemical Marketing Reporter") show that the prices of pale extract are very stable and have remained constant over the period 1974-1977 at a price equivalent to $33.04 to $34.42 per kg, 25% concentration. Information obtained directly from sources in the profession confirms that prices for pale extract vary very little (in contrast to the variations which USINEX has encountered in sales prices of crude extract) and that there is no really keen competition between refiners they want to maintain price stability.

The quantitative development of demand

Development of demand is parallel to that of production.

The most useful account of market prospects and foreseeable trends in demand may be found in Pyrethrum, a natural insecticide with growth potential, published by ITC/UNCTAD/GATT. The assessment presented there of the development of the American market can be applied, in its general outlines, to the entire world market for pale extract, taking into account the fact that equal importance is attached to protection of the environment outside the United States. According to the publication, imports of pyrethrum since 1957 have grown on an average of 5.5% a year, which is remarkable in view of the competition from synthetics. The household insecticides market seems to offer the best growth potential. With the tightening restrictions on the use of synthetic insecticides, pyrethrum, practically the only natural insecticide, can be expected to gain in importance. It would certainly pay to invest in promotional schemes that would take advantage of the natural quality of pyrethrum. The authors of the publication conclude that even without a breakthrough in a sector that would consume large volumes, the use of pyrethrum will continue to grow at the same rate as in the previous 18 years.

A continuation of the current trend would mean a four-fold increase over the 1975 volume by 2000. Such a forecast cannot be adopted, however, because 2000 is too remote and the reference period (1957-1975) corresponds to the upward

Figure III. Pyrethrum production: world and Rwanda

Costs by weight (per kg)

Transport from the factory to Kigali	RF 9 - RF 11	(about $0.12)
Transport from Kigali to the United States	RF 163	$2.38
Total	RF 172	$2.50

The ad valorem costs have been more than doubled (in absolute terms) in order to take into account the new constraints which USINEX will face in connexion with the sale of pale extract. The transport costs have been increased by one-third in order to take into account the larger number of shipments, and are calculated for extract shipped as a 50% concentrate.

Calculation of ex-factory price

		$/kg
c.i.f. selling price		33.00
Ad valorem costs (5.6%)	1.85	
Costs by weight (2.5 ÷ 2)	1.25	3.10
Price ex-factory Ruhengeri		29.90

Further confirmation that this price estimate is reliable is the generally accepted view that the commercial value of pale extract is 30% to 50% higher than that of crude extract. Reference to the selling price of USINEX crude extract in 1976 would not be meaningful, however, since this price was particularly unfavourable (there being only one buyer). Use will therefore be made of the average price for the preceding financial year (1974/75).

	Value of USINEX sales of crude extract, f.o.b., per kg 25% concentration	Estimated value of pale extract at 30% above crude	Estimated value of pale extract at 50% above crude
Accounting period 1974/75	$22.93	$29.81	$34.40

Marketing strategy

The experience already gained by USINEX after more than five years of activity in the pyrethrum market should be an asset to it in marketing its output successfully.

None the less it is advisable to recall the principles which will underlie USINEX's marketing strategy:

(a) Establishment of a seasonal price for pale extract, taking into account the prices charged by competitors;

IV. CONSTRUCTION OF PROPOSED PALE EXTRACT REFINERY

A. Siting

When the annual production of flowers in Rwanda reaches 3,000 tons, the USINEX extraction plant will produce approximately 120,000 kg of crude extract a year containing 32.5% of pyrethrins (AOAC analysis).

It is proposed to refine all the extract produced by USINEX; assuming a refinery recovery rate of 95%, total sales will exceed 150,000 kg a year (25% AOAC basis).

The new pale extract refinery will be considerably smaller than those already erected in Kenya and Tanzania. It should be considered a medium-size refinery, but larger than a number which have been operational. In the circumstances, because of the problem of scale, it is tentatively suggested that process data and parameters be related to a well-known process that has produced high quality extract for a number of years at a capacity similar to that envisaged at USINEX.

It is proposed that the new refinery should be built adjacent to the present laboratory, on fairly level ground, outside the present boundary fence but far enough from the main entrance road for safety.

The only new building associated with the erection of the refinery should be a small electrical substation, because of the length of cable run from the main substation to the new refinery. Few additional personnel and no additional laboratory and maintenance facilities are proposed.

It has been estimated that the installed utility requirements for the refinery will be approximately:

Steam	1,300 kg/h
Electricity	71 KVA
Cooling water	20 m^3/h

The present installed capacities and utilization on the crude extraction plant are as follows:

	Installed	Present utilization
Cooling water	90 m^3/h	45 m^3/h
Electricity	500 KVA	250 KVA
Steam	1,500 kg/h	800 kg/h

approximately 20%; the remainder is a diluent such as odourless kerosene or Shellsol T. The change in appearance is remarkable and the refined extract, even at 50% concentration is a readily pourable fluid of a light yellow-orange colour.

The technology employed in pyrethrum refining is not a sophisticated one. The main technical input is know-how, which varies from process to process. Its importance should not be underestimated. The main consideration in processing crude pyrethrum extract is maximizing pyrethrin recovery within the relevant constraints.

Table 7. Specification for partially dewaxed extract

	Partially dewaxed
Pyrethrum content (PBK)	25% ± 0.5% w/w
Colour	Not applicable
Flash point (ABEL)	Over 130°F
Kerosine insolubles	max. 2% w/v
Freon insolubles	max. 1.5% w/v
Diluent	Shellsol T
Water content	max. 0.2%
Viscosity	Not applicable
Specific gravity	0.80 - 0.90 at 23°C

Table 8. Specification for refined pale extract

Pyrethrin content	20% minimum
Colour (Gardner Holt)	12 maximum
Moisture	400 ppm max.
Cloud point	30°F max.
Iron as Fe	60 ppm max.
Solubility in deodourized kerosene (e.g. Isopar M)	(a) 1 part pyrethrum to 19 parts - clear (b) 1 part pyrethrum to 99 parts - clear for 2 hours
Flash point (TOC)	180°F min.
Acid number	min. 5, max. 20
Freon insolubles	0.2% at 20% assay
Extinction coefficient	0.08 max. at 20% assay
Specific gravity at 20°C	0.845 to 0.865

C. Process Description

This section should be read with reference to figure IV, which is a flow diagram of the process under consideration.

Drums containing crude pyrethrum extract are stored for a few days in the hot water tank (5) maintained at approximately 48°C until the extract is pourable. Approximately 3,000 lb of extract is transferred to a mixer (8) and subjected to seven washes of 300 gallons each at 40°C followed by decantation. The first five washes are intermediate miscella, while the last two are always clean absolute methanol. The first decanted miscellas are sent forward for a further processing through a tank (11), and the other five are held in a second tank (4) for washing the next batch of crude extract. Anti-oxidant is added to all the methanol washes to limit pyrethrum deterioration.

Because of the difficulty of pouring all the extract from the drums, they are washed out with a small amount of ISOPAR, which is then added to the contents of the first extraction mixer (8).

After extraction of the available pyrethrins, the residues are dumped into drums from the mixer (8), together with a small amount of methanol, and are not treated further.

The 650 gallons of miscella containing approximately 10% pyrethrins are transferred together with approximately 1,000 gallons of absolute methanol, to the mixer (13) where the temperature is decreased to 10°C. After allowing the precipitated waxes to settle for one hour, the dewaxed miscella is decanted off to a tank (15), and the 5 gallons of wax removed from the bottom of the mixer (13) are returned to the extraction mixer (8) with a new batch of crude extract.

After dewaxing, the methanol miscella is decolorized with charcoal. The miscella is treated in three separate parts. Each part is mixed with 150 pounds of NUCHAR in a mixer (16) and the whole filtered in a plate and frame press (18). Celite is used as a pre-coat and filter aid, and the charcoal held in the filter press is subjected to a complex system of countercurrent batch washes. Each charcoal increment receives 5 washes of 150 gallons each, the last one being absolute methanol. There is a continual upgrading of the washes; the first one is sent on to be processed as miscella. At this stage, therefore, there are approximately 2,200 gallons of dewaxed, decolorized methanol miscella containing about 5% pyrethrins in tank (21).

In order to minimize solvent losses, the residual cakes in the filter press are steamed out, and the resultant water and methanol mixture is pumped to storage tank (20) prior to rectification in the distillation column (29). The condensed methanol is returned to store for re-use.

The next stage is to distil off the methanol from the miscella and transfer the pyrethrins into kerosene (Shellsol T or Isopar) before further processing. Methanol distillation is carried out in a small flash evaporator (22) operating under vacuum at 200 mm Hg (reduced to 5 mm Hg at the end of the distillation).

During the distillation process kerosene is taken into the still (22); so at the end of the distillation a solution of about 30% pyrethrins in kerosene is obtained. This solution, which is referred to as the semi-finished product, is transferred to tank (34), using the still heater pump (25) prior to additional processing.

The next stage of the refining process is low-temperature de-resinification of the extract. The batch is split into five or six portions, using tank (35), and the semi-finished product is diluted to about 5% concentration in hexane in mixer (39), giving a resultant volume of about 600 gallons, which is then chilled to $-10^{\circ}C$. The resins that are thrown out of the solution at the low temperature are allowed to settle to the bottom of the epoxy-coated chilling vessel (39), and the hexane-kerosene miscella is decanted into tank (40).

The resins and a small amount of miscella are transferred to another small mixer (41) where they are subjected to a hexane wash. The temperature of the hexane wash is maintained at $1^{\circ}-5^{\circ}C$, and a small number of washes are applied, giving a volume of less than 600 gallons for every batch of extract.

All the hexane washes are transfered to tank (40); the resins are dumpted from the mixer (41) and discarded.

Concentrated refined pyrethrum extract of pale quality is obtained by distilling off the hexane that was used as a solvent carrier for the de-resinification stage. This is done in a small spray evaporater (42). In order to limit colour formation during this critical evaporation, a high vacuum of 4 mm Hg is maintained throughout the whole distillation cycle, and hot water at a temperature of $55^{\circ}C$ is used as a heating medium.

18. Plate and frame filter press
19. Pump for filter press
20. Methanol wash storage tank
21. Dewaxed and decolorized methanol miscella tank
22. Jacketed flash still
23. Tube and shell condenser
24. Tube and shell miscella heater
25. Recirculating pump
26. Kerosene pump
27. Tube and shell refrigerated condenser
28. Methanol still seal pot
29. 60 plate 8 in. diameter distillation column
30. Tube and shell condenser
31. Still reboiler
32. Still seal pot
33. Vent condenser
34. Semi-finished product storage tank
35. Intermediate semi-finished product storage tank
36. Semi-finished product pump
37. Hexane pump
38. Hexane secondary storage tank
39. Chilled jacketed mixer
40. Dewaxed, decolorized and de-resined miscella storage tank
41. Mixer for washing resin
42. Hexane flash still
43. Tube and shell condenser
44. Hexane still heater
45. Still seal pot
46. Still recirculating pump
47. Refrigerated vent condenser
48. Vent condenser
49. Concentrated extract storage tank
50. Extract pump
51. Pipe filter
52. Filtered extract storage tank
53. Weighing machine

to be minimal. Moreover, as in the particular case of the USINEX crude extraction plant all the necessary support functions are already operational, it is considered that generally only plant operators will be required at the throughputs under consideration.

Additional labour requirements are itemized below for a refinery operation with a three-shift system, one shift on standby, for 300 days a year.

Management: 1 pyrethrum refining expert (executing agency)

Administration: 1 clerk

General operatives: 4 shifts, each containing one supervisor and three operators.

No additional personnel should be required in the laboratory or maintenance sections.

It is suggested that about half the general operative requirements will be obtained by direct transfer from the crude extraction plant. Both production units would then have a broad base of experienced staff who could train newly recruited members on the job.

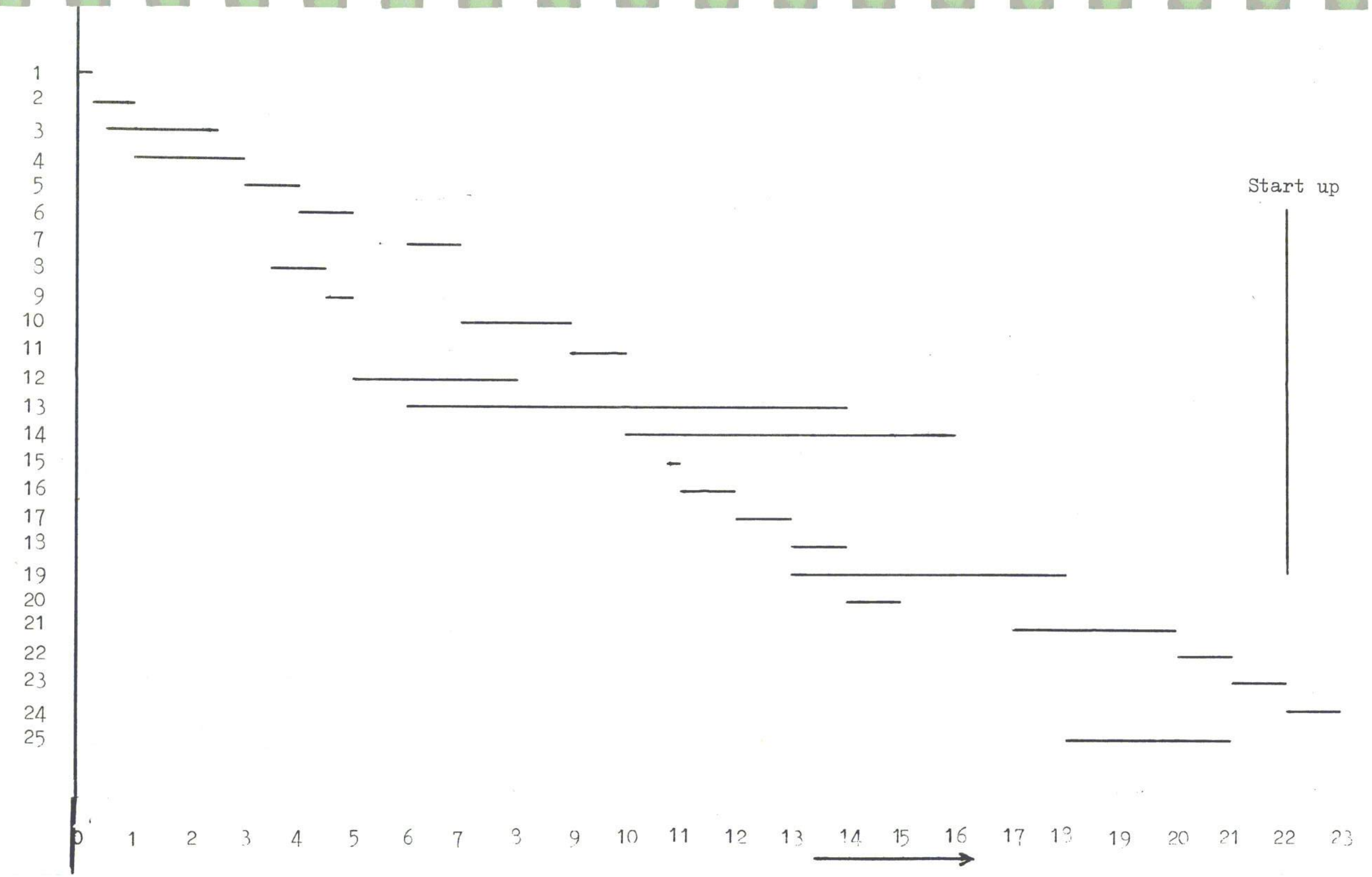
A system for training the men assigned to the refinery should be arranged and completed before start up, because the control of a refinery is much more delicate and sensitive than that of a crude extraction plant and mistakes can be very costly if made on a plant when operational, as pyrethrum is a high-value insecticide.

D. Project implementation

The critical need for a refinery at Ruhengeri makes it clear that construction should proceed as a matter of urgency.

It is proposed that an implementation unit be established as soon as possible within the executing agency entrusted with the project implementation. This is important to ensure satisfactory implementation.

Satisfactory project implementation will be achieved only if good co-ordination is maintained between the executing agency and: USINEX, the Government of Rwanda, Rwanda civil engineering companies, the company supplying "know-how", contractors, equipment suppliers, consultants, and the financing agency and other organizations.



a/ Tentatively 1 September 1977.

Figure V. General activity bar chart for pyrethrum refinery construction

Explanatory notes

References to dollars ($) are to United States dollars.

The monetary unit in Rwanda is the Rwandese franc (RF). Except where otherwise indicated, the exchange rate used to convert Rwandese francs into dollars is $US 1 = RF 93.77.

Unless otherwise stated pyrethrum extract prices refer to extract with a 25% pyrethrin content by AOAC analysis.

A slash between dates (1974/75) indicates a crop year or financial year.

Use of a hyphen between dates (1972-1975) indicates the full period involved, including the beginning and end years.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millons, except in tables.

References to "tons" are to metric tons.

The following forms have been used in tables:

A dash (-) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

A minus sign before a figure (-2) denotes a deficit or decrease, except as indicated.

Parentheses around a figure indicate that it does not contribute directly to the total of the row or column in which it appears.

Totals may not add precisely because of rounding.

The following abbreviations of organizations and company names have been used in this report:

AOAC	Association of Official Agricultural Chemists
ASPY	Association des planteurs de pyréthre
FED (EDF)	European Development Fund
ISAR	Institut des sciences agronomiques du Rwanda
OCIR	Office des cultives industrielles du Rwanda
Paysannat	Peasant Co-operative
USINEX	Usine d'extraction de pyréthrine

BBA	Bush Boake Allen Ltd
Coopers	Cooper, McDougall and Robertson Ltd
FMC	F.M.C. Corporation
MC	Mitchell Cotts and Co. Ltd
MGK	McLaughlin, Gormley King Company
PMBK	Pyrethrum Marketing Board of Kenya
TECO	Tanganyika Extract Co. Ltd

ABSTRACT

The study on the establishment of a pyrethrum pale extract refinery, was prepared by the United Nations Industrial Development Organization (UNIDO) as part of a United Nations Development Programme (UNDP) project for a pilot plant for industrialization and pyrethrum production (DP/RWA/66/503). Its purpose is to enable prospective investors to decide on the investment potential of the project. The study outlines the history of the pyrethrum industry in Rwanda to show that it has a natural advantage over other pyrethrum growing countries (high pyrethrin content of the flowers and high yield of flowers/ hectare). The Government of Rwanda has repeatedly stated its determination to continue its support for pyrethrum flower production so that it reaches 3,000 tons of dry flowers a year as soon as possible. The supply of pyrethrum flower is therefore taken as assured.

A study of the market confirms that the marketing of the country's output of pyrethrum in the form of pale extract would not upset the world market, and the producers would be able to obtain a higher price. The selection of the appropriate technology will not pose any serious problems, because processing units in different parts of the world operate satisfactorily. The national staff of the country's crude-extract plant will be a great asset for the proposed refinery. Very conservative figures are used in assessing the fixed and working capital requirements of the project. A financial analysis shows that capital required would be about $US 1.6 million, internal profitability would be 17%, and the farmers' price of flower should increase by about 30% in three years. From the third year onwards, the return on investment would be at least 6%, and the refinery would contribute to the extended operation of existing extraction facilities. An economic analysis shows that the project is highly profitable and explains the great importance the Rwandese Government attaches to this foreign currency earning industry, which also generates important rural employment opportunities. A number of actions by the Government would be required. The study refers to these in the appropriate chapters.

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INTRODUCTION

Pyrethrum flowers grown in the northern part of Rwanda are processed in a plant at Ruhengeri by USINEX to produce a partially dewaxed pyrethrin extract.

The pyrethrum crude extract plant was built in 1972 as a pilot plant with United Nations Development Programme (UNDP) funds. The United Nations Industrial Development Organization (UNIDO) was the executing agency. Although the plant was designed to treat 3,000 tons of flowers a year, it has never processed more than 1,696 tons, because of a shortage of flowers. The soils and climate of Rwanda are ideally suited for the cultivation of pyrethrum flowers, and Rwandese flowers have the highest content of pyrethrins in the world (about 1.5%). The European Development Fund helped to organize flower cultivation initially. Because of the shortage of flowers and the difficulty of selling partially dewaxed extract, USINEX, which is in charge of the operation, had financial and other difficulties. These were compounded by the arrival of synthetic pyrethrins on the market and demand by users in Europe and the United States for a refined pale extract.

UNDP and UNIDO have been trying for the last few years to help Rwanda build a pale extract refinery, and various feasibility studies have been made. Unfortunately, the $1.6 million required to finance the refinery could not be found. The present study was prepared, at the suggestion of UNDP, with a view to finding finance for the project through the UNDP Capital Development Fund or other financial organs.

In accordance with UNDP's suggestion, which was fully endorsed by the Government, the present study brings together in a single report information that will enable the financing or investment organizations (primarily UNDP) to evaluate the soundness of this project and consequently secure the financing required.

The refinery is only one of the steps being taken to improve the profitability of the pyrethrum industry: the first and most important step is the agricultural production.

This importance of flower production is shown by the large number of rural families (about 10,000) who earn their livelihood by the cultivation of pyrethrum flowers. The fate of these families is tied to the marketing of their product, which is why the refinery is also an important move towards improving the agricultural production of pyrethrum.

Despite the intertwining of the agricultural and industrial aspects of pyrethrum exploitation, the subject of the present study is essentially the profitability of the refinery, since the Government has agreed to provide the necessary organizational and financial assistance to improve agricultural production.

The existing plant for the production of partially dewaxed extract has trained a sufficient number of nationals; it is expected that in due course the Government can take over and operate the plant. Nationals trained in the operation of the pale extract refinery would be expected to take over the operation of this as well.

The study was made by a team consisting of one senior staff member from UNIDO and two consultants (one engineer and one economist). The team travelled to Rwanda where they stayed for three weeks (in Kigali and Ruhengeri) to collect the technical, economic and financial data for the study and to have discussions with the government authorities and the UNDP office at Kigali on the general concept of the study.

I. THE PYRETHRUM INDUSTRY IN RWANDA

A. Geographical location and historical development of the industry

Pyrethrum cultivation was introduced in Rwanda in 1936 with a view to producing an insecticide powder locally. Since then, pyrethrum has become the export crop of high-lying volcanic areas where coffee cannot be grown.

Pyrethrum cultivation requires the following conditions:

(a) Adequately drained, rich soils, especially volcanic soils;

(b) An altitude of between 2,000 and 2,700 m;

(c) Annual rainfall of around 1,500 mm.

The pyrethrum-cultivation area of Rwanda is located in the three prefectures where these conditions exist - Byumba, Ruhengeri and Gisenyi (see figure I) - and is at the moment concentrated in the latter two prefectures.

From 1936 to 1967 production of pyrethrum flowers was handled mainly by foreign growers. Annual production varied considerably, although yield per hectare was satisfactory, averaging 606 kg of dried flowers for the period 1953-1959. The high point was reached in 1955, with a production of 1,207 tons.

Some of the pyrethrum flowers were used domestically as an insecticide powder and some were exported in the raw state. The Government began to think of establishing a pyrethrin-extraction plant in the early 1960s. An extraction plant at Goma, Zaire, had stopped functioning and in 1963 Kenya prohibited the processing of Rwandan pyrethrum flowers in its two plants. Therefore only dry flowers could be exported, which was not economic for a number of reasons. Before industrial processing of pyrethrum could begin, however, agricultural production had to be stimulated, and this was accomplished through a project for the development of pyrethrum cultivation.

The project began in October 1967 with financial assistance from the European Development Fund (EDF). Its objective was to improve Rwanda's position in the world pyrethrum market by reducing dependency on neighbouring countries for both the processing and transporting of pyrethrum flowers. In line with this goal, the Government decided to extend the pyrethrum Paysannats (rural co-operatives) that had been started in 1961 in Ruhengeri and Gisenyi.

The project envisaged planting about 4,700 ha with pyrethrum, involving 10,000 families inside and outside the Paysannat; yield was to be 3,000 tons of

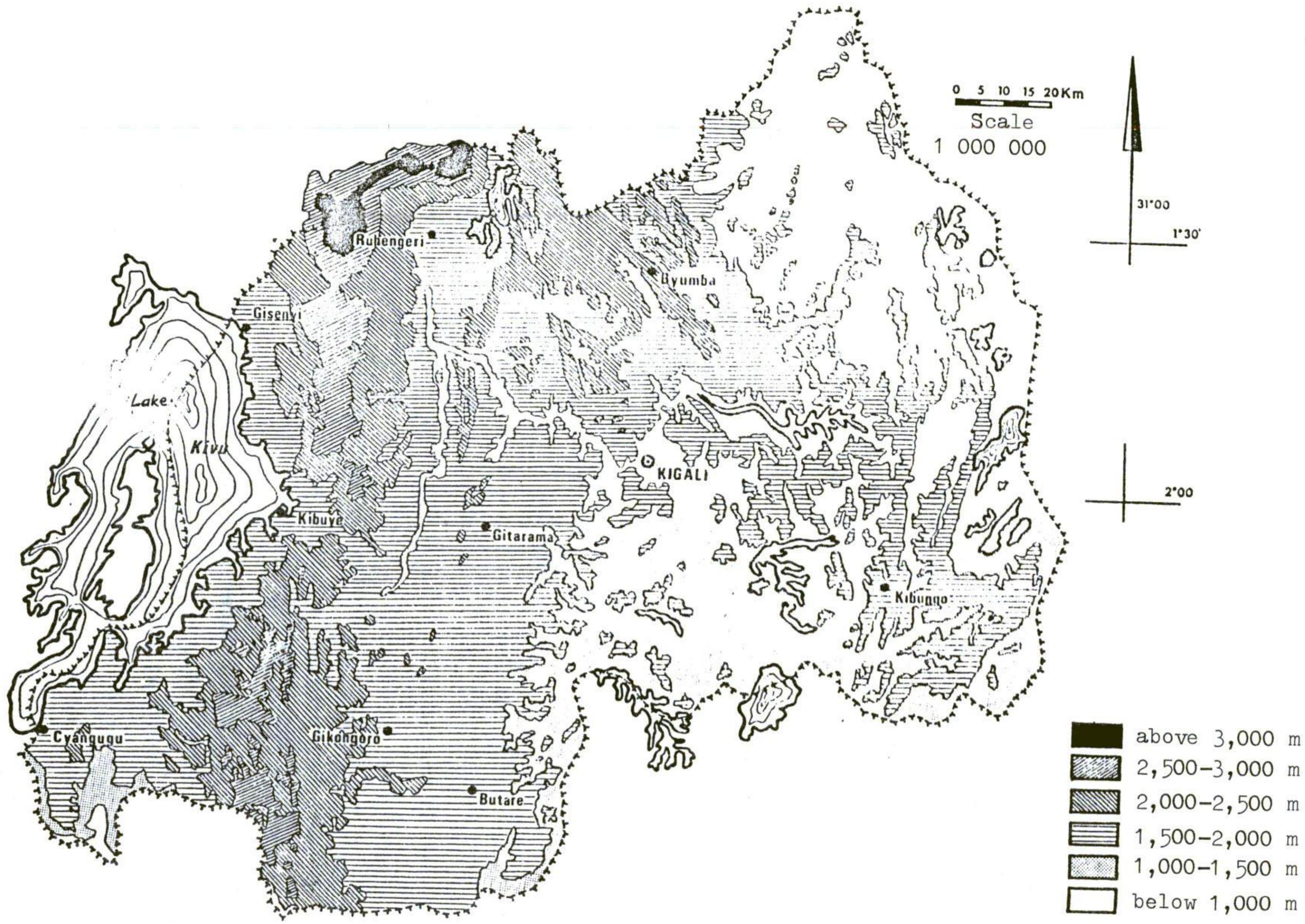


Figure I. Physical map of Rwanda

dried flowers a year. Consequently, roads were built, social services instituted, the equipment required for drying the flowers was acquired, and at the beginning of 1969 a co-operative including all those benefitting from the project was established. It was called the Association of Pyrethrum Planters (ASPY).

Thus, by 1971 pyrethrum cultivation was almost entirely in the hands of the Rwandese. Moreover, in 1972 the pyrethrum selection station of the Rwandese Institute of Agronomic Sciences (ISAR) was established at Tamira to do research into the production of selected plants.

Pyrethrum production increased slowly between 1967 and 1971. The dried flowers were sold unprocessed to Kenya and the United Republic of Tanzania. Nevertheless, production did not regain its 1955 level until the extraction plant began operation in 1972.

The project to set up the plant, "Pilot plant for pyrethrum extraction and the stimulation of industrialization" (RWA/66/503), was financed by the United Nations Development Programme (UNDP) and executed by UNIDO. The plant was constructed by a consulting firm (Messrs. Rosedowns and Thomson) between 1969 and 1972, and in February 1972 Presidential Decree No. 72/10 established the pyrethrum extraction plant USINEX as a public enterprise.

Since then, the plant has been processing all the dried pyrethrum flowers produced in Rwanda. Although equipped to process 3,000 tons of dried flowers a year to crude extract, it has been able to operate at no more than half this capacity, as shown below:

	Tons
1972	1 174
1973	1 427
1974	1 301
1975	1 753
1976	1 575

The main reason for this deficiency is that USINEX has found it difficult to sell crude extract on the world market. Moreover, since the FMC refinery in Baltimore, closed in 1972, USINEX has had only one buyer, MGK of Minneapolis.

The Government is keenly interested in establishing a refinery as an extension of USINEX's existing facilities, so as to enable Rwanda to take advantage of the added value and larger markets that would result from exporting pyrethrum in pale-extract form. Several studies have been made of this possibility and all concluded that it would be advantageous to construct a new unit for refining pale pyrethrin extract. Accordingly, the Government began consultations with suppliers of equipment in early 1977.

The current study, which incorporates the results of earlier investigations, is intended to give investors a basis for judging the profitability of the proposed refinery.

B. ASPY and the production of pyrethrum flowers

ASPY comprises all pyrethrum growers in Rwanda except those in the government enterprise (125 ha) and two expatriate planters (approximately 25 ha). As pyrethrum not covered by ASPY represents less than 4% of total production, only ASPY production will be dealt with in this chapter.

For various reasons (including changes made in the budgetary cycle of ASPY to bring it into line with the calendar year), the mission found neither reports on activities nor trading results for ASPY for the past financial year. The following information was drawn from various other sources and from personal observations and interviews.

Functioning of ASPY (see also table 1)

There are 5,800 ASPY growers within the Paysannat and 4,000 outside it. ASPY's area of operation is confined to the Ruhengeri and Gisenyi prefectures (see figure II, which also gives details of all the major services available to ASPY).

Table 1. Pyrethrum production - areas and yields

	Area planted (ha)	Number of growers	Average area per grower (ha)	Dried flowers (tons)	Average yield (kg of dried flowers per ha)
Crop season 1975/76					
Paysannat	3,199	5,800	0.55		
Outside the Paysannat	359	4,000	0.09		
Total	3,558			1,814	510
Calendar year 1976					
Paysannat	2,521	5,800	0.43		
Outside the Paysannat	344	4,000	0.09		
Total	2,865			1,500	525

Growers may buy into the co-operative by purchasing shares of RF 300 per person, which is reimbursable when they leave the co-operative. They receive the usual services of advice, supervision and assistance (insecticides, seeds for food products and selected pyrethrum clones are distributed). Within the Paysannat, each grower is expected to grow a minimum of 72 ares of pyrethrum in return for the plot assigned to him (1.8-2 ha or 180-200 ares), the rest of the land being reserved for food crops.

The co-operative buys the pyrethrum flowers from growers inside and outside the Paysannat and resells them after drying to USINEX.

	Before 1975	After 1975
Purchase price of 1 kg of fresh flowers	RF 9	RF 12
Sales price of 1 kg of dried flowers (base=1.5% pyrethrin)	RF 75	RF 84

Each delivery of fresh flowers by the grower to the reception centres or to the drying plants is recorded, after weighing, on the grower's name card.

At the end of each three-month period the weights of the deliveries are totalled for payment. As a result, however, of financial problems at ASPY (which aggravate USINEX's own difficulties), the growers have not always been paid on the agreed date. It was the growers themselves who requested the co-operative to make payments every three months, since this forced them to save. But any delay in payments poses a hardship for them, and they then tend to neglect pyrethrum in favour of other crops.

Flower production follows a seasonal cycle. It is reasonable to estimate that roughly 50% of the annual production is delivered by the growers in three months (October, November and December), which provides a basis for calculating the size of the cash reserves ASPY needs to meet its obligations to the growers at the agreed time.

Furthermore, since ASPY is paid by USINEX according to the pyrethrin content of the flowers, it should in turn pay the growers according to the quality of the flowers (percentage content of pyrethrin) and not, as it does, according to the volume of flowers delivered. Nevertheless, the negligible weight of the individual batches makes it impossible to carry out batch-by-batch analyses, and the varieties that have a high pyrethrin content often weigh less than the common ones.

To encourage production of the varieties that bring a better return to the co-operative, ASPY pays out fixed bonuses to growers who convert their pyrethrum crops to the high-yeild varieties. Once ASPY is able to ensure that the same plant stock is used throughout an entire given geographic sector, it will pay the growers concerned according to pyrethrin yield.

Facilities available to ASPY

Personnel. Most of ASPY's management staff, which also direct the activities of the Paysannat (one director and five agronomists), are provided and paid by the Ministry of Agriculture, and two experts financed by foreign sources are attached to the co-operative. ASPY's permanent staff (9 extension workers and 34 agricultural monitors) and the operational staff (400 workers) depend for their wages on the co-operative itself.

Infrastructure and material means. Under the pyrethrum project assisted by the EDF, the Government built ASPY's infrastructure, some of which (a medical centre, two schools and a veterinary centre) are funded by the public services concerned. ASPY itself is financially responsible for the following infrastructure:

(a) Roads (some 120 km of truck and tractor roads and secondary trails);

(b) Offices and shops (6) and reception centres (14);

(c) Drying plants: ASPY operates nine drying plants, one of which is rented.

ASPY has a fleet of vehicles for taking fresh flowers from the reception centres to the drying plants and dried flowers from the drying plants to USINEX, and for hauling peat. The fleet consists of three trucks and four agricultural tractors with trailers. In addition, ASPY has a tank truck and four cars.

Results

Pyrethrum production

The figures given below were gathered from ASPY sources at Ruhengeri and will appear in ASPY's next report.

Slight discrepancies exist between the ASPY and USINEX analyses of pyrethrin content, but they can be explained by differences in the analytical methods used. Therefore, only the USINEX results will be given here, since they are consistent with the technical yield of the plant and have been confirmed by the analyses carried out by the buyers of the raw extract.

Drying-plant equipment and operation

The drying plants were initially designed to operate with wood, but later, because of lack of wood, they were equipped to run on kerosene. In view of the rise in petroleum prices and the high consumption rate (about 600 litres of fuel for every 1,000 kg of dried flowers), the pyrethrum driers were converted in 1975 to peat operation. The rate of consumption is 2 tons of peat for every 1 ton of dried flowers; the cost price to the drying plant is RF 1.25 for 1 kg of peat. According to a 1975 study, the investment required for working the peat (bog work, drier conversion and the erection of storage shelters) has been put at RF 8,204,000. The same study estimated the savings in operating expenses resulting from the substitution of peat for kerosene at RF 11,550 per ton of dried flowers, making it possible to recover the investment by the end of the first year. The ratio of fresh flowers to dry flowers is close to 5:1 (in March 1977 for Ruhengeri it was 4.88:1, and for Gisenyi 5.13:1). The moisture content of the dried flowers ranges between 9 and 12%.

Financial results

	RF
1971/72	+ 3,335,957
1972/73	+ 3,672,483
1973/74	-12,791,880
1974/75 (11 months)	-22,186,915

Sources: for 1971-1973 - Mortensen Report, April 1975; for 1973-1975 - Klooss report.

Although no data seem to be available for the period 1975/76 and for the year 1976, the figures for the period 1974/75 can be broken down and the results extrapolated to the current period.

Breakdown of figures for 1974/75

	For 1,541 kg of dried flowers (RF)	For 1 kg of dried flowers (RF)
Variable costs (drying fuel RF 21,109,976 or RF 13.70/kg)	32,464,149	21.06
Fixed costs	24,348,775	15.80
Exceptional costs	5,920,000	3.84
Total	62,733,010	40.70

Adjustments to 1974-1975 figures

	(RF)	1,541 kg of dried flowers (RF)	1 kg of dried flowers (RF)
Total period	62,733,010		
Exceptional costs	- 5,920,086		
To be distributed	56,812,924		
Variable costs			
Drying fuel (2 kg peat x 1.25 x 1,541,000 kg)		3,852,500	2.50
Other variable costs		11,354,173	7.36
Total variable costs		15,206,673	9.86
Fixed costs			
24,348,775 / 11 months x 12 months		26,562,300	17.24
Total costs, fixed and variable		41,768,973	27.10

Source: Klooss report.

Allowing for a number of approximations (pyrethrin content, bonuses paid to the growers etc.), during the current period ASPY has the following margin for meeting its liabilities:

	RF
Purchase price for USINEX, 1 kg of dried flowers	84
Purchase price from growers for 5 kg of fresh flowers (equivalent to 1 kg dried flowers)	60
	24

On the basis of these figures, ASPY can balance its operations by producing 1,878 tons of dried flowers a year, as the following calculation shows:

Total margin	RF 24.00/kg
Variable costs/kg	RF 9.86/kg
Margin available to cover fixed costs	RF 14.14

$$\frac{26,562,300}{14.14} = 1,878,522 \text{ kg}$$

It should be added that ASPY's current financial situation is not in fact as poor as it might appear, since it has carried as annual operating costs an investment burden which should have been depreciated over several years.

C. USINEX and the processing of pyrethrum flowers

This section does not deal with the technical process developed by USINEX to recover pyrethrin from dried flowers in the form of a crude extract, or with technical performance since operations began. These matters are covered in the chapter on technology.

Operation

The principal instruments governing the operation of USINEX are:

(a) The Presidential Decree of 29 February 1972 establishing USINEX;

(b) Executive Decree No. 39/75 of 7 November 1975 on Public Establishments;

(c) Presidential Decree No. 227/01 of 20 December 1976 on the staff regulations of Public Establishments.

USINEX is one of the fourteen public establishments covered by the Executive Decree of November 1975; among the others are the Agency for the Development of the Bugesera-Mayaga Natural Region (OBM), the Industrial Crop Board of Rwanda (OCIR), the Office for the Pastoral and Agricultural Development of Mutara (OVAPAM), and the National Board for the Development and Marketing of Food and Animal Products (OPROVIA).

USINEX is a public establishment invested with legal status and organic administrative and financial autonomy. It is required to employ the usual methods of double-entry bookkeeping. Its staff is governed by the Presidential Decree of December 1976, which defines the categories, grades and classes and the corresponding salary levels.

The total staff of USINEX has developed as follows:

31 August 1972	62
31 August 1973	74
31 August 1974	89
31 December 1975	109
31 December 1976	117

The 1976 staff is regarded by USINEX as the maximum required to operate the extraction installation at full capacity and to provide the general services shared by the extraction operation and the refinery. The USINEX Board of Directors has four members.

Financial supervision of the plant is the responsibility of two auditors appointed by the President of the Republic on the recommendation of the Ministry of Finance.

Results

The following information is taken chiefly from USINEX financial statements. The results for 1976 will be available after 1 May 1977.

Capitalization

At 31 December 1976 the permanent capital available to USINEX amounted to RF 191,576,937, broken down as follows:

	RF	RF
Government contribution		39,423,005
Initial contribution (initial balance of allocations)	18,517,481	
Advance granted in May 1972 by OCIR (RF 20,000,000) plus related interest (balance at 31 August 1974)	20,905,524	
Subsidies from United Nations Special Fund		150,431,902
Initial contribution (initial balance of allocations)	150,263,153	
Less subsidy earmarked but not disbursed (balance statement at 31 December 1975)	- 50,614	
Reserves on equipment (balance statement at 31 December 1975)	219,363	
USINEX self-financing	1,722,030	1,722,030
	191,576,937	191,576,937

Production

The important figures are as follows:

	Production 1972-1976				
	1/3/72 to 31/8/72	1/9/72 to 31/8/73	1/9/73 to 31/8/74	1/9/74 to 31/12/75	1/6/76 to 31/12/76
Dried flowers:					
Bought (kg)	627,655	1,631,576	1,489,790	2,278,122	1,575,530
Treated (kg)	547,103	1,635,221	1,563,322	2,084,382	1,364,427
Crude extract (approx. 32% concentrate):					
Produced (kg)	23,576	71,770	71,820	95,093	59,603
Sold (kg)	20,412	68,040	77,227	50,922	72,586
Stocked (kg)	3,164	6,694	1,244	45,415	32,432
Equivalent dried flowers treated in 12 months (kg):	1,094,206	1,631,576	1,489,790	1,563,286	1,364,427
USINEX capacity (tons)	3,000	3,000	3,000	3,000	3,000
Capacity in use (%)	36	54	52	52	45

Marketing

Marketing figures are given in table 2.

Comparison of the figures for 1975 and 1976 seems to indicate that the prices obtainable vary inversely with the quantities sold.

Since 1975 USINEX has had only a single buyer.

Sales during the period 1974-1975 correspond to an average f.o.b. price of \$10.41/lb (25% pyrethrin concentration), while sales made during 1976 correspond to an average price of \$8.95/lb (25%). It appears that at the beginning of 1977, USINEX will be selling at the more remunerative price of \$10.25/lb (25%).

Financial results

The cumulative results for 58 months of operation appear as follows (see also table 3):

At	Operations	Period
31 August 1972	- 2,235,477	- 2,583,216
31 August 1973	+ 4,090,763	+ 3,496,122
31 August 1974	+33,344,041	+31,791,314
31 December 1975	+22,042,755	+19,625,279
31 December 1976	+ 843,990	+ 1,722,030

Comparison of the two tables "Marketing" and "Financial results" indicates that the latter are directly affected by the price and volume of sales. The period 1974-1975 closed with a stock of crude extract amounting to 45,415 kg, which represents a value of RF 90,948,987 chargeable under the single heading of variable costs. Since the fixed costs must be borne exclusively from receipts from quantities sold, the effect on the financial result is all the greater.

Determination of break-even point
(for figures see table 4)

The break-even point determined in kg of crude extract that USINEX could have sold is proportional to the length of the accounting period (1972 - 6 months; 1974-1975 - 16 months), which means that for the 1972 accounting period (12 months) the quantity of crude extract to be sold in order to break even would have been 60,132 kg; for 1974-1975 it would have been 51,037 kg.

Table 2. Marketing of crude extract

Marketing	1/3/72 to 31/8/72	1/9/72 to 31/8/73	1/9/73 to 31/8/74	1/9/74 to 31/12/75	1/1/76 to 31/12/76
Crude extract sold (kg)	20,412	68,040	77,227	50,922	72,586
Mean pyrethrin content (%)	30.24	31.18	32.77	33.00	32.52
Total amount of crude extract sales (RF)	45,058,652	151,870,432	193,718,129	141,658,991	177,231,722
Value of sales at the f.o.b. stage[a] (RF)	45,058,652	151,870,432	193,718,129	141,658,991	171,195,988
Average value of sales:					
F.o.b. (RF/kg)	2,207.46	2,232.08	2,508.42	2,781.88	2,358.53
Equivalent 25% pyrethrin (RF/kg)	1,824.95	1,789.67	1,913.66	2,107.48	1,813.14
Exchange rate of the United States dollar (RF)	92.11	89.26	91.85	91.91	91.91
Average price f.o.b. for 25% concentrate ($/kg)	19.81	20.05	20.83	22.93	19.73
Indices (1973 100)	(98.80)	(100.00)	(103.89)	(114.36)	(98.40)

a/ In 1976 USINEX began to sell c.i.f. Sales for that year (RF 98,569,139 c.i.f.) have been converted to f.o.b. for purposes of comparison.

Table 3. USINEX - financial results (RF)

	1/3/72 to 31/8/72	1/9/72 to 31/8/73	1/9/73 to 31/8/74	1/9/74 to 31/12/75	1/1/76 to 31/12/76
Total sales	45,068,652	151,990,682	193,856,929	141,662,891	177,327,490
Crude extract	45,058,652	151,870,432	193,718,129	141,658,991	177,231,722
Fixed costs for the report period	9,819,102	21,885,647	25,931,347	46,166,145	39,528,637
Depreciation	6,608,943	13,449,822	13,350,444	19,129,218	15,162,733
Wages	1,690,862	4,503,287	7,580,647	16,958,915	13,262,056
Others	1,519,197	3,932,538	5,000,256	10,078,012	11,103,848
Variable costs	44,085,027	130,127,775	129,198,721	195,570,902	134,906,226
Dried flowers	38,082,940	115,911,085	116,767,645	175,804,909	112,206,537
Solvents	1,919,550	3,254,663	1,864,578	2,848,561	1,154,339
Energy	1,939,967	3,352,243	4,074,849	8,204,881	6,760,392
Sales expenses	1,666,842	5,225,159	3,638,900	5,135,093	12,036,569
Others	475,728	2,384,625	2,852,749	3,577,458	2,748,389
Movement of stock:					
Initial stock		5,300,720	11,649,700	2,176,117	90,948,987
Final stock	6,600,000	11,649,700	2,176,117	90,948,987	66,857,595
Cost of merchandise sold	47,304,129	145,664,442	164,603,651	152,964,177	198,526,255
Result of operation	- 2,235,477	+ 6,326,240	+ 29,253,278	- 11,301,286	- 21,198,765
Extraordinary loss or profit	- 347,739	- 246,902	- 958,086	- 864,749	+ 3,295,516
Result for the period	- 2,583,216	+ 6,079,338	+ 28,295,192	- 12,166,035	- 17,903,249

Table 4. USINEX - determination of break-even point

	1/3/72 to 31/8/72	1/9/72 to 31/8/73	1/9/73 to 31/8/74	1/9/74 to 31/12/75	1/1/76 to 31/12/76
Quantity of crude extract produced (kg)	23,576	71,770	71,820	95,093	59,603
Fixed costs for the accounting period (RF) A.	9,819,102	21,885,647	25,931,347	46,166,145	39,528,637
Fixed costs/kg of crude extract produced (RF) B.	416.49	304.94	361.06	485.48	663.20
Variable costs (excluding sales expenses) (RF)	42,418,185	124,902,616	125,559,821	190,435,809	122,869,657
Variable costs/kg of crude extract produced (RF) C.	1,799.21	1,740.32	1,748.26	2,002.63	2,061.47
Cost/kg of crude extract ex factory (B + C) (RF) D.	2,215.70	2,045.26	2,109.32	2,488.11	2,724.67
Quantity of crude extract sold (kg)	20,412	68,040	77,227	50,922	72,586
Amount of sales (net of sales expenses) (RF)	43,391,810	146,645,273	190,079,229	136,523,898	165,195,153
Selling price/kg of crude extract, ex factory (RF) E.	2,125.80	2,155.28	2,461.31	2,681.04	2,275.85
Total margin/kg of crude extract (E - D) (RF)	+89.90	+110.02	+351.99	+192.93	-448.82
Margin of fixed costs/kg of crude extract (E - C)(RF) F.	+326.59	+414.90	+713.05	+678.41	+214.38
Break-even point in kg of crude extract (A ÷ F) (by accounting period)	30,066	52,742	36,367	68,050	184,386
Break-even point in tons of dried flowers (12 months)	1,395.42	1,201.68	791.61	1,118.71	4,220.95
Break-even point in % capacity	46.51	40.05	26.39	37.29	140.70

The break-even point in terms of the volume of dried flowers has been calculated on an annual basis.

Calculation of the break-even point as a percentage of the theoretical production capacity of USINEX (3,000 tons of dried flowers a year) shows that during the first four accounting periods, taking into account the selling prices that USINEX succeeded in obtaining, the factory broke even with a low rate of production. However, it should be emphasized that in this case the determination of the break-even point is based on the fictitious assumption that the entire quantity produced during the accounting period was actually sold, which is far from being the case, particularly for 1974-1975, when there was a deficit, since only 53% of the output was marketed. For the 1976 financial year, the break-even point is above the maximum capacity of the factory, owing to the low margin left for covering fixed costs out of the selling price.

D. The place of pyrethrum in the Rwandese economy

The importance of pyrethrum to the economy of Rwanda may be illustrated by reference to:

(a) Expenditure already earmarked;

(b) Jobs created;

(c) The place of pyrethrum in export.

Estimate of expenditure earmarked

		Expenditure (RF)	
Paysannat (1)		Actual	Planned
EDF agreement No. 215.014.11:	258,236,559		
EDF agreement No. 211.014.49:	74,175,711	336,115,967 (2)	
"Fourth EDF"	3,743,697		
Rwandese Government		(3)	25,478,550
ASPY		(4)	23,976,000
Beneficiaries of the project			110,037,600
USINEX			
Rwandese Government		41,145,035 (5)	
United Nations Special Fund		150,431,902 (6)	
United Nations technical assistance for project RWA/66/503: 393.6 man/months or $1,116,168 x 92		102,687,456 (7)	
Total expenditure (actual and earmarked): RF 789,872,510 or approx.$8.6 million		630,380,360	159,492,150

Remarks

(1) Inside and outside the Paysannat. It should be noted that the infrastructure expenses ought to be charged partly to pyrethrum and partly to food crops.

(2) Including RF 185,890,327 (or 55.30%), as technical assistance.

(3) Not including expenditure related to the ISAR station at Tamira.

(4) The report on the ASPY co-operative by G.Th. Klooss of 31 October 1975 mentions an ASPY investment of RF 102,659,777 at 31 October 1975 before depreciation. However, part of that amount came from the transfer of assets acquired in the framework of the EDF project.

(5) Including USINEX self-financing (RF 1,722,030), financial situation at 31 December 1976.

(6) Financial situation at 31 December 1976.

(7) From the beginning of the project up to 31 Decmeber 1977.

Jobs created

The jobs created should be considered on the following three levels:

(a) USINEX (105 jobs);
(b) ASPY (including peat and driers) (449 jobs);
(c) Inside and outside the Paysannat (9,800 families).

The wage-earning sector (USINEX and ASPY) has a multiplier effect on a large mass of rural manpower, that finds work in its own environment. The importance of the absorption of manpower on marginal land is revealed when one considers regional demographic and land-use data.

	Gisenyi	Ruhengeri
Total area (ha)	239,500	176,200
Cultivable land (ha)	69,826	56,427
Population	425,200	552,600
Apparent density/km^2	177	297
Agricultural land available per family (ha)	0.87	0.54

Sources: Minagri, United Nations study "Project for the development of pyrethrum growing in Rwanda", May 1965, page 9, and 1975 demographic estimates.

The place of pyrethrum in exports (RF 1,000,000)

	Exports of pyrethrum		Value of total exports (B)	% (A)/(B)
	Statistical data	Corrected date (A)		
1966	24.3	24.3	1,174	2.1
1967	29.5	29.5	1,404	2.1
1968	17.4	17.4	1,487	1.2
1969	36.0	36.0	1,424	2.5
1970	29.2	29.2	2,481	1.2
1971	59.7	59.7	2,233	2.7
1972	79.1	101.2 a/	1,795	5.6
1973	108.7	139.1	2,787	5.0
1974	165.9	212.3	3,459	6.1
1975	78.9	101.0	3,818	2.6
1976	120.6	154.4	7,391	2.1

a/ From 1972, the statistical data on external trade have been adjusted.

The values declared on the pro-forma export invoices and used by the Statistics Office are based on a standard pyrethrin content of 25%. They do not take into account the final payment, which is established on the basis of the actual pyrethrin content (average 32%) of USINEX products.

In 1972, pyrethrum represented 9.5% by value of exports of agricultural products from Rwanda. At the beginning of the decade under consideration, tea had roughly the same place as pyrethrum in exports, in 1976 the value of tea exports was about four times that of exports of pyrethrum; this rapid progress was due solely to the establishment of a sufficient number of tea-processing plants, whenever the need was felt.

II. CURRENT FLOWER PRODUCTION AND EXISTING CRUDE-EXTRACT PLANT

A. Flower production

During 1976 the factory received 1,569 tons of flowers having on an average a pyrethrin content of 1.48% and a moisture content of approximately 10%. Flower receipts during the first three months of 1976 were approximately 704 tons, as against only 506 tons for the first quarter of 1977, although a planned flower production of 1,905 tons had been budgeted for this year.

Present indications are that this level will not be reached, nor will the increase in pyrethrin content to 1.55% be attained. The average pyrethrin content of the flower received by USINEX this year is 1.5%.

The production of flowers in earlier years was as follows:

	Tons
1973/74	1,563
1974/75	1,696

The data is based on a financial year August to August. For the calendar year 1976, production of flower has been estimated at a record 1,796 tons. Yet whichever way the data is examined it would appear that for a variety of reasons production since the dramatic increases of the early 1970s has reached a plateau of between 1,550 and 1,750 tons, and that new impetus must be found if the ASPY expansion programme is to continue.

The reasons given for the decreasing rate of growth in flower production in the Paysannat participating in the ASPY cultivation scheme are:

(a) USINEX's lack of interest in expanding flower production because of difficulties in obtaining a realistic price for crude-extract sales;

(b) Delays in payments of up to six months by ASPY to the Paysannat which have made growers lose confidence in pyrethrum as a crop.

ASPY's liquidity problem could seriously impede the expansion of the pyrethrum industry in Rwanda. Examples of the peasants' loss of interest in the cultivation of pyrethrum are their not cutting back plants and not replacing plants after a growing period of five yeras. Indeed, it was found that over all, fields were in a better condition in May 1974 than in May 1977. As the main obstacle to continued pyrethrum expansion seems to be the commercial and financial difficulties of ASPY and USINEX, a solution would be to:

(a) Supply ASPY with sufficient funds to alleviate its liquidity problem;

(b) Increase extract sales prices by installing a refinery at USINEX, thus enabling the pale refined extract to be sold to the wider refined-extract market.

On the whole, in spite of the large amount of pyrethrum being planted within the Paysannat, the immediate prospects for increased flower production are not promising given the present financial constraints, and production is likely to remain at the present level.

With the installation of a refinery, which could be done within two years, the level of flower production could be raised considerably, since increased payments could then be made to the Paysannat. The management of ASPY has estimated that flower production could be augmented by 400 tons a year with additional technical assistance and financial incentives. Assuming that the refinery was operational in two years' time, a suggested profile of flower production would be as follows:

	Flowers/tons a year
1976	1,575
1977	1,575
1978	1,600
1979	1,750
1980	2,050
1981	2,500
1982	3,000
1983	3,000

The required flower production of 3,000 tons could thus be achieved approximately four years after the refinery had been installed.

B. Requirements for increasing annual production to 3,000 tons

The rated capacity of the USINEX extraction plant is 3,000 tons of dried flowers a year at 10% moisture. As no factory extension is contemplated at this time, an attempt should be made to expand production to that figure.

The tendency for flower production to peak around November and December could be counteracted by an improved payment system. Because payments are delayed the peasants now usually plant at the same time every year, which accentuates the natural cycle of the crop.

Both USINEX and ASPY successfully dealt with a production of 330 tons in January 1975, although USINEX limited its extraction capacity to 265 tons, which is equivalent to 3,000 tons a year. According to ASPY's management, flower yields of 630 kg/ha with an average pyrethrin content of 1.5% are possible at the present time. These would be easily the best yields in the world. A major increase in flower production would result from increasing the hectarage laid to pyrethrum, with a secondary improvement obtainable by introducing higher clonal varieties of pyrethrum. The hectarage currently under cultivation is:

		Hectares
Inside the Paysannat	1976	2,500
	1977 (estimated)	3,200
Outside the Paysannat	1976	300
Small growers	1976	40

If the 1977 figure is reached, flower production may be increased to 1,900 tons, but this is doubtful given the present situation of ASPY and the Paysannat.

The total land available for cultivation is:

	Hectares
Inside the Paysannat	4,300
Outside the Paysannat	600
Small growers	40

or approximately 5,000 ha. It was generally accepted in the past that the yield of flower in Rwanda was from 600 to 630 kg/ha of dried flowers. ASPY has used the higher figure for planning purposes. If, however, the total production of flower delivered to USINEX during 1975 and 1976 is calculated on the basis of the areas under cultivation of 3,558 and 2,805 ha respectively, yields are 505 and 560 kg/ha.

This discrepancy in yield may be due to one or a combination of the following factors:

(a) Reduced interest in pyrethrum growing by the Paysannat;
(b) Inaccurate estimation of cultivable areas;
(c) In-planting of pyrethrum with other crops.

Moreover, the reduction in pyrethrum cultivation and production appears to be continuing, since the USINEX factory received only 506 tons of flowers in the first three months of 1977, compared with 704 tons in the corresponding period of 1976.

Under normal conditions, with a land availability of 5,000 ha, production of approximately 3,000 tons of flowers is possible, but if yields continue to be low, flower production will be only approximately 2,500 tons. Fortunately 850 additional hectares are available at Kengi and Bondi, and they will apparently be cultivated under the auspices of USINEX. Given this additional area, and with sufficient regard for the necessary technical, management and financial inputs, flower production could reach 3,000 tons a year.

Introducing new clonal material

ASPY has limited propagation facilities and ISAR has approximately 8 ha available for a variety of clones. The clonal material distributed to the Paysannat through ASPY is strong, vigorous, nematode-resistant variety with a pyrethrin content of approximately 1.8%. Nevertheless, the amount of clonal material distributed this year will be sufficient for only 20 ha. As the total land estimated to be under cultivation is about 3,000 ha, the overall effect on increased pyrethrin content will be quite small. In fact it is possible that, with the natural decline in the pyrethrin content of old clones, the overall effect may be negligible.

Because of the important financial advantages (per kg of pyrethrum of cultivating high-pyrethrum clones,e.g. lower picking, drying and processing costs, expansion of ISAR activities in pyrethrum cultivation and propagation should be given priority.

Propagation of the new variety could be carried out by the Paysannat itself. Each member could be given a small number of clones, to be supplemented each year by additional material, and allowed to proceed with propagation in the manner that best suits him. A more practical approach, however, might be to have selected Paysannat propagators who supply material to their fellow members. Production of flowers by the propagator would be negligible, but if such a system could be properly organized the area cultivated with new clonal material could increase as follows:

	Hectares
1978	80
1979	320
1980	1,280
1981	5,120

Although this rate of expansion may be somewhat optimistic, the pyrethrin content of flowers could be increased considerably within five years.

C. Drying and transportation capacity

One of the major techno-commercial achievements of ASPY has been the conversion of all 23 of their driers from oil to peat burning. The driers now operate extremely well, with good airflow and temperature control. The original suggestion to use peat was made by UNIDO, which also suggested changing the boiler fuel in the plant from oil to peat or pyrethrum marc.

The peat has a moisture content of 25-30% and burns well in the newly designed furnace. Approximately 3½ tons of peat are required for each ton of dried flowers, but the estimated reserves of 220,000 tons should be sufficient for 25-30 years of operation.

The driers, which are situated in nine centres, have a rated capacity of 15 tons/month. With the present installation and good organization total installed drier capacity is 345 tons/month. As stated earlier, the largest production of flowers was achieved in Janaury 1975 at 330 tons.

Although it is inadvisable to install driers to deal with peak production, it is obvious that additional drying capacity will be required, and the nine extra driers proposed by ASPY may have to be reassessed if any major changes in peaking occur when flower production reaches 3,000 tons a year.

With regard to transport arrangements ASPY has earmarked funds for purchasing five more trucks for transporting the flowers from the driers to USINEX and foresees no major problems since they have already handled 330 tons in a month.

D. Flower quality

It is generally recognized that Rwanda pyrethrum flowers are the best in the world. They have a pyrethrin content of over 1.5% as compared with 1.22% in Tanzania, and 1.30% in Kenya, and they are easily processed to give a high-quality crude extract at excellent recovery rates.

Although the standard ASPY driers are otherwise satisfactory, the poor drying technique causes overdrying and pyrethrin loss. Although the usual drying time is about 16 hours, drying times of as long as 20 hours are often necessary. Furthermore, the generally static bed causes localized hot spots. With flowers that have a moisture content of less than 10%, pyrethrin loss in the drier is calculated at approximately 5-10%. The financial implication of this loss should be sufficient incentive for an appraisal of the driers.

E. The USINEX crude-extract plant

On the whole, the USINEX crude-extract plant supplied by UNIDO and UNDP gives a good impression. Most of the management functions are carried out by Rwandese with the two UNIDO experts now assigned to the project acting in a general advisory capacity. This is a marked change from 1973 when there were five UNIDO experts (project manager, chief chemist, maintenance engineer, mechanical engineer, and chemical engineer) attached to the project.

In 1974 another UNIDO expert had to be recruited to carry out administrative duties. It is gratifying to see how, since then, the Rwandese have taken over the various technical and managerial responsibilities, and it is to be hoped that their efforts will be rewarded by the emergence of an efficient, well-maintained production unit.

The plant is kept tidy and orderly in all departments, though some areas have to be cleaned continuously because of the dusty nature of the operations. The whole factory has an air of quiet efficiency, with excellent working relations between the UNIDO experts and the Rwandese counterparts and workers.

Throughout its five years history, and despite some corrosion problems and minor equipment malfunctioning, the extraction plant has satisfactorily processed all available flowers and has proved itself capable of processing 265 tons of flowers in a month, which is equivalent to a production of just over the designed capacity of 3,000 tons a year. The plant has never been under continual pressure to process flowers and has never been required to operate at much more than half its annual design capacity, except for short periods. In the circumstances it is difficult to assess performance accurately, since it has been possible to carry out essential repairs and preventive maintenance when the plant was shut down because of flower shortages.

After a false start in April 1972, plant acceptance trials were finally completed in October 1973. The plant was required to prove that over a three-day period it could process 12 tons/day of dried pyrethrum flowers, operate at a pyrethrin recovery rate of 93% and at a solvent loss of 3% by weight of flowers processed, i.e. an N-hexane loss of 45 litres a ton. Not taken into account were consumption of fuel oil, water, gas oil, steam and electricity. The plant passed its acceptance test with flying colours, processing over 46 tons of flowers with a recovery of 96% pyrethrin and a solvent loss of only 18 litres a ton.

Since then, the plant has never been able to perform at this level owing mainly to the staffs limited knowledge of technology involved and to problems with grist size, percolation and steaming out in the extractors, blocking of the steaming-out condenser and solvent removal in the final distillation unit.

Other problems noted on down time were due to breakdowns in the boiler and cooling water-pump and to the unavailability of solvent. In an attempt to stabilize process performance, plant throughput was reduced to 9 tons/day.

The data given below may give some idea of the problems facing the plant in the early years of operation:

	Percentage recovery $\left(\frac{\text{Pyrethrin in crude extract}}{\text{Pyrethrin in flowers}} \times 100\right)$
1971/72	91.5
1972/73	92.1
1973/74	99

	Utility and solvent consumption per ton of dried flowers	
	1972/73	1973/74
Solvent (litres)	79	68
Fuel oil (litres)	123	138
Electricity (kWh)	87	307
Gas oil (litres)	64	(Generator not used)

Production recovery improved dramatically when the UNIDO experts determined the best grist-particle size and reduced the percolation and steaming-out difficulties in the extractors.

In recent years the vent system, the refrigerated vent condenser system and the steaming-out lines have been modified, and vacuuming during final distillation has been improved. The plant's improved performance may be seen from table 5, which gives production data for 1976 and the first quarter of 1977, summarized below:

	1976	First quarter 1977
Recovery (%)	96.15	98.9
Solvent (litres/ton)	20.39	17.03
Electricity (kWh/ton)	358	313
Fuel oil (litres/ton)	156	153
Antioxidant (kg/ton)	0.25	0.25
Pyrethrin content of flowers (%)	1.49	1.53

Table 5. USINEX production data

(a) 1976

Flowers received	1,569,587.0 kg
Flowers processed	1,364,427.5 kg
Average pyrethrin content of flowers	1.49%
Total pyrethrin in flowers	20,135.45 kg
Crude extract produced	59.590.0 kg
Average pyrethrin content of extract	32.52%
Total pyrethrin in extracts	19,375.70 kg
Average recovery	96.15%
Utility consumption	
Hexane	20.39 litres/ton
Fuel oil	156 litres/ton
Electricity	358 kWh/ton
Extract produced	43.67 kg/ton
Receipts of flowers since 1973	
1973/74	1,563,704.0 kg
1974/75	1,694,292.5 kg
1976	1,569,787.0 kg

(b) 1977 first quarter

Flowers received	506,957 kg
Flowers processed	517,392 kg
Average moisture content	10%
Average pyrethrin content of flowers	1.53%
Crude extract produced	23,365 kg
Average pyrethrin content of extract	33.52%
Average rocovery	98.9%
Utility consumption	
Hexane	17.03 litres/ton
Fuel oil	153 litres/ton
Electricity	313 kWh/ton
Antioxidant	0.25 kg/ton

These very satisfactory performance levels have been attained by process optimization rather than by the installation of extensive additional equipment (although some small new pieces have been installed). The choice of the semi-batch percolation system as the appropriate technology has thus been justified. Similar units are being used in Ecuador, Papua New Guinea and the United Republic of Tanzania.

The increase in fuel-oil consumption is disappointing but may be due to inadequate boiler maintenance during the early years of operation. USINEX proposes to install a new dual-purpose marc/fuel oil-burning boiler because of the high cost of fuel oil in Rwanda.

F. Equipment and maintenance

Although the equipment designed for the USINEX plant works well mechanically, limitations have been imposed by the general lack of process know-how. As in any chemical-process plant, not all equipment is perfect, and process optimization is necessary in a new plant. To replace some old equipment, UNIDO purchased the following items which were recently installed:

Additional laboratory equipment
New SS steaming-out condenser
New ion-exchange water-treatment plant for the boiler
Additional dry-powder fire extinguishers

The installation of the new equipment should result in far greater process stability.

Other changes in equipment include:

(a) Purchase and installation of a flower feed-belt for the mill so as to obtain a constant feed for optimum mill operation;

(b) Modification of steaming-out filters;

(c) Replacement of steaming-out lime;

(d) Installation of a stand-by vacuum pump on the final still;

(e) Modification of vent lines.

These process changes cost relatively little.

The management of USINEX is aware that further equipment purchases will be necessary, especially of critical items, since the plant has now been operational for five years. The items under consideration are:

(a) A new marc boiler;

(b) A new compressor for the refrigeration unit;

(c) New valves for extractors;

(d) A water-cooling tower to reduce the load on the existing main water-pump.

Another major expenditure will be necessary to seal off the dust-filtration bags in the mill in order to improve conditions for the employees working there. Any other outlays will probably depend on an increase in flower production and on the installation of the refinery.

A major weakness of the project has been the poor maintenance procedures adopted for the plant. This has been partly because too few UNIDO experts were assigned to this function and because preventive maintenance, including for the six critical items of equipment, was not introduced at the plant until recently.

Down time

It is difficult to draw definite conclusions about the improvement in down time because sometimes the plant is not operational owing to flower shortages, and in the early years of operation a number of shut downs were caused by the unavailability of solvent and diesel oil.

The following data give down time as a percentage of the total time available for plant operation, which is determined by flower availability:

Cause	1972/73 (%)	1976 (%)
No fuel or solvent	14	-
No energy	13	8
Production equipment	1	2
Difficulties in steaming	4	1
Blocked lines and percolation	3	1
Various stoppages and annual shut down	6	3
Total down time	41	15

The decrease in down time was achieved chiefly through improved management and through ensuring and adequate solvent stock. Although the boiler is still the main cause of down time, there has been general improvement since better maintenance techniques were introduced. It should be noted that considerable maintenance can take place when the plant is shut down because of flower shortage.

G. Laboratory analysis and extract quality

The laboratory is supervised by a Rwandese. Its work programme is extensive, and aside from carrying out chemical analyses of flower samples received by the factory and samples of crude extracts sold to international buyers, it assists the pyrethrum-propagation company ISAR by analysing hundreds of samples of clonal material every year by UV spectroscopy.

A disagreement has apparently arisen between ISAR and USINEX about flower analysis. Unfortunately no standard samples of extracts are used for checking the accuracy of the laboratory, and therefore the only realistic way of ascertaining its efficiency is by comparing the USINEX analysis of commercial extract flow samples with those of the various buyers. As no recent analytical data is available from buyers because of delays in exchanging information, comparative data for the period November 1974 to July 1976.

It may be seen from these results that most of the USINEX analyses agree with those of the buyers M.G.K. and M.C. and that in only 3 out of 26 analyses was it considered necessary to use the services of a referee, Stilwell + Gladding of New York. The referee's analysis, however, was not particularly enlightening, since it tended to be on the high side. In fact the overall comparison of figures confirms the USINEX laboratory's international reputation in pyrethrin analysis.

H. Workshop

The eight people employed in the workshop, which is managed by a Rwandese, are able to do excellent work with the available equipment. Electric and oxyacetylene welding can be done, but the shop does not have the Argon Arc equipment needed for satisfactory welding of SS plate. The equipment installed in the workshop is given in detail in the UNIDO refinery-installation tender document. Recently two small rolling machines capable of rolling 5 mm MS and 4 mm SS plate were added, so that the workshop can now manufacture 800-litre tanks from plate. This size could be increased considerably if dished ends and rolled plate were imported.

Although the workshop has to buy bearings and shafts it is able to work with 8-in. pipe and to turn suitable "D" flanges. It should therefore be able to do the engineering installation work in the refinery project. Lifting gear and equipment of up to a 20-ton capacity is also available.

As the workshop is the only one in Rwanda with such extensive equipment facilities, it should be important in the country's industrialization.

I. Management and work force

The factory has a traditional management structure under the Director of USINEX, Mr. Mbatyé. There are four main sections (laboratory, production, maintenance and administration), each leaded by a Rwandese who has graduated from university or a similar institution. The sections employ 15, 53, 26 and 9 persons respectively giving a total work force of over 100.

As the factory is overstaffed, some of the personnel required for the refinery could be taken from it, especially at the supervisory level.

The factory is managed as a well-knit, efficient, integrated unit and the installation of a refinery alongside the crude-extraction plant should not pose any major management problems.

III. STUDY OF MARKETS FOR THE REFINERY

The success of the pyrethrum operation in Rwanda will depend on whether pale extract can be sold at a better price than crude extract, a question that this chapter is intended to answer.

A. The world pyrethrum market

Development of world pyrethrum production

Production zones

Before the first world war the main production zones were in the Balkans, but pyrethrum cultivation practically ceased there as a result of the disruption caused by the war. As a result, Japan took first place among the producer countries. During the period between the two world wars, pyrethrum production was introduced in East Africa, particularly in Kenya.

The second world war coincided with a boom in the production of pyrethrum in East Africa, first of all to make up for the cessation of supplies from Japan and later to satisfy the increased needs for insecticides resulting from the war itself. Since then the countries of East Africa have retained their leading place. In 1974-1975, Kenya, the United Republic of Tanzania and Rwanda produced 92% of the world's pyrethrum. Kenya alone accounted for 66%; Japan's share fell from 27% in 1955/56 to 1.3% in 1974/75.

The redistribution of the production zones occurred at the same time wage levels in the producer countries were rising. While the standard of living in Japan and the Mediterranean countries of Europe is too high for them to remain large producers, a number of countries with a low standard of living are interested in pyrethrum production (Bolivia, India, Indonesia, New Guinea, Thailand and others) although they have only little experience in the agricultural research applied to local conditions.

In terms of the average wage level, which is an indicator of labour costs, Rwanda, which is one of the least developed countries, has an important advantage even over Kenya. The wage-rate for unskilled manpower in Rwanda is RF 60 (Ministerial decree No. 221/09 of 3 May 1976); in Kenya it is 30% higher. At the present level of selling prices for the output of USINEX, the remuneration of the Rwandese grower (RF 60 per kilogramme of dried flowers) represents more than 50% of the value of the crude extract.

Pyrethrum cultivation is highly labour-intensive - approximately 600 man/days per year and hectare. Pyrethrum production will therefore remain the prerogative of countries that have the advantage of cheap agricultural labour.

Quantities produced

Since the 1955/56 crop year, annual production of pyrethrum dried flowers has risen by 6.7%. Table 6 illustrates the general trend.

Considerable fluctuations in the volume of production may lead to price variations that are disadvantageous to producers.

Rwanda must therefore take these fluctuations into account in its marketing strategy and endeavour in the longer term to co-operate with other producer countries in establishing buffer stocks.

Pyrethrum processing

Originally, pyrethrum was refined in the user countries. In the course of normal developments, the pyrethrum industry was relocated in the producer countries; the establishment of a refinery in Rwanda will only confirm this general development.

The present approximate pyrethrum refining capacity throughout the world (25% concentration pale extract) is as follows:

Cooper (United Kingdom)	25 tons
MC (United Kingdom)	90 tons
Prentiss (United States)	15 tons
MGK (United States)	360 tons
PMBK (Kenya)	500 tons
Total	990 tons

Existing refining capacity can process a total output of about 20,000 tons of dried flowers and would not be sufficient to process world pyrethrum output if Kenya did not sell part of its output (3,000-4,000 tons of dried flowers) in the form of powder.

The installation of supplementary capacity in Rwanda for refining 3,000 tons of dried flowers would therefore not lead to under-utilization of existing equipment, even taking into consideration the major pyrethrum refinery project in Tanzania (of the order of 400 tons of 25% pale extract). It is expected that world production of dried flowers will in any case very soon reach 30,000 tons a year, taking into account the production plans of various countries.

Table 6. Development of pyrethrum production
(tons)

Country	1955-1956	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972	1972-1973	1973-1974	1974-1975
Kenya	3,477	11,059	7,300	5,909	9,747	14,400	10,679	13,721	15,400
United Republic of Tanzania	616	5,102	4,757	2,416	2,665	4,300	3,000	3,832	4,500
Ecuador	...	1,609	1,744	1,457	1,241	1,100	800	800	800
Japan	2,000	950	838	700	600	380	300	300	300
Rwanda	1,200	120	200	640	800	1,000	1,420	1,490	1,600
Other countries	...	700	620	600	580	600	700	700	700
Total	7,893	19,540	15,459	11,722	15,633	21,780	16,899	20,843	23,300

Source: E. Casida and UNCTAD/GATT.

The place of pyrethrum in the insecticides market

There are two major categories of insecticides:

(a) Agricultural insecticides (80% of the United States market);

(b) Non-agricultural insecticides (20% of the United States market).

Pyrethrum-based insecticides are in the second category, since they have not yet been able to compete with agricultural insecticides because of their high price and their instability in sunlight.

Non-agricultural insecticides may be either natural (almost exclusively pyrethrum) or synthetic. Their applications include domestic use, use in communal establishments (hospitals, schools etc.), use in commerce (fresh food) and the food industry, and use for medical purposes.

In addition to properties expected of an insecticide - "kill effect", "knock-down effect", "repellent effect" and "flushing-out effect", which it has to a high degree, pyrethrum also has the following advantages:

(a) Unlike certain synthetic products, pyrethrum does not generally create tolerance effects and can be used against a wide range of insects;

(b) It is not toxic;

(c) Above all, it is readily degradable.

Although it is sometimes argued that pyrethrum costs more than synthetic products, its continued use in the face of competition from cheaper substitutes is sufficient proof that intrinsic qualities that the other products lack are attributed to pyrethrum in the market. The great suitability of pyrethrum for association with other products in technically very complex formulations by means of which the final product can be given all the properties peculiar to each of the components is an additional reason for believing that pyrethrum will always retain its position.

Although competing synthetic products can still benefit from economies of scale, their cost will also increase, since it is linked to the incessantly rising costs of products of the chemical industry and energy. Moreover, it must be remembered that the pyrethrum or synthetic product accounts for only about 10% of the total cost of the formulation. In other words, even if a synthetic product intended to replace pyrethrum were to cost only half as much, the final product would be only 5% cheaper and would not have the advantages and properties of a product based on natural pyrethrum.

Nevertheless, an appropriate marketing policy should be adopted, to emphasize in the eyes of the final consumer the special properties of natural pyrethrum, and a brand image of pyrethrum-based insecticides should be created that would increase sales.

Characteristics of demand

Consumer countries

The following table shows the percentage distribution of exports of pyrethrum by-product in 1974 as a percentage of total f.o.b. value.

Product	Destination	
	Developed countries	Developing countries
Flowers and powder	19	81
Extract	93	7
Marc	92	8

Source: Compiled by ITC.

Among the industrialized countries, three countries dominate the market: the United States, Great Britain, and Italy. These countries alone represent more than 60% of total world imports of pyrethrum.

Distribution system

Refiners do not normally sell pale extract directly to the final processors (the formulators and manufacturers of insecticides). The active substance (in this case, pyrethrin) represents only a very small proportion of the total volume of the insecticide (of the order of 0.2 to 0.3%). It is therefore clear that except in very rare cases, the refiner cannot market his product in small consignments to the very numerous formulators (more than 500 throughout the world) and must work with a certain number of distributors who stock the entire range of raw materials needed by the formulators. The market for pyrethrum is therefore a "closed" market dominated by the main distributors, who in turn have common interests with the refiners.

Development of prices for pale extract

From customs statistics it is possible to determine the average c.i.f. values of pale extract imported into a country, but these statistics are not reliable in view of variations in a number of factors that they do not take into account, notably, the pure pyrethrin content.

Published market lists (in the "Chemical Marketing Reporter") show that the prices of pale extract are very stable and have remained constant over the period 1974-1977 at a price equivalent to $33.04 to $34.42 per kg, 25% concentration. Information obtained directly from sources in the profession confirms that prices for pale extract vary very little (in contrast to the variations which USINEX has encountered in sales prices of crude extract) and that there is no really keen competition between refiners they want to maintain price stability.

The quantitative development of demand

Development of demand is parallel to that of production.

The most useful account of market prospects and foreseeable trends in demand may be found in Pyrethrum, a natural insecticide with growth potential, published by ITC/UNCTAD/GATT. The assessment presented there of the development of the American market can be applied, in its general outlines, to the entire world market for pale extract, taking into account the fact that equal importance is attached to protection of the environment outside the United States. According to the publication, imports of pyrethrum since 1957 have grown on an average of 5.5% a year, which is remarkable in view of the competition from synthetics. The household insecticides market seems to offer the best growth potential. With the tightening restrictions on the use of synthetic insecticides, pyrethrum, practically the only natural insecticide, can be expected to gain in importance. It would certainly pay to invest in promotional schemes that would take advantage of the natural quality of pyrethrum. The authors of the publication conclude that even without a breakthrough in a sector that would consume large volumes, the use of pyrethrum will continue to grow at the same rate as in the previous 18 years.

A continuation of the current trend would mean a four-fold increase over the 1975 volume by 2000. Such a forecast cannot be adopted, however, because 2000 is too remote and the reference period (1957-1975) corresponds to the upward phase of a long-term cycle. A realistic forecast would be an average annual increase in sales of pale extract of at least 3%. This would mean a market increase of more than 50% over 15 years. The quantity of dried flowers processed would thus increase from 20,000 tons in 1975 to 30,000 tons in 1990. This is a minimum estimate that does not take into account the much wider prospects which would be opened up if pyrethrum penetrated the market for agricultural (horticultural and arboricultural) and forestry insecticides, which appears likely in the light of experiments now under way (e.g. in Japan).

B. Marketing of the pale extract produced by USINEX

Absorption of the output of USINEX by the world market

The technical specifications and quality standards required for pale extract are not mentioned here, because the manufacturing process envisaged takes them into account and the pale extract produced by USINEX will therefore meet market requirements.

Although it is possible that USINEX may turn to account part of the pyrethrum marc (most of which, however, is used to feed the plant boiler) by placing on the domestic market an insecticide that will guarantee peasants better preservation of their stores of foodstuffs, sales on the domestic market will have only a marginal effect on the results achieved by USINEX. In the foreseeable future (up to 1990) the pale extract produced by USINEX can therefore be absorbed only by the world market.

Figure III gives an idea of production in Rwanda compared with world production. The upper curve shows the annual production in tons of dried flowers by the five most important producing countries (Ecuador, Japan, Kenya, Rwanda and the United Republic of Tanzania). The curve, which is for flowers intended for the production of pale extract, is based on actual figures for the period 1955 to 1975, and on forecasts for 1975 to 1990 (average annual increase of 3%). The lower curve shows the quantity of dried flowers sold by Rwanda - unprocessed from 1955 to 1972, in the form of crude extract from 1972 to 1978, and in the form of pale extract from 1979, taking into account that the full capacity of the plant will be achieved from 1982.

The graph is intended to give only a rough idea of the situation; the pale extract/dried flowers equivalences do not take into account the differences in pyrethrin content.

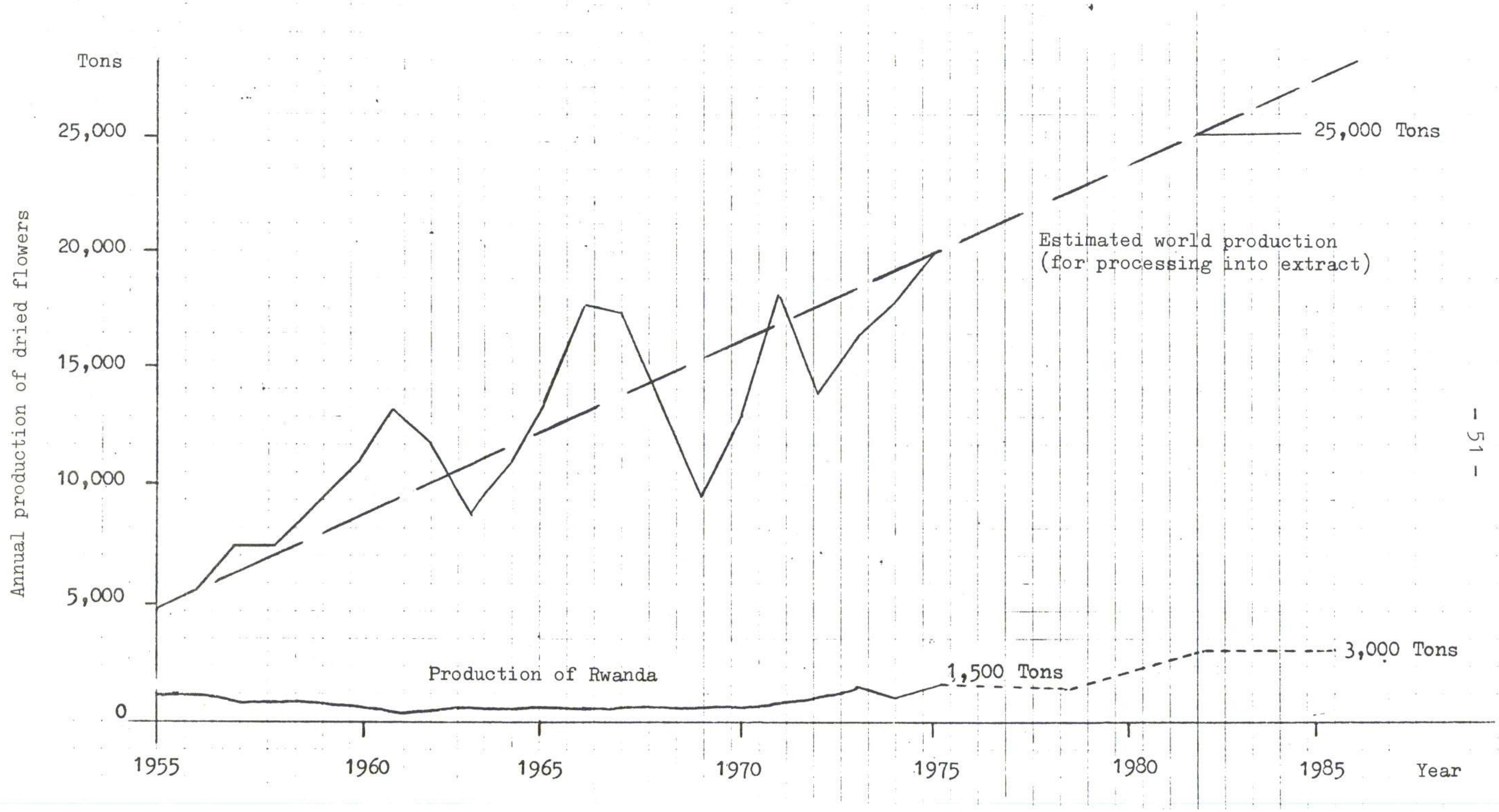


Figure III. Pyrethrum production: world and Rwanda

Rwandese production is now marketed in the form of crude extract, but after processing into pale extract, it accounts for approximately 7.5% of world sales of pale extract. In the light of the estimates shown in the graph, the additional share of the world market that Rwanda will have to claim in order to market its production of pale extract can be estimated as follows:

Rwanda's share in the world market for pale extract

Year	Total share	Increase compared with 1975
1975	7.5%	-
1982	12.5%	5%
1990	10.0%	2.5%

These figures confirm that the additional production should not be difficult to sell, particularly in view of the knowledge that USINEX already has of the market and plans to improve by a search for potential purchasers.

Estimate of the selling price of pale extract produced by USINEX

USINEX and UNIDO have both endeavoured to carry out as reliable a survey as possible; according to their information (which is highly confidential) it appears that the base price quoted in the documents listed below corresponds on the whole to the real market price. The estimate of the selling price to be used in determining the profitability of the project has therefore been prepared on the basis of information contained in the Chemical Marketing Reporter, issue of 18 April 1977, and the ITC/UNCTAD/GATT publication, Pyrethrum, a natural insecticide with growth potential. The prices quoted are \$US 12.25/lb, for 20% extract, ex-factory and \$US 132/kg, for 100% extract at a stage equivalent to c.i.f. United States port of entry respectively. The figure of \$132 is the one most commonly quoted. Expressed in standard terms (25% concentration), the prices become \$US 33.13/kg and \$US 33.00/kg respectively. The following table shows the calculation of the ex-factory price based on the lower figure of \$33.00 c.i.f.

Costs to be deducted from c.i.f. value

	USINEX accounts for 1976 (%)	Estimates adopted for 1979 (%)
Ad valorem costs (c.i.f.):		
Sales commissions	2.5	2.5
Bank and telex charges etc.	0.3	0.6
Other sales expenses	-	2.5
Total	2.8	5.6

Costs by weight (per kg)

Transport from the factory to Kigali	RF 9 - RF 11	(about $0.12)
Transport from Kigali to the United States	RF 163	$2.38
Total	RF 172	$2.50

The ad valorem costs have been more than doubled (in absolute terms) in order to take into account the new constraints which USINEX will face in connexion with the sale of pale extract. The transport costs have been increased by one-third in order to take into account the larger number of shipments, and are calculated for extract shipped as a 50% concentrate.

Calculation of ex-factory price

		$/kg
c.i.f. selling price		33.00
Ad valorem costs (5.6%)	1.85	
Costs by weight (2.5 ÷ 2)	1.25	3.10
Price ex-factory Ruhengeri		29.90

Further confirmation that this price estimate is reliable is the generally accepted view that the commercial value of pale extract is 30% to 50% higher than that of crude extract. Reference to the selling price of USINEX crude extract in 1976 would not be meaningful, however, since this price was particularly unfavourable (there being only one buyer). Use will therefore be made of the average price for the preceding financial year (1974/75).

Value of USINEX sales of crude extract, f.o.b., per kg 25% concentration		Estimated value of pale extract at 30% above crude	Estimated value of pale extract at 50% above crude
Accounting period 1974/75	$22.93	$29.81	$34.40

Marketing strategy

The experience already gained by USINEX after more than five years of activity in the pyrethrum market should be an asset to it in marketing its output successfully.

None the less it is advisable to recall the principles which will underlie USINEX's marketing strategy:

(a) Establishment of a seasonal price for pale extract, taking into account the prices charged by competitors;

(b) Refusal to grant discounts (other than quantity discounts) on the fixed price, since, in a very closed market, this would result in reprisals by competing countries, to the detriment of all producer countries;

(c) Selling to distributors, who can maintain stocks, rather than to formulators and manufacturers, since the latter represent a less stable market;

(d) In the longer term, participation with the other producer countries in agreements aimed at stabilizing prices, if necessary through the financing of buffer stocks, and in joint promotion campaigns for pyrethrum as the "natural insecticide".

These promotion campaigns should reintroduce quality labels indicating the natural pyrethrin content of the insecticide (0.20% and more), and they should be aimed at bringing about the establishment of regulations authorizing clear mention of the "relative" non-toxicity of pyrethrum-based insecticides and of their value for environmental protection.

These principles will spare USINEX some of the difficulties that it might otherwise encounter vis-à-vis already established competitors. Since the pyrethrum market is something of a "club" it is advisable to know and respect its conventions. Competitors will therefore have no reason for endangering sales of pale extract by USINEX through reprisals and dumping, especially as they know that USINEX's maximum production potential is 3,000 tons owing to the limited amount of land available for pyrethrum cultivation in Rwanda.

It is perhaps worth mentioning that a plant operating at Goma, in Zaire, has successfully marketed its output (its customers include some distributors who are members of the "club") while remaining financially and technically independent of the "club".

IV. CONSTRUCTION OF PROPOSED PALE EXTRACT REFINERY

A. Siting

When the annual production of flowers in Rwanda reaches 3,000 tons, the USINEX extraction plant will produce approximately 120,000 kg of crude extract a year containing 32.5% of pyrethrins (AOAC analysis).

It is proposed to refine all the extract produced by USINEX; assuming a refinery recovery rate of 95%, total sales will exceed 150,000 kg a year (25% AOAC basis).

The new pale extract refinery will be considerably smaller than those already erected in Kenya and Tanzania. It should be considered a medium-size refinery, but larger than a number which have been operational. In the circumstances, because of the problem of scale, it is tentatively suggested that process data and parameters be related to a well-known process that has produced high quality extract for a number of years at a capacity similar to that envisaged at USINEX.

It is proposed that the new refinery should be built adjacent to the present laboratory, on fairly level ground, outside the present boundary fence but far enough from the main entrance road for safety.

The only new building associated with the erection of the refinery should be a small electrical substation, because of the length of cable run from the main substation to the new refinery. Few additional personnel and no additional laboratory and maintenance facilities are proposed.

It has been estimated that the installed utility requirements for the refinery will be approximately:

Steam	1,300 kg/h
Electricity	71 KVA
Cooling water	20 m^3/h

The present installed capacities and utilization on the crude extraction plant are as follows:

	Installed	Present utilization
Cooling water	90 m^3/h	45 m^3/h
Electricity	500 KVA	250 KVA
Steam	1,500 kg/h	800 kg/h

As a new marc boiler is being installed by the USINEX management, it may be seen that no major capital expenditure will be required for electrical systems, steam, or cooling water supply or installation, except where they are directly related to the refinery equipment installation.

The refinery building will have the same construction as the present building erected at Ruhengeri.

Although the refinery will operate under USINEX management, it is proposed to erect it separate from any of the present buildings to permit some degree of independence and to emphasize that both crude extraction plant and refinery should operate as entirely separate profit centres.

The refinery will have bulk blending chemical and products storage separate from the crude-extraction plant. This will not result in crude extract facilities being redundant, as it is expected that small quantities of crude extract will be sold to some buyers.

Ample housing is available for the expatriate staff engaged on the project at the UNDP housing estate, and accommodation is available for construction supervisors at the guesthouse situated on the housing estate.

B. Technology of pyrethrum refining

The refining of pyrethrum extracts became an important issue approximately 15 years ago with the introduction of the oil-based aerosol for spraying household insecticides. It was found that crude extracts, even at the low concentrations required by formulators, blocked the valve of the aerosol and caused discoloration of curtains and wall paper that had been sprayed by aerosols.

The problems were overcome by the production of refined extract, and the quality of the refined extracts produced has been sufficiently high to permit the introduction of very fine and sophisticated valve systems and water-based aerosols. General specifications for partially dewaxed and refined extract are given in tables 7 and 8.

Crude extract contains about 33% pyrethrins as an oleo-resin. It is a very viscous black mass that is difficult or impossible to pour, depending on its source. Refining to a pyrethrin content of 25% reduces the wax content to approximately 20%; the remainder is a diluent such as odourless kerosene or Shellsol T. The change in appearance is remarkable and the refined extract, even at 50% concentration is a readily pourable fluid of a light yellow-orange colour.

The technology employed in pyrethrum refining is not a sophisticated one. The main technical input is know-how, which varies from process to process. Its importance should not be underestimated. The main consideration in processing crude pyrethrum extract is maximizing pyrethrin recovery within the relevant constraints.

Table 7. Specification for partially dewaxed extract

	Partially dewaxed
Pyrethrum content (PBK)	25% $\pm$ 0.5% w/w
Colour	Not applicable
Flash point (ABEL)	Over 130°F
Kerosine insolubles	max. 2% w/v
Freon insolubles	max. 1.5% w/v
Diluent	Shellsol T
Water content	max. 0.2%
Viscosity	Not applicable
Specific gravity	0.80 - 0.90 at 23°C

Table 8. Specification for refined pale extract

Pyrethrin content	20% minimum
Colour (Gardner Holt)	12 maximum
Moisture	400 ppm max.
Cloud point	30°F max.
Iron as Fe	60 ppm max.
Solubility in deodourized kerosene (e.g. Isopar M)	(a) 1 part pyrethrum to 19 parts - clear (b) 1 part pyrethrum to 99 parts - clear for 2 hours
Flash point (TOC)	180°F min.
Acid number	min. 5, max. 20
Freon insolubles	0.2% at 20% assay
Extinction coefficient	0.08 max. at 20% assay
Specific gravity at 20°C	0.845 to 0.865

The operations used in pyrethrum refining are:

(a) Dewaxing;

(b) Decolorization;

(c) De-resinification;

(d) Extract stabilization.

Processes which have been proposed or used for pyrethrum refining fall into two main classes: solvent extraction processes and distillation processes.

Distillation processes have not achieved commercial success. Neither they nor processes that utilize solvent extraction of the flowers directly are considered further.

Examination of solvent extraction processes reveals a fairly general pattern: a non-specific purification process is used to obtain crude pyrethrum extract using a suitable solvent, and the product is chilled to separate impurities. The solvent is removed by distillation to yield a concentrated extract that, depending on the initial solvent used, may not be completely soluble in the petroleum distillate normally used in standardizing pyrethrum extracts. To overcome this, the concentrated extractive is dissolved in a lower aliphatic hydrocarbon solvent, chilled to aid separation of more impurities and, if necessary, decolorized with charcoal. After filtration and distillation the concentrated extract is standardized with a suitable petroleum distillate.

The following are the most commonly used solvents:

Dewaxing	Methanol
De-resinification	Methanol Hexane
Decolorization	Hexane
Stabilization	Kerosene, Shellsol T.

The similarity of the major processes is remarkable, since there are more selective solvents for use in pyrethrum refining. It is felt, however, that the choice is determined by economic factors and solvent availability.

For the purpose of this study, a well-known classical process that has been successfully and commercially used for a number of years is described in detail in the next section. A complete equipment list and utility requirements are also given.

C. Process Description

This section should be read with reference to figure IV, which is a flow diagram of the process under consideration.

Drums containing crude pyrethrum extract are stored for a few days in the hot water tank (5) maintained at approximately 48°C until the extract is pourable. Approximately 3,000 lb of extract is transferred to a mixer (8) and subjected to seven washes of 300 gallons each at 40°C followed by decantation. The first five washes are intermediate miscella, while the last two are always clean absolute methanol. The first decanted miscellas are sent forward for a further processing through a tank (11), and the other five are held in a second tank (4) for washing the next batch of crude extract. Anti-oxidant is added to all the methanol washes to limit pyrethrum deterioration.

Because of the difficulty of pouring all the extract from the drums, they are washed out with a small amount of ISOPAR, which is then added to the contents of the first extraction mixer (8).

After extraction of the available pyrethrins, the residues are dumped into drums from the mixer (8), together with a small amount of methanol, and are not treated further.

The 650 gallons of miscella containing approximately 10% pyrethrins are transferred together with approximately 1,000 gallons of absolute methanol, to the mixer (13) where the temperature is decreased to 10°C. After allowing the precipitated waxes to settle for one hour, the dewaxed miscella is decanted off to a tank (15), and the 5 gallons of wax removed from the bottom of the mixer (13) are returned to the extraction mixer (8) with a new batch of crude extract.

After dewaxing, the methanol miscella is decolorized with charcoal. The miscella is treated in three separate parts. Each part is mixed with 150 pounds of NUCHAR in a mixer (16) and the whole filtered in a plate and frame press (18). Celite is used as a pre-coat and filter aid, and the charcoal held in the filter press is subjected to a complex system of countercurrent batch washes. Each charcoal increment receives 5 washes of 150 gallons each, the last one being absolute methanol. There is a continual upgrading of the washes; the first one is sent on to be processed as miscella. At this stage, therefore, there are approximately 2,200 gallons of dewaxed, decolorized methanol miscella containing about 5% pyrethrins in tank (21).

In order to minimize solvent losses, the residual cakes in the filter press are steamed out, and the resultant water and methanol mixture is pumped to storage tank (20) prior to rectification in the distillation column (29). The condensed methanol is returned to store for re-use.

The next stage is to distil off the methanol from the miscella and transfer the pyrethrins into kerosene (Shellsol T or Isopar) before further processing. Methanol distillation is carried out in a small flash evaporator (22) operating under vacuum at 200 mm Hg (reduced to 5 mm Hg at the end of the distillation).

During the distillation process kerosene is taken into the still (22); so at the end of the distillation a solution of about 30% pyrethrins in kerosene is obtained. This solution, which is referred to as the semi-finished product, is transferred to tank (34), using the still heater pump (25) prior to additional processing.

The next stage of the refining process is low-temperature de-resinification of the extract. The batch is split into five or six portions, using tank (35), and the semi-finished product is diluted to about 5% concentration in hexane in mixer (39), giving a resultant volume of about 600 gallons, which is then chilled to $-10^{\circ}C$. The resins that are thrown out of the solution at the low temperature are allowed to settle to the bottom of the epoxy-coated chilling vessel (39), and the hexane-kerosene miscella is decanted into tank (40).

The resins and a small amount of miscella are transferred to another small mixer (41) where they are subjected to a hexane wash. The temperature of the hexane wash is maintained at $1^{\circ}-5^{\circ}C$, and a small number of washes are applied, giving a volume of less than 600 gallons for every batch of extract.

All the hexane washes are transfered to tank (40); the resins are dumpted from the mixer (41) and discarded.

Concentrated refined pyrethrum extract of pale quality is obtained by distilling off the hexane that was used as a solvent carrier for the de-resinification stage. This is done in a small spray evaporater (42). In order to limit colour formation during this critical evaporation, a high vacuum of 4 mm Hg is maintained throughout the whole distillation cycle, and hot water at a temperature of $55^{\circ}C$ is used as a heating medium.

On completion of the distillation, the concentrated extract is stored in tank (49) and, in order to achieve complete de-resinification, is filtered through a pipe filter (51). If necessary, celite is used as a filter aid. A kerosene wash used for extract dilution is applied to reduce pyrethrin loss.

The final stages of the process are fairly standard operations and are used on all refining processes.

The filtered pale concentrate extract is stored in tank (52); prior to dispatch, sufficient extract is weighed into the blending tanks (54), where kerosene is added to adjust the pyrethrin content to the required level. This operation may require a few days before the laboratory is satisfied that the necessary dilution has been achieved. Finally, the extract is weighed accurately into double-duty lacquered drums. Because of the value of the extract the drums are double sealed prior to dispatch.

Equipment requirements

The following equipment is required for the process described (items 1 to 56 correspond to the components of the flow diagram in figure IV):

1. Main hexane storage tank
2. Main methanol storage tank
3. Intermediate hexane storage tank
4. Intermediate methanol storage tank
5. Heating tank for extract drums
6. Kerosene storage tank
7. Intermediate kerosene storage tank
8. Methanol/PD extract, mixer extractor
9. Clean methanol pump
10. Methanol miscella pump
11. Methanol miscella storage tank
12. Methanol miscella intermediate tank
13. Jacketed mixer for dewaxing
14. Dewaxed methanol miscella pump
15. Dewaxed methanol miscella storage tank
16. Mixer for carbon addition
17. Carbon filter pump

18. Plate and frame filter press
19. Pump for filter press
20. Methanol wash storage tank
21. Dewaxed and decolorized methanol miscella tank
22. Jacketed flash still
23. Tube and shell condenser
24. Tube and shell miscella heater
25. Recirculating pump
26. Kerosene pump
27. Tube and shell refrigerated condenser
28. Methanol still seal pot
29. 60 plate 8 in. diameter distillation column
30. Tube and shell condenser
31. Still reboiler
32. Still seal pot
33. Vent condenser
34. Semi-finished product storage tank
35. Intermediate semi-finished product storage tank
36. Semi-finished product pump
37. Hexane pump
38. Hexane secondary storage tank
39. Chilled jacketed mixer
40. Dewaxed, decolorized and de-resined miscella storage tank
41. Mixer for washing resin
42. Hexane flash still
43. Tube and shell condenser
44. Hexane still heater
45. Still seal pot
46. Still recirculating pump
47. Refrigerated vent condenser
48. Vent condenser
49. Concentrated extract storage tank
50. Extract pump
51. Pipe filter
52. Filtered extract storage tank
53. Weighing machine

54. Two extract dilution and blending tanks
55. Extract recirculating pump
56. Weighing machine
57. Two vacuum pumps
58. Hot water system
59. Hot water pumps
60. 16 ton frecn refrigeration unit
61. Calcium chloride tank heat exchanger
62. Calcium chloride pump
63. One compressor
64. Valves, various
65. Instruments, various
66. Methanol vent lines
67. Hexane vent lines
68. Steam lines
69. Steam traps
70. General piping
71. Hot water lines
72. Vacuum lines
73. Cooling water lines
74. Refrigeration lines
75. Compressed air lines
76. Fire fighting equipment, effluent treatment, lagging, paint and tools.

Most of the items are of a simple construction and mainly manufactured in mild steel. Only when the surface is in contact with concentrate or dilute refined extract is it essential to manufacture equipment from 18-8 stainless steel. In many cases where intermediate miscellas and extract have to be processed, epoxy coated tanks and vessels have been used quite successfully by a number of companies. However, even though most of the equipment is fairly unsophisticated, it is expected that all the equipment required for the refinery will have to be imported into Rwanda. The USINEX workshops are able to manufacture only small tanks, which are not suitable for the refinery operation.

Labour requirements

In comparison with the requirements of the extraction plant now in existence the labour requirements for a pyrethrum refinery may be considered to be minimal. Moreover, as in the particular case of the USINEX crude extraction plant all the necessary support functions are already operational, it is considered that generally only plant operators will be required at the throughputs under consideration.

Additional labour requirements are itemized below for a refinery operation with a three-shift system, one shift on standby, for 300 days a year.

Management: 1 pyrethrum refining expert (executing agency)

Administration: 1 clerk

General operatives: 4 shifts, each containing one supervisor and three operators.

No additional personnel should be required in the laboratory or maintenance sections.

It is suggested that about half the general operative requirements will be obtained by direct transfer from the crude extraction plant. Both production units would then have a broad base of experienced staff who could train newly recruited members on the job.

A system for training the men assigned to the refinery should be arranged and completed before start up, because the control of a refinery is much more delicate and sensitive than that of a crude extraction plant and mistakes can be very costly if made on a plant when operational, as pyrethrum is a high-value insecticide.

D. Project implementation

The critical need for a refinery at Ruhengeri makes it clear that construction should proceed as a matter of urgency.

It is proposed that an implementation unit be established as soon as possible within the executing agency entrusted with the project implementation. This is important to ensure satisfactory implementation.

Satisfactory project implementation will be achieved only if good co-ordination is maintained between the executing agency and: USINEX, the Government of Rwanda, Rwanda civil engineering companies, the company supplying "know-how", contractors, equipment suppliers, consultants, and the financing agency and other organizations.

It would seem advisable that at least one highly qualified and experienced technician is assigned to the unit, particularly in view of the extensive travelling involved.

As the site of the refinery has been chosen to limit interruption of the operation of the crude extraction plant, the erection of the refinery can be considered as a separate project from the extraction plant operation and should proceed normally.

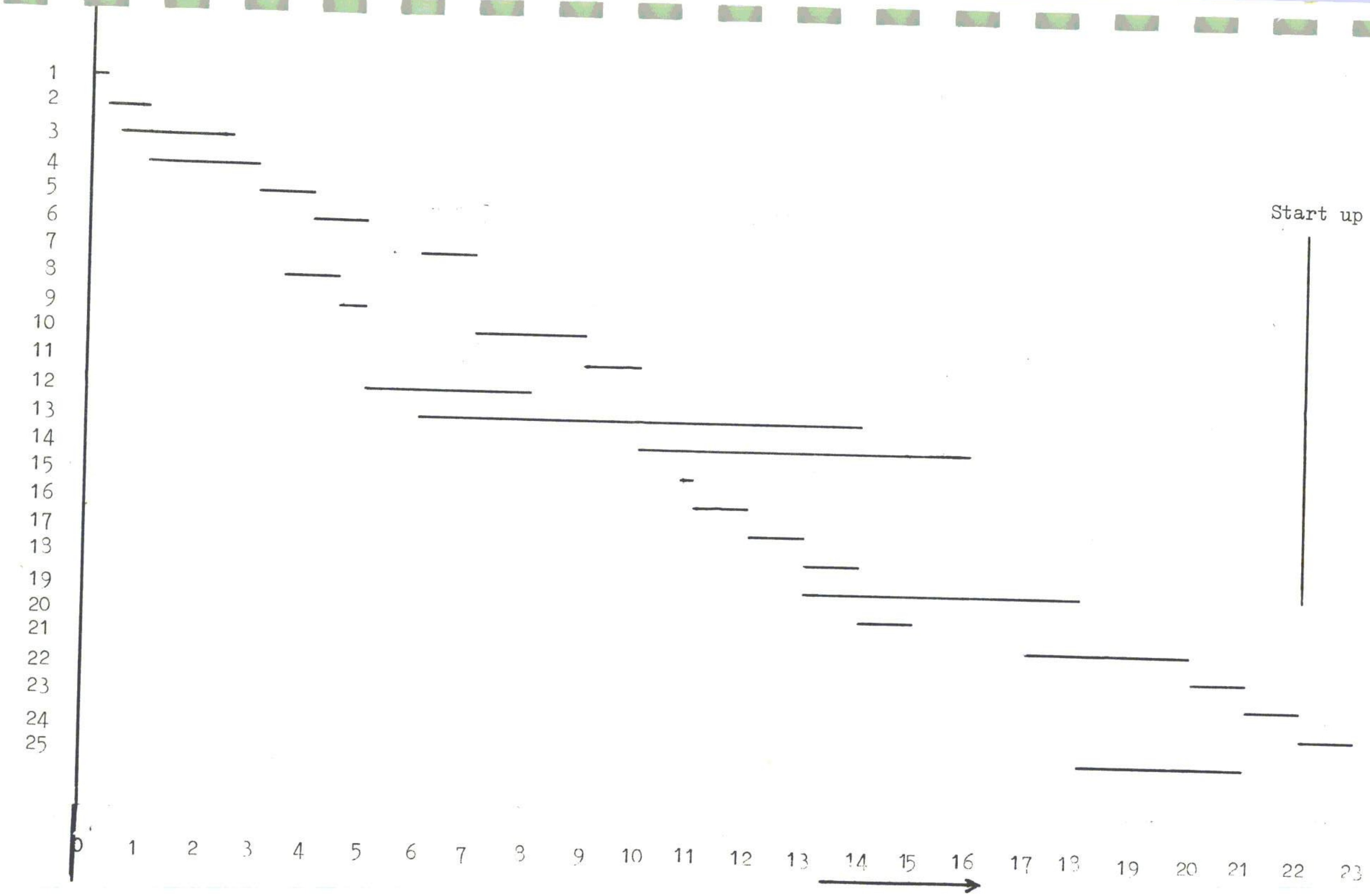
Since it is likely that the company supplying the technical "know-how" will have little or no engineering capability, it will be necessary to involve a contracting or consulting company to do the project, process, electrical and mechanical design work and undertake a full contractural commitment to erect the plant on a turnkey basis.

Equipment procurements and shipping to the Ruhengeri site will be the responsibility of the selected contractor, working under the guidance of the executing agency. The building work is expected to be assigned to a Rwandese company that also has the equipment and skilled personnel to carry out the equipment installation. An expert provided by the executing agency would be assigned to duties on the refinery installation.

It will be seen from the bar chart (figure V) that the project is expected to take 22 months to complete after financial approval is obtained and UNIDO has identified that it has the experience and expertise to be the executing agency. The key to the activities covered by the bar chart will be found in table 9.

Although it would be possible to reduce the project implementation period by a few months by reducing the period required for satisfactory equipment procurement, there is only a very small margin of slack for the civil engineering activity. A reduction is therefore considered inadvisable, particularly since many activities overlap.

It is suggested that a period of three months should be allowed for in-plant training of certain key refinery workers (supervisors, for example). These workers must be trained prior to start-up, but not too soon as their knowledge and experience should be as fresh as possible.



a/ Tentatively 1 September 1977.

Figure V. General activity bar chart for pyrethrum refinery construction

Table 9. Key to activities covered by bar chart (figure V)

Activity number	Activity	Time
1	Set up implementation unit	1 week
2	Prepare and revise technical specifications	3 weeks
3	Preliminary technical discussions	2 months
4	Issue of tender documents and receipt of bids	2 months
5	Assess bids	1 month
6	Sign contracts, supply of equipment, know-how etc.	1 month
7	Prepare civil engineering tender documents	1 month
8	Site survey and soil investigations, Ruhengeri	1 month
9	Finalize plot plan	2 weeks
10	Issue civil documents for tender	2 months
11	Assess bids, place civil contracts	1 month
12	Process and project design (electrical, civil, mechanical)	3 months
13	Equipment and civil engineering procurement	8 months
14	Shipping and transporation of equipment	6 months
15	Mobilize civil contractor	1 week
16	Site preparation and grading	1 month
17	Drains, sewers and firemain construction	1 month
18	Road and fence construction	1 month
19	Construct main refinery buildings	5 months
20	Electrical installation (including substation)	1 month
21	Install equipment	3 months
22	Pipe up equipment	1 month
23	Wire up electrical equipment	1 month
24	Start up and commissioning	1 month
25	Training of key workers	3 months

As the question of payments relates directly to the bar-chart activities, the following financially important events are enumerated:

	Month
Preliminary site and soil investigations	$3\frac{1}{2}$
Sign contract for supply of equipment, installation and commissioning	5
Period of materials procurement	6-14
Termination of project design	8
Place civil contracts	10
Mobilize civil contractor	11
Electrical installation commences	14
Civil engineering work terminates	21
Electrical installation terminates	22
Plant start up	22

Plant performance trials will take four months and are not expected to be completed until five months after start-up.

Payments will be made on the basis of contractual obligations, but typical contracts used by the main contractor for the USINEX extraction plant were as follows:

(a) Standard cash terms of payment:

(i) 30% of value payable with order;
(ii) 70% of value against shipping documents;

(b) Special export terms of payment:

(i) 10% of value payable with order;
(ii) 10% of value payable against shipping documents;
(iii) 80% of value payable in eight equal 6-monthly instalments over four years.

Interest at 8% per annum on the amount outstanding is included in and payable with each instalment. If it is assumed that contracts for equipment supply were signed at month 5, and shipping documents were received at two-monthly intervals at months 8, 10, 12 and 14, the schedule of payments under the special export terms would be roughly as follows (capital equipment cost $500,000 f.o.b. Europe):

Month	Payment ($)	Interest ($)	Total ($)
5	50,000	-	50,000
8	12,500	-	12,500
10	12,500	-	12,500
12	12,500	-	12,500
14	12,500	-	12,500
20	50,000	1,600	51,600
26	50,000	1,400	51,400
32	50,000	1,200	51,200
38	50,000	1,000	51,000
44	50,000	800	50,800
50	50,000	600	50,600
56	50,000	400	50,400
60	50,000	200	50,200
		Total	552,000

As the project will be executed on a turn-key basis it is suggested that the UNIDO system should be used to determine the cash flows. Payment under a fixed-price contract would then be made as follows:

5% of the contract price in advance within less than a month after notification has been given to begin the study work;

25% on delivery of the process dossier;

20% on delivery of the equipment dossier;

20% on delivery of the civil engineering dossier;

30% to be retained until the test run on the finished plant has been completed, and the performance indicated in the contractor's tender has been attained.

The sum retained as a guarantee would be adjusted at the time of settlement on the basis of the cost-of-living index of a country selected by the contractor.

V. COSTS OF PALE EXTRACT REFINERY

Total investment requirements are estimated at $1,647,417, made up as follows:

Total investment (Working capital No. 1 included)			$
Installed equipment and spares		A.	876,470
Total building costs		B.	173,000
Know-how and royalties			250.000
Start-up expenses		C.	25,000
Vehicles		D.	25,000
Experts	(a) Pyrethrun expert (2 years)		105,000
	(b) Consultant (1 year)		60,000
	(c) Miscellaneous, travel, meetings		23,000
Contingency for inflation factors (10% of A., B., C. and D.)			109,947
			1,647,417

A. Capital investment

From the equipment list outlined in chapter IV, it is possible to estimate equipment capital cost. However, since inflation has remained low in Switzerland over the last few years, it was decided to use equipment costs quoted by Swiss companies so that a reasonable extrapolation could be made.

Packing, freight and insurance costs for sea transportation are based on a recent UNIDO purchase of Swiss equipment for the USINEX plant. Pursuant to the instructions of the Ministry of Planning and Natural Resources, no duty will be incurred on capital equipment items imported into Rwanda for the pale extract refinery. Other data are based on a general estimate and are self explanatory. The figure of 10% of the equipment f.o.b. value assumed for spares is not considered excessive in view of the isolated situation of the installation. The building and distillation tower costs are quotations provided by a Rwandese civil engineering company. The experts were informed that the land adjacent to the USINEX factory (and used for morc dumping) is owned by the USINEX company and will be made available free of charge for the building of a pyrethrum refinery.

It will be noted that all cost data are initially given in a single currency, but in the last section of this chapter, estimates are separated into local and hard currency requirements.

Equipment and spares	$
Estimated equipment cost f.o.b. Basle (for breakdown see table 10)	472,032
Spares (10% of equipment cost)	47,203
Total cost equipment and spares f.o.b. Basle	519,235
Freight and insurance Basle-Ruhengeri (21.73% f.o.b. value)	112,829
Installation (20% equipment f.o.b. costs)	94,406
Electrics, substation and offsites	80,000
General engineering fees	70,000
Total cost installed and spares equipment	876,470

Buildings	$
Land levelling	9,000
Building	164,000
Total land and building costs	173,000

Know-how	
This is a very difficult figure to estimate, but a figure of $250,000 is assumed	250,000
Total	1,299,470

Depreciation

It is suggested that equipment should be depreciated over 15 years and buildings over 30 years.

Table 10. Itemized equipment costs

(for explanation of items see chapter IV.C)

Item	Cost ($)	Item	Cost ($)	Item	Cost ($)
1	17,703	26	1,814	51	1,279
2	17,703	27	10,920	52	360
3	4,870	28	600	53	2,400
4	4,870	29 }		54	14,400
5	6,000	30 }	13,424	55	2,402
6	13,200	31 }		56	2,400
7	2,707	32 }		57	4,689
8	15,994	33	4,767	58	600
9	1,814	34	2,880	59	1,814
10	1,814	35	1,800	60	12,000
11	2,707	36	1,814	61	1,800
12	4,870	37	1,814	62	1,814
13	24,508	38	2,707	63	6,000
14	1,814	39	18,000	64	9,696
15	4,870	40	9,741	65	4,800
16	12,000	41	4,800	66	1,800
17	1,814	42	28,304	67	1,800
18	18,000	43	10,920	68	7,200
19	1,814	44	3,483	69	2,400
20	8,203	45	840	70	9,000
21	7,561	46	2,402	71	960
22	9,837	47	10,920	72	1,920
23	4,767	48	4,767	73	8,100
24	1,923	49	4,472	74	1,800
25	1,814	50	2,402	75	2,700
				76	31,130
				Total	472,032

B. Solvent, chemicals and utility requirements

The estimates given are for the consumption of the chemicals and solvents required for the production of 1 kg of 25% refined extract (AOAC analysis):

Fuel oil	2,497 l
Cooling water	943.8 l
Electricity	2.86 kWh
Hexane	0.998 l
Methanol	0.897 l
Antioxidant	0.0149 kg
Nitrogen	0.94 m^3
Carbon	0.0156 kg
Kerosene (average)	0.5 l
Filter aids	0.007 kg
Drums	0.01

The figures given are for an efficient well-operated plant. A slight reduction in solvent consumption might be possible in a modern plant installed in Ruhengeri.

Utility costs

Unit costs have been ascertained for the various chemicals and solvents delivered to Ruhengeri. These, taken in conjunction with the consumption data given in the previous section, permit a calculation of the cost of process materials and utilities consumed at the refinery. The figures given in the following table are for 25% refined extract (AOAC).

	Unit cost (RF)	Cost per kg of extract (RF)
Fuel oil	25.60/ l	63.92
Cooling water	3.0/ m^3	3.17
Electricity	4/ kWh	11.44
Hexane	39.81/ l	39.73
Methanol	76.9/ l	68.97
Antioxident	390/ kg	5.81
Carbon	154/ kg	2.40
Kerosene (Shellsol T)	41.9/ l	20.95

	Unit cost (RF)		Cost per kg of extract (RF)
Filter aid	60/	kg	0.42
Drums	2,959/	drum	29.59
Nitrogen			4.00
Maintenance			8.00
Total			258.40

C. Start-up expenses

Because of the isolated situation of the USINEX plant, it is expected that a six-months' supply of chemicals and solvents at least will be required prior to start-up. The plant has been designed with this consideration in mind.

Solvent requirements and costs are given below. It should be noted that an initial drum purchase of only 400 units is contemplated, as drums will become available as solvent is used up. Fuel oil should be available every two months.

	Quantity	Value RF
Fuel oil	62,624 l	1,603,174
Hexane	75,089 l	2,989,293
Methanol	67,490 l	5,189,981
Antioxidant	1,121 kg	437,190
Nitrogen	70,725 m^3	300,960
Carbon	1,173 kg	180,642
Kerosene	37,620 l	1,576,278
Filter aids	526 kg	31,560
Drums	400	1,183,600
	Total	13,492,678

General start-up and commissioning

These fees have been estimated at $25,000, as only 3 experts (process engineer, mechanical engineer, erector engineer) should be required for a period of one or two months.

Labour costs

As indicated in chapter IV labour requirements for the refinery are:

1 Pyrethrum expert from an international agency (2 years)

4 Plant supervisors

12 Plant operatives

1 Administration clerk

1 Consultant for an estimated period of 12 months (proposed in addition to the refinery labour requirements)

The monthly cost for each function is:

Pyrethrum expert	$4,400
Supervisor	RF 15,000
Operator	RF 6,000
Clerk	RF 6,000
Consultant	$5,000

For Rwandese workers, the company is expected to pay 13 months salary a year and 5% social security.

Annual wage requirements are therefore $52,800 and RF 1,719,900; $60,000 is required for a consultant during commissioning and start-up and for the initial six-month running period. The consultant will also be available to participate in the various performance tests.

Miscellaneous equipment

It is suggested that the expert assigned to the project and the consultant will require the services of a car. Capital expenditure of $25,000 will cover this item adequately.

Maintenance

Maintenance has been indicated as a direct in-line operating cost.

D. Local and foreign currency requirements

Financial inputs have been analysed to ascertain the local currency and foreign exchange components. A detailed analysis is given in the following section.

It may be seen that most expenditure, except that for the erection of the buildings and equipment installation, will require hard currency.

Land

nil

Buildings

Local expenditure		Imported materials
(a) Distillation tower	RF 2,341,889	RF 957,975
(b) Main refinery buildings	RF 12,698,814	RF 4,450,734
		(import duty approximately 18%)

Machinery and equipment

All equipment and spares will be imported and payment will be made in hard currency. Both motor cars will be paid for in hard currency. No duty is payable on machinery and equipment.

General engineering fees

These are payable in hard currency.

Installation charge

As it is likely that installation will be carried out by a Rwandese company, payment for services will be made in local currency.

Electrical installation

As all electrical equipment will be imported and installation will be carried out by skilled expatriate fitters, all payments will be made in hard currency.

Know-how

It is considered that payment will be made in hard currency.

General start-up and commissioning

These fees will be payable in hard currency.

Labour costs

All Rwandese labour will be paid in local currency, but both expatriates will be paid in hard currencies, except for local allowances.

Packing, freight and insurance

Total charges are 21.73% of the value f.o.b. Europe.

Insurance (payable in Rwanda francs) is 1.6% of the value f.o.b.

The only other charges (transportation within Rwanda and storage in Kigali) are payable in local currency. The charges amount to approximately 2% of the value f.o.b.

Chemicals and solvents

Chemicals and solvents may be divided into two main categories:

(a) Solvents, which are available in Rwanda and are distributed by companies such as BP-Fina, and Shell;

(b) Chemicals (such as antioxidant, nitrogen, carbon, and filter aids, which are imported. Drums can also be placed in this category.

The following examples illustrate the situation:

1. Hexane delivered to USINEX by BP-Fina costs RF 37.81 a litre, including all transport costs. Duty, which has been paid, is RF 1.81 a litre.
2. If USINEX imports ɘxane directly from Mombasa the costs are as follows:

	Value (RF/kg)
F.o.b. Mombasa	36.74
Rail Mombasa - Kampala	3.85
Road Kampala - Kigali	4.57
Insurance	2.06
Value kigali	47.20
Customs	7.08
Storage	0.63
Transport Kigali - Ruhengeri	6.19
c.i.f. Ruhengeri	61.10

RF 61.10 a kilogram is equivalent to RF 40.94 a litre.

3. The importation of an 800 kg consignment of antioxidant would be costed as follows:

	RF
Value f.o.b. Europe	233,216
Transport to Kigali	18,949
Insurance (7.8375% of c. and f.)	19,763
Value Kigali	271,928
Tax (15%)	40,789
Transport Kigali - Ruhengeri by company vehicle	-
c.i.f. Ruhengeri	312,717

Cost per kilogram RF 390.

4. The cost of a consignment of 150 drums is as follows:

	RF
Value f.o.b. Mombasa	182,832
Transport Mombasa - Ruhengeri	155,755
Insurence (0.025%)	2,475
Duty (15% c.i.f. value)	50,788
c.i.f. Ruhengeri	391,850

Exportation of refined pyrethrum extract

Charges associated with sales of refined extract have been calculated for both air and sea freight.

(a) Sea freight:

	RF
Insurance (8%)	22.0
Transport Ruhengeri - Kigali	4.6
Transit Kigali	0.7
Export tax	- (exempt)
Transport Kigali - Dar-Es-Salaam	12.5
Transit Dar-Es-Salaam	1.9
Transport Dar-Es-Salaam - Europe	8.6
Charges Ruhengeri - Europe	50.6

(b) Air freight:

	RF
Insurance (8%)	22.0
Transport Ruhengeri - Kigali	4.6
Transit Kigali	0.7
Export tax	- (exempt)
Transport Kigali - Europe	67.0
Charges Ruhengeri - Europe	94.3
Europe - New York add	73.0
New York - Minneapolis add	62.0

VI. ANALYSIS OF FINANCING AND PROFITABILITY OF THE REFINERY

A. General information

General plan of the study

According to the plan of operation for the refinery, start-up will be 1 July 1979, and industrial production will begin on 1 August 1979, subject to the usual reservations concerning compliance with the deadlines assigned for each of the preliminary stages.

The useful life of the refinery is estimated at 15 years. Since the first year of its operation will be 1979, the financial analysis will cover the 15 trading years from 1979 to 1993 (years "1" to "15").

Since the refinery is an extension of the existing (extraction) plant, the profitability study for the refinery must take into account, in addition to the costs directly imputable to the refinery:

(a) The cumulative financial results of USINEX at the time the refinery begins production;

(b) The useful life of and amortization plan for the USINEX installations;

(c) The estimated cost of manufacture of crude extract.

Cumulative financial results of USINEX at the beginning of year 1

An estimate of the results for the years 1977 and 1978 (years -1 and 0) is made in section E of this chapter. The financial analysis assumes that at the beginning year 1, USINEX will show no cumulative loss or profit.

It must be stressed that before the refinery starts operating, USINEX will certainly not be able to increase the price of flowers purchased from ASPY, whose situation cannot improve as a result of USINEX operations until 1979. Appropriate measures should therefore be taken in the meantime to help ASPY through this difficult period.

Useful life of and amortization plan for the USINEX installations

Refinery

Refinery	Annual rate of straight-line depreciation (years 1 to 15)
Refinery equipment	6 2/3%
Refinery know-how	20%
Refinery building	3.85%

The refinery building will be amortized over a period of 26 years, so that the end of the amortization period will coincide with the end of the amortization period of the existing USINEX building (at 3% since 1972). At the end of that period the existing building would have a book value of zero.

Extraction

From the accounting point of view, the extraction equipment (existing plant) should normally have been written off in 15 years, rather than 10 (period selected by USINEX in order to remain on the safe side and probably to take into account the constraints involved in perfecting the equipment). In the study it has not been considered advisable to rectify the amortization plan for past accounting periods or to amend the 10% depreciation rate applicable to the intermediate years -1 and 0 (which would have run counter to the general assumption of continuing previous operating conditions). At the beginning of year 1, therefore, the extraction equipment will have depreciated by 68 1/3% (after accelerated amortization for the 82 months March 1972 - 31 December 1978). The remaining 31 2/3% will be amortized from year 1 in five years (at 6 1/3% a year) so that all the maintenance installations will have been finally written-off in around 12 years.

From the technical point of view, it has been estimated that the extraction installation could continue operating throughout the useful life of the refinery (15 years) if supplementary maintenance expenses were provided for after the end of the amortization period. Figure VI shows how the assumptions made above fit together. The implications for the operating account are as follows:

(a) Annual rate of depreciation (replacing the previous rate of accelerated depreciation):

years 1 to 5 inclusive	6 1/3%

(b) Supplementary maintenance (as percentage of purchase value):

years 6 to 10 inclusive	7%
years 11 to 15 inclusive	8%

Residual value: 0

The other assets of USINEX will be considered to have a residual value of 0 at the end of each depreciation period; so full renewal of the initial expenditure will be necessary.

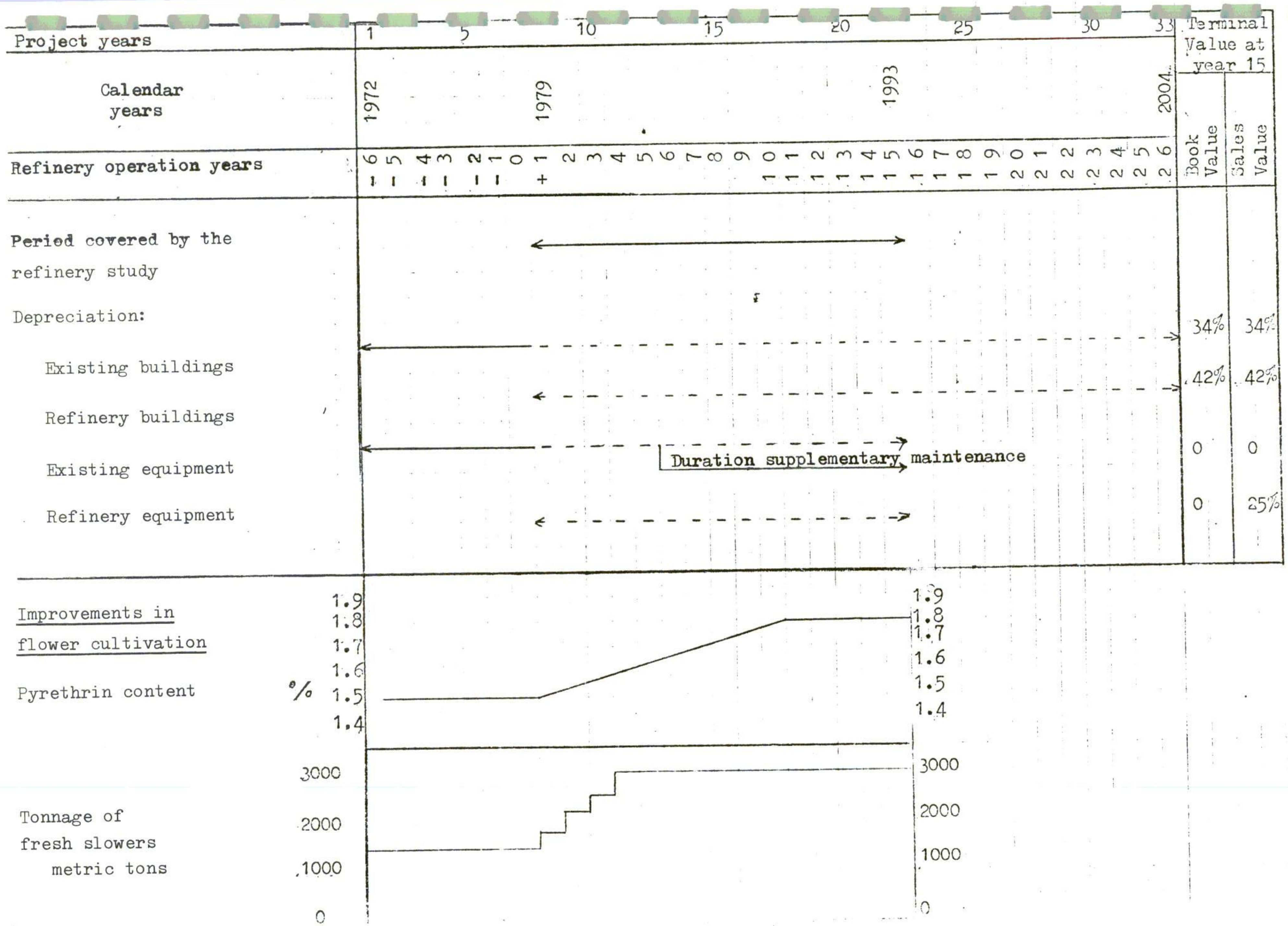


Figure VI. Depreciation of various facilities

Elements of the estimated cost of manufacture of crude extract

Flowers

See, below, supply estimates.

Other materials consumed for extraction

The cost for the business year 1976 was RF 178.90 per kg of 32.5% crude extract, equivalent to RF 137.53 per kg of 25% extract. Estimates for years 0 and 1 are as follows:

Year	Fuels, solvents and other imported expendable materials (RF)	Electricity and water (RF)	Total (RF)
1976 (results)	121.30	16.23	137.53
Year 1 (1976 + 10%)	133.43	17.85	151.28
Year 0 (-1 + 10%)	146.77	19.64	166.41
Year 1 (0 + 10%)	161.45	21.60	183.05

The estimates include an annual increase of 10% to cover the risk of rising prices. The assumptions are conservative, since the provisional operating account for USINEX for the first quarter of 1977 shows a cost of expendable materials that is declining slightly by comparison with 1976 prices (RF 168.44/kg 32.4% crude extract, for the first quarter of 1977 compared with RF 178.90/kg, for the 12 months of 1976).

Fixed costs changeable to extraction

These are also based on the results for 1976 (see table 11).

Supply estimates

Weight

Year	Tons of dried flowers
-1	1,575 (maintenance of 1976 level)
0	1,575 (maintenance of 1976 level)
1	1,750
2	2,050
3	2,500
4 to 15	3,000

Table 11. Fixed costs chargeable to extraction

Year		Manufacturing installations		Depreciation of other assets (RF)	Other fixed charges: a/ (RF)	Total fixed costs (RF)
		Depreciation (RF)	Supplementary maintenance (RF)			
	1976 (results)	10,557,220		4,605,513	24,365,904	39,528,637
Estimates	- 1	10,557,220		4,605,513	25,584,199	40,746,932
Estimates	0	10,557,220		4,605,513	26,863,409	42,026,142
Estimates	1 to 5	6,686,836		4,605,513	28,206,580	39,498,329
Estimates	6 to 10	-	7,390,054	4,605,513	28,206,580	40,202,147
Estimates	11 to 15	-	8,445,776	4,605,513	28,206,580	41,257,869

a/ The results for 1976 are increased by 5% a year up to year 1 to take into account possible increases in wage levels and contingencies.

Quality

Flower quality is expected to improve from year 1 to year 10 by an additional 0.03% pyrethrin content a year up to a maximum of 1.80% (a very reasonable assumption, since varieties exist that have contents of 2%).

Price of flowers

Prices for years -1 and 0 will be the same as in 1976. From year 1, it is considered that the refinery should pay a price that would gradually increase up to a level believed to be remunerative enought for the grower, i.e. an equilibrium price which would afford a solid foundation for the whole phyrethrum operation. Any increase beyond the equilibrium price will not be incorporated into the estimated charges of USINEX and will be shown as an unallocated residual profit of the refinery (for strengthening the pyrethrum operation, food crops, and the like). The equilibrium price has been determined on the basis of various analyses and the final criterion that, under present conditions, a cash yield of RF 50,000 per hectare is satisfactory, i.e. taking into account the optimum yield of 630 kg of dried flowers per hectare, RF 80/kg of dried flowers, or RF 16/kg of fresh flowers (1.50% concentration).

It is on these figures that the estimates given below of the price which ASPY will charge USINEX for 1 kg of dried flowers have been calculated, taking into account a constant margin for the services of ASPY of RF 25/kg of dried flowers. (In view of the increase in amounts processed, this margin should easily cover the costs of ASPY's services.)

Price of dried flowers sold to USINEX by ASPY

Year	Grower's remuneration (based on 1.50% concentration) per kg		Pyrethrin content (%)	Grower's remuneration per kg of dried flowers (based on actual % pyrethrin concentration)	ASPY margin	Selling price to USINEX
	Fresh flowers	Dried flowers				
1	13	65	1.53	66.30	25	91.30
2	14	70	1.56	72.80	25	97.80
3	15	75	1.59	79.50	25	104.50
4	16	80	1.62	86.40	25	111.40
5	16	80	1.65	88.00	25	113.00
6	16	80	1.68	89.60	25	114.60
7	16	80	1.71	91.20	25	116.20
8	16	80	1.74	92.80	25	117.80
9	16	80	1.77	94.40	25	119.40
10 to 15	16	80	1.80	96.00	25	121.00

Technical yields

The extraction and refinery yields (99% and 95% respectively) are assumed not to vary throughout the duration of the study. The following table shows estimated pale extract production for years 1-15.

Estimated pale extract production

Year	Dried flowers (tons)	Pyrethrin content (%)	Equivalent 100% pyrethrin (kg) (A)	Crude extract (kg) 100% (A x 0.99)	Crude extract (kg) 25% (B)	Pale extract (kg) 25% (B x 0.95)
1	1,750	1.53	26,775	26,507	106,029	100,728
2	2,050	1.56	31,980	31,660	126,641	120,309
3	2,500	1.59	39,750	39,353	157,410	149,540
4	3,000	1.62	48,600	48,114	192,456	182,833
5	3,000	1.65	49,500	49,005	196,020	186,219
6	3,000	1.68	50,400	49,896	199,584	189,605
7	3,000	1.71	51,300	50,787	203,148	192,991
8	3,000	1.74	52,200	51,678	206,712	196,376
9	3,000	1.77	53,100	52,569	210,276	199,762
10 to 15	3,000	1.80	54,000	53,460	213,840	203,148

Elements in the estimated production cost of pale extract

Flowers

See above.

Other materials consumed by the refinery

	RF/kg (25% pale extract)	
Fuel, solvents and other imported expendable materials	235.79	
5% for contingencies	11.79	
	247.58	247.58
Electricity and water	13.67	
5% for contingencies	0.68	
	14.35	14.35
Total		261.93

Fixed expenses chargeable to the refinery

Costs chargeable to the refinery are depreciation, maintenance, labour, insurance and financial costs. Other fixed costs that refer to USINEX operations (maintenance of installations and vehicles, administrative and production personnel, insurance etc.) have already been indicated (beginning with the 1976 results) under the heading "Fixed costs chargeable to extraction".

Depreciation

The estimate of depreciation must be based on the capital cost of the refinery, which has been evaluated as follows:

		Estimates based on indications given in the technical report ($US)		Estimates following 5% increase for contingencies on certain items ($US)
Production equipment		876,470		920,293
Building		173,000		181,650
Know-how		250,000		250,000
Initial working capital:				
(a) Additional stock of expendable materials	146,660		153,993	
(b) Miscellaneous liabilities	25,000		25,000	
	171,660	171,660	178,993	178,993
Total		1,471,130		1,530,936

	Purchase price (RF)	Annual depreciation rate (%)	Annual depreciation allocation (RF)
Production equipment	86,295,875	6.67	5,753,058
Building	17,033,320	3.85	655,783
Know-how	23,442,500	20	4,688,500

Maintenance. Cost has been estimated at RF 1,200,000.

Insurance. It has been estimated that the annual cost will increase from RF 1,250,000 to RF 1,700,000 during year 10 because of the increasing value of the stocks.

Refinery labour costs

For the operation of the refinery, USINEX has taken into account the possibility of putting to optimum use the existing personnel (as of 31 December 1976) by assigning to the refinery two foremen and one administrative clerk, who were recruited for the extraction operation.

The payroll costs are as follows:

Qualifications	No.	Monthly pay (RF)	Man/ months	Total annual pay (RF)	Charges (5%) (RF)	Wages bill (RF)
Skilled workers, foreman	2	15,000	26	390,000	19,500	409,500
					Rounded to:	430,000
Unskilled workers	12	3,500	156	546,000	27,300	573,300
					Rounded to:	600,000
					Total	1,030,000

Technical assistance required

One expert for two years (estimated annual costs: $52,800)

Twelve man/months of consultant services (estimated cost: $60,000)

Although these costs are chargeable to the refinery, they should not be carried on the USINEX operating account any more than were the costs of the technical assistance from which USINEX has already benefited. These costs will be charged under the heading of the technical assistance provided within the framework of Rwanda's foreign aid programme.

Financial costs

These will be calculated after the estimate of the amounts outstanding, taking into account an annual rate of interest of 8% payable annually on the total amount of the outstanding balance, and a repayment period of 14 years that includes a two-year deferment on the capital. These conditions are in line with those generally applied by the Rwandese Development Bank.

Summary of fixed costs (before finance charges)
(Rwandese francs)

Year	Amortization	Maintenance	Insurance	Labour	Total
1	11,097,341	1,200,000	1,250,000	1,030,000	14,577,341
2	11,097,341	1,200,000	1,300,000	1,030,000	14,627,341
3	11,097,341	1,200,000	1,350,000	1,030,000	14,677,341
4.	11,097,341	1,200,000	1,400,000	1,030,000	14,727,341
5	11,097,341	1,200,000	1,450,000	1,030,000	14,777,341
6.	6,408,841	1,200,000	1,500,000	1,030,000	10,138,841
7	6,408,841	1,200,000	1,550,000	1,030,000	10,188,841
8	6,408,841	1,200,000	1,600,000	1,030.000	10.238.841
9	6,408,841	1,200,000	1,650,000	1,030,000	10,288,841
10 to 15	6,408,841	1,200,000	1,700,000	1,030,000	10,338,841

Other data

Basis of evaluation. The outlays and receipts have been estimated from 1979 (year 1), onwards in constant money for the entire period in question.

Exchange rates. Import rate $1 = RF 93.77
Export rate $1 = RF 91.91

Customs provisions. Capital equipment directly imported by USINEX is assumed to enjoy total exemption from import taxes and duties, according to assurances given by the Government to this effect.

B. Estimated operating account before financing costs

Crude extract production costs (see table 12)

Pale extract production cost (see also table 13)

The quantities of pale extract produced correspond to the quantities of crude extract produced with allowance made for the technical efficiency of the refinery

Table 12. Crude extract production costs

Years	Quantity of crude extract produced (25% concentration) (kg)	Dried flowers Quantity (tons)	Dried flowers Unit price/kg dried flowers (RF)	Dried flowers Cost (RF 1,000)	Other expendable materials (RF 183.05/kg) (RF 1,000)	Total variable costs (RF 1,000)	Fixed costs (RF 1,000)	Crude extract production cost (RF 1,000)
1	106,029	1750	91.30	159,775	19,409	179,184	39,493	218,682
2	126,641	2050	97.80	200,490	23,182	223,672	39,498	263,170
3	157,410	2500	104.50	261,250	28,814	290,064	39,498	329,562
4	192,456	3000	111.40	334,200	35,229	369,429	39,498	408,927
5	196,020	3000	113.00	339,000	35,881	374,881	39,498	414,379
6	199,534	3000	114.60	343,800	36,534	380,334	40,202	420,536
7	203,143	3000	116.20	348,600	37,186	385,786	40,202	425,988
8	206,712	3000	117.80	353,400	37,839	391,239	40,202	431,441
9	210,276	3000	119.40	358,200	38,491	396,691	40,202	436,893
10	213,840	3000	121.00	363,000	39,143	402,143	40,202	442,345
11	213,840	3000	121.00	363,000	39,143	402,143	41,258	443,401
12	213,840	3000	121.00	363,000	39,143	402,143	41,258	443,401
13	213,840	3000	121.00	363,000	39,143	402,143	41,258	443,401
14	213,840	3000	121.00	363,000	39,143	402,143	41,258	443,401
15	213,840	3000	121.00	363,000	39,143	402,143	41,258	443,401

(0.95). At the beginning of year 1 the refinery will receive the stock of crude extract available at the end of the previous period (18,711 kg of 25% crude extract). Since the refinery will be in production for only five months during year 1, it will be unable to process all the crude extract during that year. A series of intermediate movements of stock will therefore take place as follows (all figures in kg):

Year	Crude extract produced during the year	Crude extract stock at the end of the previous year	Crude extract delivered to refinery during year	Crude extract refined	Crude extract consumed by the refinery	Crude extract stock at the end of the year
1	106,029	18,711	124,740	71,500	75,263	49,477
2	126,641	49,477	176,118	158,426	166,764	9,354
3	157,410	9,354	166,764	158,426	166,764	0

The corresponding effect on the cost of the crude extract consumed by the refinery during the period under consideration will thus be (all figures in RF):

Year	Value of initial crude extract stock	Crude extract production costs	Value of final crude extract stock	Crude extract cost in the production of pale extract
1	29,432	218,682	102,045	146,069
2	102,045	263,170	19,438	345,777
3	19,438	329,562	0	349,000

It will be assumed that from year 4 onwards the entire quantity of crude extract produced will be consumed by the refinery during the same year.

Estimated operating account of the refinery before financing costs

During the five financial periods elapsed USINEX held stocks of finished products which represented an average of 30.76% of the value of its sales. Since pale extract should sell far more easily than crude, it has been estimated that stocks should represent on the average only 20% the tonnage available for sale. The value of the stocks does not include fixed costs chargeable to the refinery.

Table 13. Pale extract production costs
(RF 1,000)

Years	Quantity of pale 25% produced, concentration (kg)	Cost of crude extract used in the production of pale extract (RF)	Variable refinery costs (261.93/kg of pale extract (RF)	Sub-total for the evaluation of the value of pale extract stocks (RF)	Fixed refinery costs (RF)	Pale extract production cost (RF)
1	71,500	146,069	18,728	164,797	14,577	179,374
2	158,426	345,777	41,497	387,274	14,627	401,901
3	158,426	349,000	41,497	390,497	14,677	405,174
4	182,833	408,927	47,889	456,816	14,727	471,543
5	186,219	414,379	48,776	463,155	14,777	477,932
6	189,605	420,536	49,663	470,199	10,139	480,338
7	192,991	425,988	50,550	476,538	10,189	486,727
8	196,376	431,441	51,437	482,878	10,239	493,117
9	199,762	436,893	52,324	489,217	10,289	499,506
10	203,148	442,345	53,211	495,556	10,339	505,895
11	203,148	443,401	53,211	496,612	10,339	506,951
12	203,148	443,401	53,211	496,612	10,339	506,951
13	203,148	443,401	53,211	496,612	10,339	506,951
14	203,148	443,401	53,211	496,612	10,339	506,951
15	203,148	443,401	53,211	496,612	10,339	506,951

Table 14 shows estimated stock movements and indicates the ex-factory cost of the products sold.

Sales costs are treated as recoverable costs.

Costs ad valorem:

Commission on sales 2.5% of c.i.f. value

Costs by weight (per kg):

Transport from the factory Ruhengeri to Kigali RF 11.00

Costs f.o.b. Kigali to c.i.f. United States $2.38

(Costs by weight take into account that the extract is shipped as a 50% concentrate.)

Table 15 gives estimates of the sales costs.

Table 14. Pale extract: stock movements and ex-factory cost

	Initial stock		Output		Sales estimates		Final stock		Ex-factory cost of quantities sold (RF 1,000)
	Quantity (kg)	Value (RF 1,000)	Quantity (kg)	Cost (RF 1,000)	Available (kg)	Quantity sold Available (kg)	Quantity (kg)	Value (RF 1,000)	
1	0	0	71,500	179,374	71,500	57,200	14,300	32,959	146,415
2	14,300	32,959	158,426	401,901	172,726	138,181	34,545	84,446	350,414
3	35,545	34,446	158,426	405,174	192,971	154,377	38,394	95,129	394,491
4	38,594	95,129	182,833	471,543	221,427	177,142	44,285	110,648	456,024
5	44,285	110,648	186,219	477,932	230,504	184,403	46,101	114,660	473,920
6	46,101	114,660	189,605	480,338	235,706	188,565	47,141	116,904	478,094
7	47,141	116,904	192,991	486,727	240,132	192,106	48,026	118,587	485,044
8	48,026	118,587	196,376	493,117	244,402	195,522	48,880	120,193	491,511
9	48,880	120,193	199,762	499,506	248,642	198,914	49,728	121,784	497,915
10	49,728	121,784	203,148	505,895	252,876	202,301	50,575	123,372	504,307
11	50,575	123,372	203,148	506,951	253,723	202,978	50,745	124,050	506,273
12	50,745	124,050	203,148	506,951	253,893	203,114	50,779	124,133	506,868
13	50,779	124,133	203,148	506,951	253,927	203,142	50,785	124,148	506,936
14	50,785	124,148	203,148	506,951	253,933	203,146	50,787	124,153	506,946
15	50,787	124,153	203,148	506,951	253,935	203,148	50,787	124,153	506,951

Table 15. Breakdown of selling costs

	Sales		Transport Ruhengeri-Kigali (RF 11/kg, 50% concentration) (RF 1,000)	F.o.b.-c.i.f. costs ($2.38/kg, 50% concentration) (RF 1,000)	Seller's commission 2.5%/c.i.f. (RF 1,000)	Other selling costs 3.1%/c.i.f. (RF 1,000)	Total selling costs (RF 1,000)
	Tonnage (kg)	C.i.f. value at $33/kg = RF 3,033 (RF 1,000)					
1	57,200	173,488	315	6,383	4,337	5,378	16,413
2	138,181	419,103	760	15,419	10,477	12,992	39,648
3	154,377	468,225	849	17,226	11,705	14,515	44,295
4	177,142	587,272	974	19,767	13,431	16,655	50,827
5	184,403	559,294	1,014	20,577	13,982	17,338	52,911
6	188,565	571,918	1,037	21,041	14,297	17,729	54,104
7	192,106	582,657	1,057	21,436	14,566	18,062	55,121
8	195,522	593,018	1,075	21,818	14,825	18,384	56,102
9	198,914	603,306	1,094	22,196	15,082	18,702	57,074
10	202,301	618,579	1,113	22,574	15,339	19,021	58,047
11	202,978	615,632	1,116	22,650	15,390	19,085	58,241
12	203,114	616,045	1,117	22,665	15,401	19,097	58,280
13	203,142	616,130	1,117	22,668	15,403	19,100	58,288
14	203,146	616,142	1,117	22,668	15,403	19,100	58,288
15	203,148	616,148	1,117	22,668	15,403	19,100	58,288

Table 16. Estimated trading results before interest
(RF 1,000)

	C.i.f. value of sales	Costs		Total cost	Trading profit
		Ex-factory cost of sales	Selling costs		
1	173,488	146,415	16,413	162,828	10,660
2	419,103	350,414	39,648	390,062	29,041
3	468,225	394,491	44,295	438,786	29,439
4	537,272	456,528	50,827	507,355	29,917
5	559,294	473,751	52,911	526,662	32,632
6	571,918	478,261	54,104	532,365	39,553
7	582,657	485,267	55,121	540,388	42,269
8	593,018	491,272	56,102	547,374	45,644
9	603,306	497,907	57,074	554,981	48,325
10	613,579	503,566	58,047	561,613	51,966
11	615,632	506,536	58,241	564,777	50,855
12	616,045	506,868	58,280	565,148	50,897
13	616,130	506,936	58,288	565,224	50,906
14	616,142	506,946	58,288	565,234	50,908
15	616,148	506,951	58,288	565,239	50,909

C. Estimated trading results after charges

Long-term loan to finance capital investment in the refinery

This investment has been estimated (see above) at $1,530,936, or RF 143,555,869.

The schedule of capital expenditure is expected to be as follows:

Item	Year -1	Year 0	Year 1
Production equipment) Buildings) Know-how)	5%	65%	35%
Initial stock of expendable materials			100%

The corresponding movements of funds (in foreign currencies and Rwandese francs) are shown in tanle 17.

Table 17. Movement of capital funds

Item	Currency of payment	Year -1	Year 0	Year 1	Total
Production equipment	RF	556,773	7,238,055	3,340,641	11,135,469
	$	(40,077)	(521,001)	(240,462)	(801,540)
	Equivalent RF	3,758,020	48,854,264	22,548,122	75,160,406
	Total	4,314,793	56,092,319	25,888,763	86,295,875
Buildings	RF	611,512	7,949,651	3,669,070	12,230,233
	$	(2,561)	(33,294)	(15,367)	(51,222)
	Equivalent RF	240,154	3,122,007	1,440,926	4,803,087
	Total	851,666	11,071,658	5,109,996	17,033,320
Know-how	RF	-	-	-	-
	$	(12,500)	(162,500)	(75,000)	(250,000)
	Equivalent RF	1,172,125	15,237,625	7,032,750	23,442,500
	Total	1,172,125	15,237,625	7,032,750	23,442,500
Initial stock of expendable materials	RF	-	-	-	-
	$			(178,993)	(178,993)
	Equivalent RF			16,784,174	16,784,174
	Total			16,784,174	16,784,174
	Grand total	6,338,584	82,401,602	54,815,683	143,555,869

Long-term loan: year -1: RF 7 million
year 0: RF 85 million
year 1: RF 55 million

RF 147 million

or approximately $ 1.6 million

The breakdown of repayments on these loans is given below assuming: a two-year moratorium on amortization of the capital, an interest rate of 8%, repayment period of 12 years and, equated annuities.

Capital repayment schedule (RF 1,000)

	7,000		85,000		55,000		Total	
Year	Interest	Capital	Interest	Capital	Interest	Capital	Interest	Capital
0	377	* (nil					377	
1	377	nil	4,568	nil			4,945	
2	↑	583	4,568	* (nil	2,956	nil	7,901	583
3		583	↑	7,083	2,956	* (nil	7,901	7,666
4		↑		7,083	↑	4.583	↑	12,249
5						4.583		12,249
6						↑		↑
7								
8								
9								
10								
11								
12	↓	↓					↓	↓
13	377	583	↓				7,901	12,249
14	nil	nil	4,568	7,083	↓	↓	7,524	11,666
15	nil	nil	nil	nil	2,956	4,583	2,956	4,583

* Moratorium on repayment of capital.

Estimate of working capital required by USINEX

The following assumptions are made:

(a) Flowers. The 50% of annual production currently picked in the peak period (three months) will be reduced by more efficient staggering to 40% or a maximum of 12,000 tons. The plant should absorb 1,080 tons in three months, but it would be advisable to envisage that the plant might be expected to absorb 300 tons of dried flowers, or 10% of the annual amount purchased, since USINEX should have the means to pay ASPY promptly, in the interests of the growers;

(b) Expendable materials. In view of USINEX's location, it would be advisable to continue to provide for an average stock of five months (two months for fuel and six months for other expendable materials);

(c) Stocks of intermediate products. The value of the crude extract stored awaiting refinement at the beginning of the year will be taken into account. Thereafter, no allowance will be made for stocks of intermediate products, this under-estimation being offset by deliberate over-estimation of stocks of the final product (pale extract);

(d) Stocks of pale extract. These have been estimated at 20% of the quantity available for sale;

(e) Time-lag in payment for sales. Estimated at the equivalent of one month on the annual sales value;

(f) Liquidity. Estimated at one-third of annual fixed costs less depreciation;

(g) Supplier credits. These could have been deducted from the working capital requirements but, as a precautionary measure, they have not been considered as permanent resources.

Table 18 plots the development of the working capital required by USINEX on the basis of the above assumptions.

Table 18. Working capital requirements (RF 1,000)

	Stocks				Outstanding payments for sales	Liquidity	Estimated total working capital	Increase over previous year
	Flowers	Expendable materials	Crude extract	Pale extract				
1	15,977		102,045	32,959	14,457	10,562	176,000	
2	20,049	24,767	19,438	84,446	34,925	10,578	194,203	18,203
3	26,125	26,932		95,129	39,019	10,595	197,800	3,597
4	33,420	31,807		110,144	44,773	10,611	230,755	32,955
5	33,900	32,396		114,325	46,608	10,628	237,857	7,102
6	34,380	32,985		116,402	47,660	13,107	244,534	6,677
7	34,860	33,574		117,862	48,555	13,124	247,975	3,441
8	35,340	34,163		119,707	49,418	13,140	251,763	3,793
9	35,820	34,753		121,306	50,275	13,157	255,311	3,543
10	36,300	35,342		123,635	51,132	13,173	259,582	4,271
11	36,300	35,342		124,050	51,303	13,525	260,520	938
12	36,300	35,342		124,133	51,337	13,525	260,637	117
13	36,300	35,342		124,148	51,344	13,525	260,659	22
14	36,300	35,342		124,153	51,345	13,525	260,665	6
15	36,300	35,342		124,153	51,346	13,525	260,666	1

Cash forecasts

Resources

(a) Working capital. The capital that will be available to USINEX at the beginning of year 1 can be estimated as follows:

	RF
USINEX proprietary capital on 31 December 1976	191,576,937
Fixed assets	- 107,788,574
Working capital financed from proprietary	+ 83,788,363
Depreciation: year -1	+ 15,162,723
year 0	+ 15,162,723
	114,113,809
Renewal of investment, years -1 and 0	- 4,113,809
Working capital available from proprietary capital	110,000,000

(b) Long term loans;

(c) The cash flow forecast for years 1-15 (profit, less interest and depreciation) as shown in table 19.

Table 19. Cash flow forecast (RF 1,000)

Year	Cash flow before interest			Interest charges	Cash flow less interest on long-term loans
	Amortization	Profit	Total		
1	22,389	10,660	33,049	4,945	28,104
2	22,389	29,041	51,430	7,901	43,529
3	22,389	29,439	51,828	7,901	43,927
4	22,389	30,421	52,810	7,901	44,909
5	22,389	32,463	54,852	7,901	46,951
6	11,014	39,720	50,734	7,901	42,833
7	11,014	42,492	53,506	7,901	45,605
8	11,014	45,405	56,419	7,901	43,513
9	11,014	48,317	59,331	7,901	51,430
10	11,014	51,225	62,239	7,901	54,338
11	11,014	51,118	62,132	7,901	54,231
12	11,014	50,897	61,911	7,901	54,010
13	11,014	50,906	61,920	7,901	54,019
14	11,014	50,908	61,922	7,524	54,393
15	11,014	50,909	61,923	2,956	58,967

Requirements

(a) Capital investment programme;

(b) Loan repayments (capital only);

(c) Renewal of investments (office equipment, vehicles, laboratory equipment) estimated at RF 9 million for each 3-year period;

(d) The working capital required by USINEX (cf. table 18): year 1 and the annual increase during years 2-15. This gives the forecast of cash requirements appearing in table 20.

The cash forecasts, which have been stopped deliberately at year 10, show that, with the exception of years 1 and 2, the refinery will have no cash problems.

Trading profits which should not be significantly affected by loans other than the long-term loans mentioned (RF 147 million), could be estimated as follows:

Trading profits

	Before interest	Interest	After interest		Before interest	Interest	After interest
1	10,660	4,945	5,715	9	48,317	7,901	40,416
2	29,041	7,901	21,140	10	51,225	7,901	43,324
3	29,439	7,901	21,538	11	51,118	7,901	43,217
4	30,421	7,901	22,520	12	50,897	7,901	42,996
5	32,463	7,901	24,562	13	50,906	7,901	43,005
6	39,720	7,901	31,819	14	50,908	7,524	43,384
7	42,492	7,901	34,591	15	50,909	2,956	47,953
8	45,405	7,901	37,504				

Table 20. Forecast of cash requirements (RF 1,000)

Years	-1-	0	1	2	3	4	5	6	7
Resources									
Brought forward		661	3,259			13,954	13,659	41,259	56,166
Working capital			110,000						
Long-term loans	7,000	85,000	55,000						
Cash flow			28,104	43,529	43,927	44,909	46,951	42,833	45,605
Total	7,000	85,661	196,363	43,529	43,927	58,863	60,610	84,092	101,771
Brought forward				34,453	9,710				
Requirements									
Capital investment	6,339	82,402	54,816						
Loan repayment				583	7,666	12,249	12,249	12,249	12,249
Renewal					9,000			9,000	
Working capital			176,000	18,203	3,597	32,955	7,102	6,677	3,441
Total	6,339	82,402	230,816	53,239	29,973	45,204	19,351	27,926	15,690
Net	+616	+3,259	-34,453	-9,710	+13,954	+13,659	+41,259	+56,166	+86,081

Years	8	9	10	11	12	13	14	15
Resources								
Brought forward	86,081	118,557	145,195					
Working capital								
Long-term loans								
Cash flow	48,518	51,430	54,338					
Total	134,599	169,987	199,533					
Requirements								
Capital investment								
Loan repayment	12,249	12,249	12,249					
Renewal		9,000						
Working capital	3,793	3,543	4,271					
Total	16,042	24,792	16,520					
Net	+118,557	+145,195	+183,033					

D. Internal rate of return for the refinery

Table 21 shows the elements for calculating the internal rate of return for the project.

The residual assets comprise:

	RF
Existing building	18,977,467
New building	7,206,405
Refinery installation	21,573,969
Stock of pale extract	124,153,000
Total	171,910,841

The internal rate of return may be estimated by interpolation at 17.09%.

E. Estimate of the cumulative trading results of USINEX at the beginning of year 1

Production of pale extract

Years -1 and 0: 1,575 tons of dried flowers x 1.5% Py x 0.99 = 23,389 kg or 93,556 kg of 25% extract.

Sales of crude extract

(a) Selling price (estimated): $9.75/lb 25% extract, f.o.b. Kigali, equivalent to RF 1,973.80/kg

This estimate of the selling price (certainly higher than the abnormally low 1976 price of $8.95/lb) is reasonable, considering the following:

(i) The average price 1974-1975 was $10.41/lb (the beginning of 1977, USINEX sold some batches at $10.25/lb);

(ii) Rwanda has obtained agreement in principle regarding the application of the provisions of the Lome Convention, the purpose of which is to stabilize income from the export of commodities of the ACP countries. Without prejudice to either the final decision or the calculation procedure, the stabilized force, based on the four years preceding 1976 (which is considered as a particularly unfavourable year), would be at least $9.50/lb 25% extract, f.o.b. Kigali;

Table 21. Elements for calculating rate of return (RF 1,000)

	Outgoings				Incomings			Present value, discounted	
	USINEX resources	Repayment of long-term loans	Reinvest-ment	Total	Cash flow	Residual assets	Net	at 18%	at 17%
0	191,577			191,577			- 191,577	- 191,577	- 191,577
1					28,104		28,104	23,817	24,020
2		583		583	43,529		42,946	30,843	31,373
3		7,666	9,000	16,666	43,927		27,261	16,592	17,021
4		12,249		12,249	44,909		32,660	16,846	17,429
5				12,249	46,951		34,702	15,168	15,828
6			9,000	21,249	42,833		21,584	7,995	8,414
7				12,249	45,605		33,356	10,471	11,114
8				12,249	48,518		36,269	9,649	10,329
9			9,000	21,249	51,430		30,181	6,804	7,346
10				12,249	54,338		42,089	8,042	7,756
11				12,249	54,231		41,982	6,798	7,465
12			9,000	21,249	54,010		32,761	4,495	4,979
13		12,249		12,249	54,019		41,770	4,857	5,426
14		11,666		11,666	54,398		42,732	4,211	4,744
15		4,583	9,000	13,583	58,967		45,384	3,790	4,306
16						171,911	171,911	12,167	13,942

(b) Quantities sold:

	25% extract (kg)
Production year -1	93,556
Production year 0	93,556
Accumulated stock at beginning of year -1: (32,432 kg 32.52% concentration)	42,188
	229,300
Estimated stock at end of year 0 (20% of annual output)	-18,711
Sales for the two years	210,589

(c) Sales for years -1 and 0 (f.o.b. Kigali)
210,589 kg x RF 1,973.80 = RF 415,660,568

Cost of merchandise sold

	year -1	year 0	Total
	(RF)	(RF)	(RF)
1,575 tons dried flowers x 2 years at RF 84/kg			264,600,000
Other materials consumed:	14,153,152		
year -1 RF 151.28/kg			29,721,806
year 0 RF 166.41/kg		15,568,654	
Sub-total			294,321,806
Cost of delivery stock:			
RF 294,321,806 ÷ 187,112 kg = RF 1,572.97/kg x 18,711 kg			-29,431,866
Cost of initial stock (balance 31 December 1976)			+66,857,595
Fixed costs	40,746,932	42,026,142	82,773,864
Cost ex-factory			414,521,399

Transport and insurance Ruhengeri - Kigali

210,589 kg, 25% extract	
(transport conditions for crude average 32% extract)	
164,523 kg x RF 11/kg	1,809,753
Cost f.o.b. Kigali	416,331,152

Results

	RF
Cumulative profit at end of 1976	1,722,030
Sales for years -1 and 0 RF 415,660,568	
Cost of merchandise sold at	
the corresponding stage RF 416,331,152	- 670,584
	1,051,446
Interest due in year 0 on loan for equipment	
of refinery contracted in year -1	- 377,000
Forecast accumulation at end 1978	674,446

F. Commentary

It was shown in chapter I that, if the pyrethrin operation is limited to the extraction of pyrethrin, the entire operation seems to be doomed to failure in the more or less distant future.

The financial analysis of the project for adding a refining activity to the existing extraction operation shows, however, that:

1. The operation is profitable. The profit margin (net of all charges) as a percentage of the ex-factory production costs would be:

Year	Margin (%)
1	3.90
3	5.46
5	5.18
10	8.03

The return on capital (USINEX resources plus long-term loans, refinery) would be:

Year	Return (%)
1	1.69
3	6.36
5	7.25
10	12.80

2. This profitability is explained by:

(a) The more remunerative selling price of pale extract;

(b) The higher level of utilization of capacity and hence the better use of capital. The ratio of turnover (annual sales) to the capital invested would be 0.77 for extraction (average over five years) and 1.27 for refinery (average of the first five years).

3. This profitability factor will benefit the pyrethrum growers as is shown by the percentage distribution of the factory production price of 1kg of pale extract.

Factory production price distribution (%)

Year	Production price ex-factory	Growers	Share going to ASPY	Share going to USINEX
1	100	45.92	17.31	36.77
3	100	51.97	16.34	31.69
5	100	55.24	15.69	29.07
10	100	56.93	14.82	28.25

4. The various indices presented do not show clearly the true financial profitability of the project. If the project is not executed, some of the investments already made in the pyrethrum operation would cease to be used. In addition to the profitability of the project, there must therefore be added the cost of relinquishing the capital investment already made, which would not be recoverable.

5. The study of the financial profitability of the project is intended only to show that the operation of the refinery will leave a disposable surplus. As USINEX is a public non-profit establishment, it will be for the Government to decide on the distribution of this disposable surplus in the interests of the other parties taking part in the operation: ASPY, the growers, and the entire rural population.

6. The profits of USINEX will, however, be distributed only progressively as the USINEX operation is consolidated.

7. The Government must first examine the arrangements to be made to give USINEX adequate working capital at the time of the start-up of the operation (the supplier credit that USINEX would then be able to use would doubtless not be adequate to guarantee an adequate level of working capital).

8. No accounting and financial estimate has been made of the profitability of a refinery considered as a seperate operation from extraction. Such an analysis would be complex, implying sharing of costs and income among separate "cost centres", and the idea was rejected mainly because it has nothing to do with the existing situation. The financial analysis therefore confirms not only the obvious close relationship between extraction and refining but also the relationship between agricultural production and the industrial processing of pyrethrum. The close relationship in terms of accountancy should foreshadow to a certain extent institutional integration, which it is for the Government to establish.

9. It is recommended that the authorities take the appropriate steps to support ASPY and the entire agricultural sector without waiting to receive the necessary resources from the operation of the refinery.

VII. ECONOMIC PROFITABILITY

A. The project and its objectives

Land and foreign exchange are the scarcest resources in Rwanda; land because of the high density of the population in relation to the availability of arable land and foreign exchange as the result of a persistent deficit in the balance of payments. The purposes of the proposed pyrethrum refining plant are to promote a more efficient use of land and to generate additional foreign-exchange earnings.

At present the main earner of foreign exchange is coffee, which accounted for 46.2% of total exports in 1977. Tea and cinchona were introduced in recent years with encouraging results, but the share of these together with pyrethrum (crude extract) is still low, accounting for 17.3% of total exports in 1977 (the share of pyrethrum proper was 5.8%). Because of the country's dependence on a monoculture and the necessity of increasing its capacity to earn foreign exchange to meet rising import needs, the Government attaches high priority to the diversification of exports. During the Second Five-Year Plan (1977-1981) it intends to give as high a priority to the production of industrial export crops as to the production of food crops since the latter could be jeopardized if the export sector were to stagnate.

The establishment of a pyrethrum refining plant is a logical and timely development in the light of Plan objectives and strategy. Pyrethrum has already proved its worth as a foreign-exchange earner. The refinery, when established, will increase the volume and value of exports since the market for pale extract is more secure than that for crude extract. It is also expected to stimulate a more efficient use of land by farmers and thereby to increase their incomes. The project would have a favourable social effect through increased incomes, which in turn would have a multiplier effect on the national economy. The cultivation of pyrethrum would also serve farmers in an activity above the level of subsistence farming. Many of the benefits that could justifiably be attributed to the project cannot be quantified, and decision makers should keep these intangible benefits of the project in mind.

To facilitate an overall evaluation of the economic effect of the project, this chapter is not limited merely to the simple arithmetic of a social cost-benefit analysis. Instead, it includes an overview of the country's economy and of the goals of the Plan, an assessment of the project in terms of national efforts and objectives, a discussion of the approach used for appraising economic benefits, a calculation of economic benefits including a description of the basis for estimating shadow prices, and the findings of the economic analysis.

Overview of the economy and plan objectives

In 1976, the GDP of Rwanda was estimated at RF 46,273 million and its population numbered 4,263,000. *Per capita* GDP was thus about $US 117.[1/] Agriculture was the predominant sector; its contribution to GDP, although it has declined steadily in recent years,[2/] was about 57% in 1976. Over 96% of the population were engaged in agriculture and related activities in the rural areas. Industrial development was still in an embryonic stage, the share of the industrial sector being less than 4.4% of GDP. Employment in industry was 15,683, accounting for only 12.5% of the total of those gainfully employed. Industrial activities were limited to simple import-substitute manufacturing or to the primary processing of a few agricultural products. The largest industry was a brewery located at Gisenyi.

The rapid rate of growth of the economy, which took place between 1964-1970,[3/] came to a halt in the succeeding years lately because of inflationary processes in the international economy arising out of the unstable international monetary system and the sharp increase in oil prices. Between 1971 and 1975, the annual growth rate is estimated to have been less than the average annual growth rate of the population, thus resulting in a decline in *per capita* income. The setback in agricultural production owing to adverse climatic conditions was largely responsible for the slowing down of the economy during this period. In 1976, agricultural output rose substantially and there was an upswing in the economy. The downward trend of the main cash export crop - coffee - was reversed in 1974 because of the rise in producer prices following the failure of the coffee crop in Brazil. The subsequent stabilization of the price at a high level (45 RF/kg in 1974) has acted as an incentive to farmers to increase output, thus improving the prospects of maintaining economic growth in the immediate future.

1/ At the official rate of exchange of $US 1.00 = RF 92.84.

2/ Share of agriculture in GDP: 1964, 76%; 1970, 66%; 1972, 63%; 1974, 61%.

3/ GDP is estimated to have grown at 8% per annum.

In the long run, however, the prospects of economic development will depend on the success of measures taken to overcome the formidable difficulties faced by Rwanda. Some of these are common to developing countries such as lack of skills and technology. But foremost in the case of Rwanda is the pressure of the population on the land. Density of population, which is about 261 inhabitants per km^2 of arable land, is one of the highest in Africa. If the present rate of population growth (2.6%) is maintained, the country faces the prospect of its population doubling by the end of the century, which would have serious consequences for land use and food supply unless timely and effective measures are taken to improve agricultural techniques and to raise productivity. At the same time yields per hectare of food crops have generally been declining in recent years as a result of marginal land being brought under cultivation and as a result of a deterioration of land from intensive farming using traditional techniques.

The economic development of Rwanda is hindered not only by the problem of the supply of food keeping pace with population growth, but also by the need to generate the income for investment in other sectors of the economy, which could only be done by expanding industrial crops for export. The country's balance of payments has continued to be in deficit, and it has been able to carry on external transactions only through a generous external assistance.

Given these constraints and challenges, the Government has designed a strategy of economic development, the Second Five-Year Plan (1977-1981), which has as basic policy objectives:

(a) To meet the food supply needs of the population;

(b) To promote a better utilization of human resources;

(c) To improve the living conditions of the individual and the community;

(d) To increase its foreign-exchange earnings.

To achieve these objectives the highest priority will be given to integrated rural development using the communes, the smallest administrative unit, as the focal points of development efforts.4/ This would enable the involvement of the entire population in the achievement of national objectives; the

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4/ Communes cover an average area of 300 km^2 in which on the average there are 30,000 inhabitants.

effective promotion of national unity and cohesion; and the equitable regional and individual distribution of the fruits of economic development.

In quantitative terms, the Plan foresees an annual rate of growth of GDP of 6.1% which would mean a rise in <u>per capita</u> GDP of 3.5%. The rate of growth of agriculture would be 5.0% per annum. The rate of food crop production is projected at a growth rate of 3.7% per annum which would thus be above the rate of growth of population (2.6%). Industrial crop production is expected to grow at the much higher rate of 12.7% per annum although its share of value added in agriculture would still be less than 10%. As a result of these efforts it is expected that there would be significant improvements in the income differential between the rural and urban population. With the anticipated rise in the purchasing power of the rural population derived from increases in output and prices of food and industrial crops, the prospects for speeding up the process of industrialization is expected to improve significantly.

The Plan envisages an annual rate of growth of 7.1% for the industry, mining and construction sector with manufacturing proper growing at an annual rate of 16.5%. The fastest growing industries are expected to be leather and textiles (60% per annum), building materials (67% per annum), chemicals (28.5% per annum) and agro-industries (8.2% per annum). Rwanda has a natural advantage for developing import-substitute industries, especially of bulky materials such as cement and bricks because of its distance from the sea (the nearest port, Mombasa, being 1,700 km away). Plan targets for the manufacturing sector appear attainable provided exports from Rwanda continue to expand and provided the requisite local skills and industrial infrastructure are developed in time.

<u>The project</u>

The tasks set for the manufacturing sector by the Plan are:

(a) To increase domestic processing of agricultural produce;

(b) To develop agricultural input industries;

(c) To promote labour-intensive industries;

(d) To expand import-substitute industries;

(e) To promote increased domestic processing of agricultural and mineral resources.

The proposal to create a pyrethrum refinery at Ruhengeri falls within these objectives. In co-operation with UNDP and UNIDO the Government has directed its efforts towards establishing such a refinery and has made a number of pre-feasibility surveys leading to the present feasibility study.

In 1972 a pyrethrum extraction plant was established at Ruhengeri with the assistance of UNIDO/UNDP. It is operated by the parastatal organization USINEX. Dried flowers are supplied to USINEX by ASPY, which is a co-operative managing an agricultural settlement scheme known as the Paysannat. Some 6,000 families are members of ASPY, which has granted each family 1.8 to 2 hectares with the proviso that they plant pyrethrum on 0.72 ha of their plots. Some 4,500 families outside the Paysannats so-called "hors paysannats" - and private planters also supply pyrethrum to ASPY. Agricultural extension services, fertilizers and seedlings are provided to the Paysannat free of charge. ASPY has also set up and operates driers (23 in all at present). Its services are financed by the margin of gain from the price of sales of dried flowers to USINEX and the price ASPY pays to the pyrethrum growers. Production and prices in recent years were as follows:

	1973	1974	1975	1976	1977
Output (tons dried flowers)	1,209	1,274	1,814	1,500	1,905
Price to the farmer (RF/kg)	9	9	12	12	12
USINEX price[5/] (RF/kg dried flowers)	75	75	84	84	84

The current price of 12 RF/kg although satisfactory from the point of view of the farmer considering his contractual obligations to ASPY would appear to be less attractive considering his possible income from alternative crops, particularly potato cultivation, as indicated in the comparative figures below:

	Pyrethrum	String beans	Peas	Wheat	Potatoes
Farm-gate price (RF/kg)	12	22.50	20.50	17	7
Yield per ha (kg/ha)	3,150	720	790	1,600	7,500
Revenue from 1 ha (RF)	37,800	16,200	16,200	27,200	52,500

5/ 1 kg dried flowers = 5 kg fresh flowers.

The main current problem acting as a disincentive to farmers in growing pyrethrum would seem to be the delay in payments. At present the delay is six months because of stockpiling of crude extract owing to a slackening of demand on the international market. The purpose of the refinery project is, therefore, not only to increase the domestic value added content of this important Rwandese resource but also to stabilize incomes arising from the more assured long-term market for pale extract. Not only would it be possible to pay the farmer promptly, but it should also be possible to increase his earnings through higher prices paid for fresh flowers.

The proposed refinery is an extension of the existing crude extract plant. It would thus form an integral part of the upstream activities, namely the "paysannats", ASPY and USINEX. The Government is considering an operational structure which would assure the effective co-ordination of these activities. This could take the form of a single authority over ASPY, USINEX and the refinery or, alternatively, of interlocking functions of their respective boards of directors. In any event, an appropriate mechanism would be needed to co-ordinate operational policies at all levels.

The refinery would have a capacity for processing crude extract derived from an input of 3,000 tons of dried flowers per year. The cost of investment is estimated at RF 143,333,869, of which RF 120,190,161 would be in foreign exchange. No additional investments (with the exception of additional repair and maintenance) are foreseen for the crude extract plant during the estimated economic life of the project, which is 15 years. To attain a yearly supply of 3,000 tons of dried flowers, ASPY would, however, need to expand its fresh flower-drying capacity. A total of nine new driers would be needed.

The production cost of the refinery at full production level is estimated at RF 506,951,000. As USINEX has already trained a number of skilled Rwandese personnel, the need for expatriate services would be limited to the first two to three years of operations. Project costs would also include costs for additional inputs in growing pyrethrum. Project benefits would represent the value of the pale extract, which is entirely exported, and the expected rise in farmers' incomes. The international market of pale extract has been taken at $US 33 (c.i.f. United States of America) per kg on the basis of 25% pyrethrin content.

B. Appraising economic benefits

The Plan specifies four criteria for the choice of investment projects, namely:

(a) Economic profitability;

(b) Effects of the project on employment;

(c) Effects of the project on the balance of payments;

(d) Contribution of the project to the resolution of the country's food supply problem.

Four parameters have accordingly been developed to enable the comparison of alternative projects based on the above criteria. The parameters are given by the formulae:

$$A_1 = \frac{Ex96,000}{K},\ A_2 = \frac{P}{K},\ A_3 = \frac{D}{K},\ \text{and}\ A_4 = \frac{M}{T}$$

where: 96,000 = average annual wage of unskilled labour
E = amount of local employment created
K = annual cost of capital
P = annual turnover
D = improvement in the balance of payments because of the project
M = local raw materials by value
T = value of inputs

As the refinery project is an extension of investments already undertaken, namely the crude extract plant and the ASPY operations, net economic benefit is the difference of incremental outputs and incremental costs.

Project incremental benefits are made up to two parts: (a) the value of pale extract marketed and (b) the increased incomes of pyrethrum farmers. Incremental costs are composed of (a) investment and operational costs of the refinery and (b) additional costs to farmers in producing 3,000 tons per annum of dried flowers. These latter costs are assumed to consist of land rental for additional acreage and increases in family labour. Other input costs at the farm level are assumed to be absorbed by ASPY out of the margin between the price it gets for dried flowers and the price it pays farmers for fresh flowers. This margin is assumed to balance economic costs and benefits since ASPY is a non-profit-making co-operative.

The net present value (NPV) of the project is, therefore, calculated according to the following formula:

$$NPV \quad \frac{B_r - Oc - K + Ba}{(1 + i)\ n}$$

where: B_r = benefit streams of refinery

Oc = cost streams of refinery

K = investment costs of refinery

Ba = incremental agricultural benefits

i = discount rate

n = economic life of the project.

Costs and benefits have been calculated using shadow prices for foreign exchange and for unskilled farm labour to reflect their opportunity costs in the economy. Capital has not been shadow priced because the project does not compete with a private sector project nor is it likely to be used in another public sector project. Rents, taxes and duties have been eliminated since they are internal transfers but insurance costs incurred in foreign exchange have been retained since they constitute real costs to the economy. As land for the refinery plant construction is within the bounds of the crude extract plant, it has no alternative use and thus its opportunity cost is zero. Land for pyrethrum growing has, however, been included as a cost since it has alternative uses in producing food and cash crops but has not been foreign-exchange shadow-priced since the alternative agricultural produce (potatoes) is not internationally traded. Administrative, supervisory and skilled labour have been valued at their market prices since market wage rates closely reflect their opportunity costs. Unskilled farm labour has been shadow-priced, however, because of the labour surplus in Rwanda. The price of fresh flowers is determined by policy; it has therefore been revalued to reflect the earnings foregone from other crops. It is assumed that the price thus calculated would remain constant over the life of the project. As to pale extract, the entire output has been valued at export prices (c.i.f. United States) since it is entirely internationally traded.

C. Economic profitability

The calculations of economic benefits are presented in tables 22 - 26; they are based on the assumption and estimates made in this chapter.

Table 22 indicates the nature and timing of project investment costs. The foreign-exchange component is corrected by the factor 1.30. Table 23 gives the operation costs of the refinery. The foreign exchange components and unskilled labour costs are shadow-priced. Costs such as depreciation, interest etc. have been excluded since they are considered as transfers within the economy. Table 24 shows the output of the refinery valued at market prices and then shadow-priced. Table 25 provides estimates of the benefits and cost streams of farmers resulting from the project.

Table 26 brings together all the economic benefits and costs of the project, on the basis of which net benefits have been calculated. These were discounted. At rates of 8% and 20%; the former may be considered to approximate the social discount rate. The calculations show that even at the substantially higher rate of discount of 20%, the project is highly profitable and substantially beneficial to the National economy.

Table 22. Investment costs
(RF)

Item		Year		
		-1	0	1
Equipment:	local currency	556.8	7 238.0	3 310.6
	foreign exchange	3 758.0	48 854.3	22 548.1
Start-up costs:	local currency	-	-	-
	foreign exchange	1 172.1	15 237.6	7 032.8
Building:	local currency	611.5	7 950.0	3 669.1
	foreign exchange	240.2	3 122.0	1 440.9
Working capital:	local currency	-	-	-
	foreign exchange	-	-	16 784.2
Total		6 338.6	82 401.9	54 815.7
of which:	local currency	1 168.3	15 188.0	7 009.7
	foreign exchange	5 170.3	67 213.9	47 806.0
Investment costs (shadow priced)		7 889.7	102 566.1	69 157.5

D. Estimation of shadow prices

Foreign exchange

The ability of Rwanda to export is not commensurate with its import requirements. Foreign exchange policy in the circumstances is designed to ration

Table 23. Cost streams of the refinery
(RF 1,000)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
a. <u>Production costs</u>															
Crude extract	146,069	345,777	349,000	408,927	414,379	420,536	425,988	431 441	436 893	442 345	443 401	443 401	443 401	443 401	443 401
Imported inputs	17 701	39 223	39 223	45 266	46 104	46 842	47 781	48 619	49 457	50 295	50 295	50 295	50 295	50 295	50 295
Utility	1 027	2 274	2 274	2 663	2 672	2 721	2 769	2 818	2 867	2 916	2 916	2 916	2 916	2 916	2 916
Maintenance and repair	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200
Labour	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030	1 030
Expatriate costs	4 456	5 013	2 785	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal (a), of which:	171 483	394 517	395 512	459 044	465 385	472 429	478 768	485 108	491 447	497 786	498 842	498 842	498 842	498 842	498 842
local currency	138 203	324 662	326 771	381 505	386 433	392 433	396 988	402 365	406 840	411 766	412 822	412 822	412 822	412 822	412 822
foreign exchange	32 680	69 255	68 141	76 939	78 352	79 765	81 180	82 143	84 007	85 420	85 420	85 240	85 240	85 240	85 240
unskilled labour	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
b. <u>Other costs</u>															
Insurance	1 250	1 300	1 350	1 400	1 450	1 500	1 550	1 600	1 650	1 700	1 700	1 700	1 700	1 700	1 700
Transport	6 698	16 179	18 075	20 741	21 591	22 078	22 493	22 893	23 290	23 687	23 766	23 782	23 785	23 785	23 785
Commissions etc.	9 715	23 439	26 220	30 086	31 320	32 026	32 628	33 209	33 784	34 360	34 475	34 498	34 503	34 503	34 503
USINEX repair	-	-	-	-	-	7 390	7 390	7 390	7 390	7 390	8 446	8 446	8 446	8 446	8 446
Subtotal (b), of which:	17 663	40 918	45 645	52 227	54 361	62 994	64 061	65 092	66 114	67 137	68 387	68 426	68 434	68 434	68 434
local currency	565	1 020	1 119	1 254	1 304	2 815	2 845	2 873	2 902	2 931	3 145	3 146	3 146	3 146	3 146
foreign exchange	17 098	39 898	44 526	50 973	53 057	60 179	61 216	62 219	63 212	64 206	65 242	65 280	65 288	65 288	65 288
Total costs	189 146	435 435	441 157	511 271	519 746	535 423	542 829	550 200	557 561	561 992	567 229	567 268	567 276	567 276	567 276
Costs at shadow prices	203 599	467 701	474 477	549 165	558 689	576 927	585 068	593 029	601 247	608 331	610 948	610 948	611 008	611 008	611 008

Table 24. Benefit streams of the refinery

Year	Output (kg)	Value at market price (RF 1,000)	Value at shadow price of foreign exchange (RF 1,000)
1	57 200	173 488	225 534
2	138 181	419 103	544 834
3	154 377	468 225	608 693
4	177 142	537 272	698 454
5	184 403	559 294	727 082
6	188 565	571 918	743 493
7	192 106	582 657	757 454
8	195 522	593 018	770 923
9	198 914	603 306	784 298
10	202 301	613 579	797 653
11	202 978	615 632	800 322
12	203 114	616 045	800 859
13	203 142	616 130	800 969
14	203 146	616 142	800 985
15	203 148	616 148	800 992

available earnings among competing demands, and, consequently, the official exchange rate does not reflect the marginal willingness to pay for foreign exchange. To be sure, the free market exchange rate of the RF is observed to be about 25% above the official exchange rate of the United States dollar.

The shadow price of foreign exchange is taken to be the ratio of weighted average of domestic market prices of imported goods to c.i.f. prices. In the case of Rwanda, the former is made up not only of customs receipts at Kigali but also of transport and insurance costs from the nearest port because of the preponderance of these costs in the make-up of domestic prices. On the basis of data on imports and import levies, the correction factor for foreign exchange was estimated at 45%, i.e. the value of $US 1 to be equal to about RF 135. As the project is sensitive to this correction factor, the calculations have also been made at the substantially lower level of 30%, i.e. $US 1 = RF 120.

Table 25. Agricultural costs and benefits

	Year 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Land under cultivation (ha)	3 000	3 182	3 417	4 167	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000
Additional land brought under cultivation due to project (ha)	-	182	417	1 167	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Rental of incremental land (RF 1,000)	-	4 495	10 300	28 825	49 400	49 400	49 400	49 400	49 400	49 400	49 400	49 400	49 400	49 400	49 400	49 400
Increase in labour units due to project (1,000 man-days) a/	-	66	132	420	720	720	720	720	720	720	720	720	720	720	720	720
Incremental labour costs (RF 1,000)	-	1 980	3 960	12 600	21 600	21 600	21 600	21 600	21 600	21 600	21 600	21 600	21 600	21 600	21 600	21 600
Incremental costs (RF 1,000)	-	6 475	14 260	41 425	71 000	71 000	71 000	71 000	71 000	71 000	71 000	71 000	71 000	71 000	71 000	71 000
Fresh flower product[illegible]ons)	7 875	8 750	10 250	12 500	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000
Value of production at farm gate price of RF 14 per kg (RF 1,000)	110 250	122 500	143 500	175 000	210 000	210 000	210 000	210 000	210 000	210 000	210 000	210 000	210 000	210 000	210 000	210 000
Incremental value of production (RF 1,000) b/		12 250	33 250	62 500	99 750	99 750	99 750	99 750	99 750	99 750	99 750	99 [illegible]	99 750	99 750	99 750	99 750
Net incremental farmers' benefits (RF 1,000)	-	5 775	17 990	21 075	28 750	28 750	28 750	28 750	28 750	28 750	28 750	28 750	28 750	28 750	28 750	28 750

a/ Assuming labour required as 360 man-days on the average.

b/ At a shadow price of RF 14 per kg of fresh flowers.

Table 26. Net economic benefits
(RF 1,000)

Year	Benefits				Costs			Net benefits	Net present value	
	Refinery	Agriculture	Terminal value	Total	Investment	Operational	Total		At 8% discount rate	At 20% discount rate
-1	-	-		-	7 890	-	7 890	-7 890	-7 890	-7 890
0	-	-		-	102 566	-	102 566	-102 566	-95 386	-85 438
1	225 534	5 775		231 309	69 156	203 599	272 755	-42 446	-35 644	-28 764
2	544 834	17 990		562 824	-	467 701	467 701	95 123	75 147	55 076
3	608 693	21 075		629 768	-	474 477	474 477	155 291	114 915	74 850
4	698 454	28 750		727 204	-	549 165	549 165	178 039	121 067	71 572
5	727 082	28 750		755 832	-	558 689	558 689	197 143	124 200	66 043
6	743 493	28 750		772 243	-	576 927	576 927	195 316	113 283	54 493
7	757 454	28 750		786 204	-	585 068	585 068	201 136	108 613	46 865
8	770 923	28 750		799 673	-	593 029	593 029	206 644	103 322	40 089
9	784 298	28 750		813 048	-	601 247	601 247	211 801	97 429	34 312
10	797 653	28 750		826 403	-	608 331	608 331	218 072	93 771	29 440
11	800 322	28 750		829 072	-	610 948	610 948	218 142	87 257	24 432
12	800 859	28 750		829 609	-	610 998	610 998	218 611	80 886	20 549
13	800 969	28 750		829 719	-	611 008	611 008	218 711	74 362	17 061
14	800 985	28 750		829 735	-	611 008	611 008	218 727	69 993	14 217
15	800 992	28 750		829 742	-	611 008	611 008	218 734	63 433	11 812
16	-	-	152 933	152 933	-	-	-	152 933	41 292	6 882
Net present value at 8% and 20% discount rate									1 227 237	440 825

Shadow wages of labour

Expatriate and skilled local labour are valued at the market wage rates since these closely reflect their opportunity costs. Because of the country's high unemployment and resultant labour surplus, the same cannot be claimed for unskilled labour. For pyrethrum planting and construction of the refinery, unskilled labour will be drawn from the family unit in agriculture which will mean additional effort or using up seasonal slack. The supply price of this labour is assumed to be at a rate reflecting average consumption in the family unit, which is calculated to be RF 30 per day. This is used as the shadow cost of unskilled labour in both pyrethrum cultivation and construction of the refinery. It may also be derived by calculating extra consumption from the formula $w\ c - d\ (1-c')$, where w = industrial wage rate, c = propensity to consume of the labourer, d = average consumption of the labourer in the agricultural family unit and c' = propensity to consume of the family unit. Assuming $c' = 0.97$ (on the basis of the observed 3% savings rate on rural income) and $c = 0.75$ (on the grounds that the labourer would also be obliged to transfer part of his income to his former posts),and taking d = per capita consumption in rural areas (RF 9,882 per annum) and the market wage rate, w = RF 60 per day, the shadow labour cost would be RF 30.

Discount rate

Market rates of interest in Rwanda are low and differentiated among borrowers. Savings earn 3% and the Central Bank lends to the Government at a rate of 2% to 3%. Medium and long-term credits by the Banque Rwandaise de Développement (BRD) have averaged about 7.5%, and commercial bank lending for short-term loans is at rates of between 8% and 11%. The BRD is stated to use a discount rate of 10% to 12% for projects it finances. The low market rates of interest would seem to reflect a generally low rate of return on projects.

A low social discount rate implies a policy objective of enabling a larger volume of investment and hence of attaching greater importance to consumption in the future than at present. The appropriate social discount rate cannot be equated to the marginal internal rate of return in the private sector because the capital market is imperfect for mobilizing savings for an optimal investment rate. Hence the choice of an appropriate social discount rate is a choice among complementary national objectives requiring that policy makers make value judgments concerning their relative importance.

Benefit streams of the project are evaluated at 8% and also at the much higher level of 20%. The former rate is assumed to reflect social discount rate in Rwanda, while the latter rate has been used by way of sensitivity analysis.

Valuation of outputs and inputs

Pale extract output is all exported. It is valued at export prices less transport and insurance costs inside and outside the country. The latter costs are charged to the project. Export prices are assumed to remain constant throughout the economic life of the project (15 years). Similarly, prices of crude extract from USINEX and dried flowers from ASPY are valued at their market prices and assumed to remain constant through the life of the project. On the other hand, the price offered to the farmer for fresh flowers is determined by policy and hence considered not to reflect its real value to the farmer. Free to choose his cropping pattern, he will make his production decision in accordance with economic rationale. Potato planting would seem to be the most profitable alternative crop. It is estimated that at a cost of production of RF 24,270 (shadow priced for labour) per hectare he could expect to get RF 49,000 worth of potatoes, while for a production cost of RF 65,125 his output of pyrethrum is estimated at 9,500 kg per hectare. These relationships lead to the conclusion that the farmer would respond to pyrethrum growing at a price level of RF 14 per kilo of fresh flowers, assuming costs of fertilizers and seeds are borne by ASPY out of its margin of sales to USINEX. This price is used for valuing the farmer's output of fresh flowers.

Land rental

Again economic choice will dictate the most efficient use of land. Further the Plan gives the highest priority to the production of food crops. There is, therefore, an economic cost to the use of land for growing pyrethrum, although the project does not by and large displace existing crops. This cost is equaled to the benefits that might have been realized with food crop production. Again potato are taken as proxy for calculating land rental, it being the difference between the value of potato output and the cost of production associated thereof per hectare. Value of output per hectare being RF 49,000 and input costs RF 24,300 (shadow priced), land rental costs are taken at RF 24,700.

Other inputs

Other inputs whether at the USINEX, ASPY or farmer level are valued at either market or c.i.f. prices as appropriate.

E. Conclusions

The calculations indicate that it would be highly profitable for Rwanda to create the proposed pyrethrum refining unit; NPV at the relatively high discount rate of 20% comes to RF 440,825. The project would yield substantial foreign exchange per unit of domestic resources used since the main cost element of the refinery, namely pyrethrum, is a Rwandese natural resource. Consequently, the project would contribute significantly to foreign-exchange earnings. It would also lead to a more efficient use of land since higher farm-gate prices would encourage farmers to make production decisions in accordance with economic rationale and efficiency.

The economic profitability of the project would obviously be sensitive to the international price of pale extract. The risk and uncertainty implied are indicated in table 27, in which economic profitability is measured assuming a reduction of 15% in the price level. Even with a fall of this amount and using the high discount rate of 20% the project would prove viable, however, since NPV comes to RF 93,803 million.

Lastly, while the economic analysis in this chapter has dwelt on the quantifiable elements of benefits and costs directly related to the project, it is important to point out that in order to ensure the efficiency of the total pyrethrum operation the Government will need:

(a) To provide additional extension services to the farmer;

(b) To increase the pyretherin content of flowers;

(c) To expand ASPY investments in road networks and drier facilities;

(d) To continue to improve the operational efficiency of ASPY and USINEX;

(e) To ensure prompt payment to farmers;

(f) To raise the farm-gate prices of fresh flowers;

(g) To set up an appropriate marketing organization for pyrethrum;

(h) To encourage close co-ordination among ISAR, ASPY, OCIR, USINEX and the future refinery;

(i) To pursue measures that would lead to the creation of regional and interregional pyrethrum producers' associations.

Table 27. Sensitivity analysis (assuming a 15% reduction in the price of pale extract)

Year	Value of pale extract	Benefits including agriculture	Net benefits	NPV at 20%
-1	–		7 890	7 890
0	–		102 566	85 438
1	191 704	199 085	73 670	51 127
2	463 109	481 099	13 398	7 744
3	517 389	538 464	63 987	30 842
4	593 686	622 436	73 271	29 382
5	618 020	646 770	88 081	29 419
6	632 700	661 450	84 523	23 582
7	643 836	672 586	87 518	20 304
8	655 285	684 035	91 006	17 564
9	666 653	695 403	94 156	15 217
10	678 005	706 755	98 424	13 189
11	680 274	709 024	98 076	10 985
12	680 730	709 480	98 482	9 159
13	680 824	709 574	98 566	7 590
14	680 837	709 587	98 579	6 309
15	680 843	709 593	98 585	5 324
16	–	152 933	152 933	6 882
NPV at 20% discount rate				93 803

VIII. GENERAL RECOMMENDATIONS

A crude extraction plant was installed in Rwanda in 1972. Cultivation of flower is now approximately 1,509 tons as against 1,796 tons in 1976. The reasons for this situation are very complex and will be found in detail in the main body of the report. Some recommendations covering the whole Rwandese pyrethrum industry are considered necessary, however, since the pale extract refinery will be established in the next two years.

The main divisions of the pyrethrum industry are as follows:

(a) Propagation and cultivation;

(b) Collection and drying of flowers;

(c) Extraction and refining;

(d) Marketing.

Propagation and cultivation

In order to make the Paysannat readily accept propagation of high pyrethrum content clones, increase the areas under cultivation for pyrethrum and improve flower yields by adopting better cultivation practices, additional incentives and extension services must be made available. Increased rates for flowers must be payable to the Paysannat so as to make additional pyrethrum cultivation attractive compared to the cultivation of other crops.

In order to assist the Paysannat with up-to-date and effective cultivation techniques, the extension services provided by ASPY must be improved and strengthened. Further, to encourage cultivation of high pyrethrum content clones, ASPY should perhaps introduce later a differential payment system based on the quality (pyrethrum content) of the flowers cultivated. With regard to the cultivation of high yielding clones, the propagation facilities at ISAR should be extended by more than 20 hectares so that the Paysannat could be provided with reproduction material every year.

It follows from the above that for the improved flower cultivation programmes to succeed, continual improvements in management and the operational efficiency of ASPY are necessary. As a first step, a reappraisal and reassessment of the payment system for flowers is needed to alleviate the problem of delayed payments to the Paysannat and the farmers' resultant lack of interest in pyrethrum as a crop.

It is felt that the problem of delayed flower payments can be partly solved by the injection of sufficient capital into ASPY to alleviate its chronic liquidity problems. Sufficient funds for this purpose should be made available from government sources.

Collection and drying

At the present flower production level the road system within the Paysannat, collection system and drier installations appears to be adequate. However, to achieve an annual production of 3,000 tons of dried flowers, an extension of these services and facilities will be necessary. The importance of strengthening ASPY's management and technical service is highlighted here, because a further 1,500 hectares of land is expected to be brought under pyrethrum cultivation. The finance for this additional cultivation and associated infrastructure and driers will have to be made available. Further research and development may be needed to get a uniformly dried product.

Extraction and refining

Although the USINEX extraction plant has shown itself capable of processing at high recoveries approximately 1,900 tons of flowers per annum, additional equipment must be installed so as to ensure that the plant will function satisfactorily for a number of years at its design capacity of 3,000 tons a year. The equipment needed (new dual purpose fuel oil/marc boiler, water cooling tower, and compressor for refrigeration unit) is described in the body of this report.

Although Rwandese nationals now carry out most management functions, many of the senior appointments were made only recently, and the management should be strengthened with the aid of specialized training schemes wherever possible.

The refinery should be built at Ruhengeri as soon as practicable, because it will help to stabilize and develop the Rwandese pyrethrum industry. Refined extract has a more secure world market than crude extract and this, together with the profitability of the refinery operation, will enable USINEX to:

(a) Maintain a reasonable and adequate stock of extract and limit any liquidity problem;

(b) Pay ASPY more promptly for flowers received. This would also result in the Paysannat receiving money sooner;

(c) Pay more for flowers and thus stimulate the various cultivation programmes outlined above.

An improved market strategy is required and the isolationalist policy adopted previously should be discouraged.

An appropriate market organization must be established with powers to co-operate with other national pyrethrum marketing organizations. A situation in which USINEX has vast stocks of unsold extract at the end of 1976 cannot be allowed to continue. The installation of a refinery will assist in maintaining a realistic stock situation.

Finally, it is strongly recommended that a body or organization should be established with sufficiently strong powers to co-ordinate all pyrethrum activities at ISAR, ASPY, Paysannat, USINEX, and the marketing organization so as to ensure adequate liaison throughout the pyrethrum industry.