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UNITED NATIONS INDUSTRIAL
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PALM AND PALM KERNEL OIL*.

An agro-industrial pre-feasibility study .

Prepared by a consultant for the Office of the
Board of Investment, Government of Thailand

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ABBREVIATIONS USED IN THIS REPORT

฿ -- Thailand unit of currency, Baht, valued about $0.05

BEP -- break-even point

cif -- cost, insurance, freight

cm -- centimeter (0.394 inch)

EC -- European Community

FAO -- Food and Agriculture Organization of the United Nations

ffa -- free fatty acid

ffb -- fresh fruit bunch (of oil palm tree)

GNP -- Gross national product

ha -- hectare (2.471 acres)

kg -- kilogram (2.2046 lbs.)

km -- kilometer (0.6214 miles)

kwh -- kilowatt hour

rai -- unit of area measurement in Thailand (6.25 rai = 1 hectare)

I. PROJECT INTRODUCTION

In a determined effort to promote and diversify investment in the agro-industrial sector, the Government of Thailand has undertaken a series of studies relating to prime agricultural commodities being currently produced in the country, from which a number of selected products have been examined in some detail and presented as investment opportunities to encourage the interest of potential foreign and domestic investors.

This report provides a source of information concerning the availability, suitability and cost of raw materials to produce a specific product, the cost of operating in Thailand and a market analysis for the product either for local consumption, import substitution and/or export. Investigations were carried out to assess the economic viability of the project, it's impact on the economy of the country and the possibilities it offers for the creation of employment opportunities.

Consideration has been given to the requirements of this particular project for investment incentives in order to show a sizeable net return on invested capital.

Information has been provided about Thailand and it's economy with a summary of the current Five Year Plan, the investment climate and related laws, and other basic information to assist a potential investor.

As an annex to this pre-feasibility study, there is a product Area Report that identifies a wide range of possible processed and semi-processed products, and in general, evaluates the domestic and foreign markets for them.

In selecting the product to be given priority for study as an investment opportunity, the socio-economic affects, technical feasibility, availability of labor supply, availability of, or plans to provide, the required infrastructure, together with restraints on pollution of the environment, were taken into consideration.

This pre-feasibility and product area study is only intended to bring this potential opportunity to the attention of an investor, who it is anticipated would use it as a base to launch a more detailed feasibility study, that would be required before making a decision to establish or expand this product industry in Thailand.

These studies have been funded in part by a loan from the United States Agency for International Development, (USAID), and the Board of Investment's Project Development Division, under whose direction they are being carried out. The BOI is being assisted by Chemonics International Consulting Division of Early California Industries Incorporated in association with Checchi and Company, also of Washington D.C. The Board of Investment would like to take this opportunity to thank the team of Consultants and USAID for their assistance in carrying out these studies.

This pre-feasibility study and annexed product area study, was prepared by Alfred A. Strauss, (Essential & Seed Oil Products Specialist), Frank L. Turner (Feasibility Analyst) and Peter M. Amcotts (Project Manager).

Grateful acknowledgement is made of the assistance given by many Thai Government officials, United Nations and U.S. offices and libraries, and by industrialists and others in the private sector.

SUMMARY

SEED OIL PRE-FEASIBILITY STUDY AND AREA STUDY

Oil seeds have become important crops in Thailand's agriculture. The first part of this study is a result of a survey of the principal oil seeds produced and their processing into oils and meals and their distribution both internally and externally.

The object of the survey was to ascertain the present situation of the seed oil processing industry with a view of appraising likely investment opportunities.

The survey led to the conclusion that oilseed processing capacity was considerably in excess of the supply of raw materials both currently and for the immediate future. Several factors appear to inhibit a marked increase of farmers' oilseed production.

This condition led to the conclusion that palm oil would become the product that would supply the deficit portion of the domestic vegetable oil consumption and provide a surplus for export to the burgeoning world market.

The RTG is making strenuous efforts to settle farmers, especially landless farmers, in organized communities. This program has been successful in the establishment of smallholder oil palm groves and the construction of extracting facilities both publicly and privately owned to process the smallholders' output.

The following study makes a preliminary appraisal of a palm oil extraction facility to be established in southern Thailand to process the production of a smallholder community to be established.

The study concludes that an investment in a processing facility would have a substantial impact since it offers

employment opportunities including the smallholders, which were heretofore unavailable in the region.

Development of 2,000 hectares of oil palm grove will be spaced over a five year period with the extraction facility to be commissioned in the third year after the first planting. The factory will have a first stage capacity of 5 tons[1/] of raw material per hour, followed by an additional 5 tons per hour unit about three years later. Cost of the first phase at current prices (1977) is U.S. $1,307,000 and the cost of the cost of the second phase $415,000.

The break-even point is $566,000 in sales which will be achieved between the second and third years of operation.

Based on the estimates used in this study, average annual profit before taxes is $829,000 resulting in an annual rate of return of 48%.

The payback period is in the sixth year considering the level of profits and losses in the initial years of operation.

II. GENERAL PROJECT DESCRIPTION. PALM AND PALM KERNEL OIL.

For more than ten years, the Royal Thai Government has pursued a program of establishing communities in several regions of the country for settling the landless on plots to which they are given title. Administered by the Ministry of Welfare, the program has succeeded in attracting settlers. In one recently opened area, there were some 2,000 applicants for 600 plots of land.

Observing that the climate in the southern part of the country was similar to that of neighboring Malaysia and desirous of complementing the rubber crop on which the area was highly dependent, Government became interested in the development of a palm oil industry.

1/ Tons in this study are metric.

Beginning with an 8-hectare experimental plot near Satun (6° 35'N, 100° 05'E) in 1969 that was successful, the Public Welfare Department of the Ministry of Welfare induced 240 members of the Southern Region Development Program to grow palm trees on 380 hectares, each member with 1.6 hectares to cultivate. In 1974 the plantation was expanded to 1,460 hectares with the final objective of bringing 3,240 hectares under palm cultivation. A temporary state-owned extraction facility at Satun processes fresh fruit bunches (ffb) from the groves. A new, modern extraction plant will replace it in 1977.

Results of the Government initiative were so encouraging that private capital was attracted to the infant palm industry. The Board of Investment granted promotion privileges to the Thai Oil Palm Industry Co., Ltd., which constructed its own extraction plant in Krabi (8° 05'N, 98° 50'E).

A new organization, Thai Palm Development Co. Ltd., has been granted promotional privileges. The Company has set a production goal of 2,500 tons of oil annually when in full operation.

There are some 9,600 hectares of unoccupied land available in Nakhorn Sri Thammarat Province, Phra Saeng District. (80° 36'N, 99° 15'E) of which about 6,400 hectares are arable. The land is under the control of provincial authorities. The Land Settlement Division of the Ministry of Public Welfare is prepared to initiate development of the arable land on the same pattern that has proven successful in other areas. Each settler is given 2.8 hectares (18 rai) on which he plants 1.6 hectares (10 rai) in oil palm and about one hectare (6 rai) in a cash crop and 0.3 hectares (2 rai) in subsistence crops. Government lends him $25/month for subsistence and planting expenses up to a limit of $2,250. The loan will be repaid from proceeds of ffb sales to the processing plant.

The area has been logged and is now covered in underbrush which will be cleared, burned and planted with a cover crop until the main planting begins. Government will construct settler housing, community roads, water supply, power and other amenities. All-weather roads from the groves to the factory will be constructed by Government.

The settlement project envisages the establishment of 2,000 hectares of oil palm over a five-year period which will require the presence of some 1,200 farmers and their families.

The project described herein envisages the construction and operation of a modern extraction facility to process the produce from the settlement groves. The factory can be constructed in two phases some five years apart. Each phase will be capable of processing five tons of ffb per hour.

This report is a preliminary appraisal of the technical and financial feasibility of investing in the infant palm oil industry in Southern Thailand.

III. RAW MATERIAL

A. Description and Technical Discussion

The oil palm, *Elaeis guineensis*, indigenous to Africa has been successfully transplanted to Southeast Asia, where it is grown on large plantations, and to South and Central America in smaller plantings. These countries are included in a land area extending from 15° north latitude to 12° south which produces over 95% of the world production of palm oil.

The oil palm produces maximum yields under a very limited range of climatic conditions. These include (a) rainfall of 2,000mm or more distributed evenly throughout the year; that is to say, no marked dry seasons, (b) a mean maximum temperature of 29° to 32° C and a mean minimum of about

22° to 24° C and (c) constant sunshine for at least 5 hours per day rising to 7 in some months.

Dahomey, among major producers, probably has the severest climate for oil palms with a 3-month dry period and an average annual rainfall of just under 1,270mm. Average yields there are about 2 tons of oil per hectare compared with yields of 4.5 tons in Malaysia which probably has the optimum climate for palm cultivation.

The oil palm is a very diverse plant in that there is great variation in the characteristics of it's different parts. The fruit itself consists of a fleshy oleaginous mesocarp surrounding a nut, the shell of which encases the palm kernel. The fruit exhibits a variation in size and form which greatly affects yields. The internal fruit forms have been divided into three basic classifications, the Dura, Pisifera, and Tenera. Fruit forms are described as follows:

Dura:	shell 2.8mm thick, low to medium mesocarp content 35 to 65%.
Tenera:	shell ½ to 4mm thick, medium to high mesocarp content 60 to 96%.
Pisifera:	shell-less.

Plantation palms, as differentiated from wild trees, consist almost exclusively of the Tenera type which is actually a cross between the Dura and the more rarely occurring Pisifera forms and commonly is referred to as Dura X Pisifera (DXP) varieties. The Tenera fruit generally has an oil content of 20-21% per ton of ffb, about twice as high as the Dura, while the palm kernel content tends to be about half, or 5% kernels per ton. Highly developed in Malaysia, DXP yields up to 22 tons of ffb per hectare and the oil content of well-ripened fuitlets normally reaching 50 to 55%.

The groves that have been planted in Southern Thailand beginning in 1969, used germinated seed from Malaysia since there was no domestic nursery stock. Nursery techniques have been adopted from Malaysian practices by three presently established groves.

IV. OPTIMUM PROJECT SIZE

A. Raw Material Considerations

1. Volume. Experience with three oil palm operations in the southern provinces indicates that 1,600 hectares in trees is the minimum feasible area to justify an economic size processing facility. Development of 2,000 hectares, which are available within the area, will provide a production increment above the minimum thereby ensuring a continuing operation in the event that adverse weather prevents normal crops.

Processing capacity in this study is based on output from an initial undertaking of developing 2,000 hectares to full production. A schedule of clearing and planting that has been achieved by the established operations in the south is suggested for the subject project:

Year	Hectares
First	400
Second	250
Third	450
Fourth	450
Fifth	450
	2,000

Generally, oil palm will bear fruit during the third year after planting, and design and construction of the processing facility should be coordinated with that event. Maximum yield is reached the eighth to ninth year after planting and 25 years is considered the tree's useful life as it becomes too tall for the ffb to be harvested.

In order to arrive at processing capacity, it is necessary to establish crop projections in relation to the areas under cultivation. An estimate of annual production of ffb in relation to the age of the palms is shown in Table 2.

The first smallholder groves were planted in 1969 and the first harvest was in 1974. The maturation period up to 1977 has not been long enough to provide accurate yield data. Estimated yields from settlement groves in Table 1 are derived from estimates made by Hunting Technical Services Ltd., in their feasibility study of a similar area and from data collected by the International Bank for Reconstruction and Development (World Bank) which were of Malaysian origin. Anticipated yields will be somewhat lower than the best Malaysian ones.

Experience in the industry has shown that the ffb crop during any one peak month can reach 12% of the annual total. Peak-month harvest estimates are shown in Table 2.

In calculating the required processing capacity, two eight-hour shifts working up to 400 hours per month of 25 days are assumed following current Malaysian practice. On this time basis and anticipated peak monthly harvests, minimum capacity can be determined by dividing the latter by 400. By doing so, a processing facility having a capacity of five tons of ffb per hour as the first phase of operations is indicated. This capacity is considered the smallest practicable, commercial size. On the basis of peak monthly harvest estimates, continuous operation at a full five ton rate cannot be achieved until the fourth harvest year. When peak harvests dictate, the second phase would add an equal capacity and the factory could operate at 500 hours during peak months.

2. <u>Cost/Price</u>

The primary purpose of the project being resettlement of the landless, the cost of establishing the palm groves and the requisite road system will be borne by Government.

Although not taken into account in the financial analysis, it is of interest to know the costs incurred in previous settler plantings. The land is Government-owned and neither its cost or its value is considered. (Table 3).

The current (1977) universal price paid at the "farm gate" for ffb without reference to grading is $0.045/kg. This price has been in effect since the beginning of the re-settlement program and is used in this study in computing costs in the first years of factory operation. Estimated cost for later years is shown in the financial projections (See Section VI-D later in this report).

V. MARKET STUDY

A. Domestic Market

1. Past Trends and Projections: Volume and Value

Thailand's imports of palm oil have risen spectacularly since 1974 indicating a vastly increased use in end products (Table 4). An exceptional local use is as the additive in reconstituted milk which, with ice cream, and other dairy products are currently (1977) enjoying a large increase in sales. Consumption of ice cream is increasing at a rate of 30-35% per annum. Magnitude of the importation, mainly from Malaysia, also partly is due to the short supply of other domestic seed oils.

A large domestic market exists for reconstituted, sweetened, condensed milk which uses a non-milk fat. The raw materials for this product are powdered milk, vegetable oil and sugar.

Despite the penetration of detergents into the laundry soap and washing powder market, there is a large consumption of toilet and other varieties of soaps which use vegetable oil in their manufacture. The rise in seed and coconut oil prices opens a wider market for the cheaper palm oil.

There are hundreds of domestic cosmetic manufacturers, but most of them are small, backyard operations. A few major companies produce under license from foreign firms. No estimates are available in regard to the size of the domestic market. However, it is believed, in the trade, that the Bangkok market alone accounts for more than Baht 40 million (U.S.$2.0 million) in imported perfumes, hair preparations, body and face powders, cosmetics and toiletries. There is a 100% tariff on imported cosmetics plus a 20% business tax payable at customs. To the consuming public, prestige brands are foreign brands. Although imports are not being reduced, an increasing number of foreign brands are being manufactured under license.

Thailand has a substantial manufacturing industry which constantly is widening the range of goods produced. Import data suggest that one of the input raw materials is palm oil. Palm oil's price advantage over others will continue to provide a local market of industrial uses.

Refined palm oil also is used as a household cooking medium, it being on the retail market under a trade name.

2. Distribution Systems

Supply of palm oil to manufacturers in urban centers would be made by either railway tank car to a bulk receiving and storage depot and thence by tank truck to smaller volume customers. The means of supply to larger users would depend largely on their location with regard to highway, railway or waterway. Definite arrangements for supply and distribution to other wholesalers are beyond the scope of this study.

B. Foreign Market

1. Supply Projections Table 5 shows the major palm oil producing countries. During the five year period, 1970 through 1974, Malaysia produced 31% of their total, Nigeria 23%, Indonesia 12% and Ivory Coast 4%. Most of Nigeria's output is consumed locally and Nigeria will probably soon become an importer. Foreign exchange from petroleum exports is available for the importation.

By 1980, Malaysia will have gained on all other producers and will account for 50% of world output. By 1985, its share will rise further to about 66%. The African countries will continue as major producers but will consume an increasing amount of their output domestically.

2. Imports: Volume, Past Trends, Projections and Value/Price

Palm oil finds its major market in the principal importing countries in the manufacture of edible products, mostly compound cooking fats, mayonnaise and margarine for both household and commercial bakery use. Also, there is a limited demand for use in the manufacture of soaps and candles and as a finishing flux in the tin plate industry.

Palm kernels yield an oil that is very similar to coconut oil and the two virtually are interchangeable.

World-wide palm oil imports are projected to grow at a very rapid pace, namely 11.8% annually to 1980 and 8.6% from 1980 to 1985. (Table 6). This rapid growth is largely accounted for by six phenomena:

First, palm oil prices are the lowest among edible oils and it's price advantage has increased steadily. In 1970, palm oil was 22% cheaper than soy bean oil and became

33% less by 1975. It was 28% cheaper than cottonseed oil in 1970 and became 44% cheaper in 1975. Similar price advantages have occurred with respect to sesame and other edible oils. Recent-year price differences are shown in Table 11.

Current technology and market preference contribute to a lower price since palm oil is a 'hard' (semi-solid) oil and is less widely used than the 'soft' free-flowing oils which generally are preferred and which enjoy a larger market than the former. Expansion of oil palm cultivation will induce a continuing price disparity with palm oil commanding the lower range.

Second, the demand for fats and oils will probably keep pace with rising per capita income in the developing countries, magnified by population increases. Fats and oils' consumption rises rapidly in correspondence with increasing per capita income. Most developing countries consume 3 to 5 kg per capita; industrialized countries on the order of 27 to 30kg per person. When consumption is in the 3 to 5 kg range, a rule of thumb holds that for every $100 increase in per capita income, a 0.5 kg increase in fats and oil consumption ensues. This means that as the four Asian population giants, China, India, Japan and Pakistan, continue to experience rising incomes, their imports of fats and oils will rise quite rapidly.

China's population was 823 million in 1974 and was rising at an annual rate of 1.7%; per capita income was rising faster (in constant prices) at 4%. India's population in 1974 was 610 million and was increasing 2.3% annually; India's per capita GNP will doubtless continue to rise but at a slower pace than China's, possibly at 1.5% yearly.

Japan's current consumption of fats and oils is low by European and U.S. standards. Continuing GNP growth per capita at an estimated 7% should result in a major expansion of fats and oils' imports doubling current consumption and reaching 25 kg per capita by 1985.

In combination, the three Asian countries mentioned, plus Pakistan, should have requirements of nearly three million additional tons of fats and oils by 1985 as a result of the rise in income magnified by the increase in population. Local production in the face of food shortages is not likely to meet demand.

Within the context of rising consumption of all fats and oils, palm oil will rise faster than the competing oils as it is expected to maintain its price advantage. Since the largest suppliers, Malaysia and Indonesia, are in Asia, a freight cost advantage accrues to buyers in China, India, Pakistan and Japan. Since these countries usually buy on the basis of price criteria, palm oil will be preferred.

Third, a likely contribution to the increase in palm oil imports is the continuing major consumption of the EC, the U.S., and Japan. These countries account for about 80% of world imports. Palm oil's continuing price advantage and the low or non-existent tariff rates of the U.S., EC, and Japan should combine to continue the level of importation shown in Table 8.

Table 6 shows the upsurge of the developing countries whose imports in 1975 were only 20% of the total but which are likely to reach 30% in 1985 due to population and income growth.

Fourth, contributing to world consumption is the gradually increasing proportion of semi-processed oil being imported. This change opens the door to higher demand in the importing countries who may find it easier to adapt palm oil to applications for which soy bean, cotton seed or peanut oil hitherto were considered best suited.

Fifth, a situation favoring future imports of palm oil in world markets is the steady improvement in port handling facilities that has been proceeding since the mid 1960s. Malaysian palm oil exports which used to move in large part through Singapore are now increasingly being shipped through improved bulk handling facilities in their own ports. Table 6 shows diminishing volume of oil handled in Singapore as improvements have been made in Indonesian ports.

Sixth, the fact that the palm can produce more oil per hectare than any other oil seed effects future production. With land shortages beginning to emerge in many places, high priority will be placed on attaining the highest productivity from land. This factor, plus the low cost of production and the new plantings now beginning to bear fruit, should keep palm oil competitive and yet sufficiently profitable to assure continued penetration of world and, certainly, the nearby markets of Asia.

C. Conclusions regarding Markets

Table 9 shows that deficits in edible oils occurred world wide in 1974 and 1975 and that a small surplus developed in 1976 followed by a deficit in 1977 during which a slight decline in world production is expected.

During the later years, shown in Table 9, i.e. 1980 and 1985, a slight surplus is forecast suggesting year-to-year carryovers of some supplies. However, the price advantage enjoyed by palm oil is expected to continue and the developing countries handicapped by foreign exchange shortages, will feel compelled to buy where the price is lowest. The projection, therefore, assumes that palm oil will increase its penetration of the world market and that other oils, rather than palm, will be in surplus from time to time.

Underlying the analysis in Table 9 is the assumption that the demand in developing countries will rise with incomes and will move upward briskly after 1985. This may mean that there will be a high demand for palm oil that can only be met if investors start developing plantations, and the building of processing and handling facilities in the late 1970s so as to be prepared to supply the market in 1985 and beyond.

VI. THE PROJECT

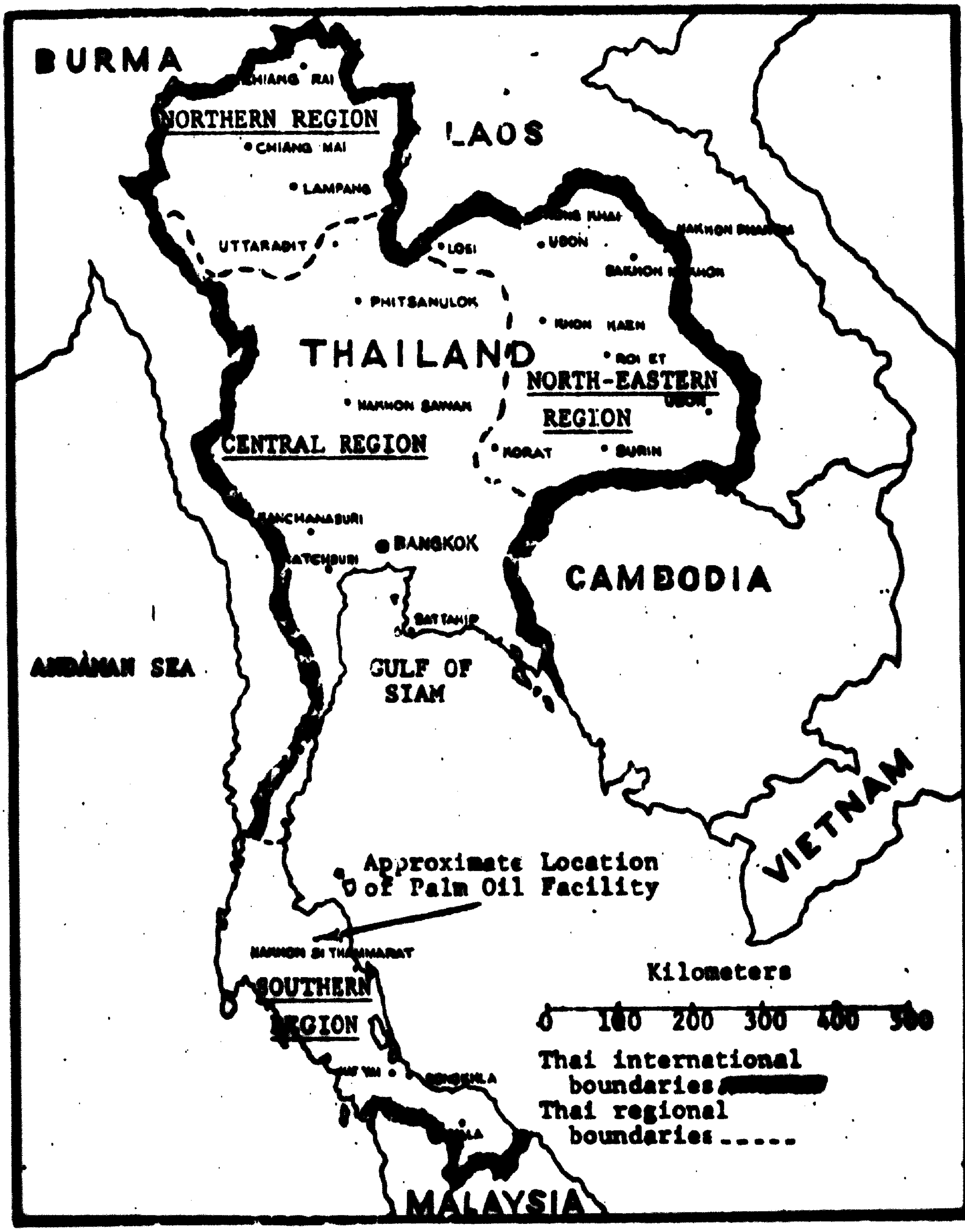
A. General Description

In accordance with the Land Settlement Division's program, the proposed development is located in Nakhon Si Tammarat Province in an area centered on Phra Saeng District at 8^{o} 34' north, 99^{o} 15' east. The area lies at the termination of Highway 41 and is approximately 20 km west of the Southern Line of the national railways system. The North-South axis of the area is about 25 km in length and the East-West 8 km. The gross area is approximately 58,000 hectares and for the purpose of this study the area planted to palm is taken as 2,000 hectares (See Figure 1 for location of site).

Hydrogeology, topography, soils and climate are considered favorable for the cultivation of oil palms. Precipitation is a critical factor affecting growth of the trees and their production of fruit. Average annual rainfall in the area is 2,438mm (96 inches) which is somewhat above the optimum and within the range in which oil palms are cultivated elsewhere.

This study envisages construction and operation of a factory for processing the harvests obtained from the smallholder groves.

Figure 1
GENERAL LOCATION OF PROPOSED PROJECT



More than any other oil seed crushing industry, the type and efficiency of palm fruit processing is a primary determinant of the quantity and quality of the oil produced. This is due primarily to the particular characteristics of the palm fruit and secondarily to the degree of management involved in harvesting and processing fruit bunches.

Quality of palm, or any vegetable oil, is inversely related to its free fatty acid (ffa) content. When palm fruit becomes overripe or bruised, ffa increases rapidly thereby degrading quality. The ffa increase is caused by a very active enzyme which, fortunately, can be completely inactivated by high temperatures. Thus, the need for prompt processing necessitates locating the processing facility in the growing area.

Location must consider primarily the organization of fruit harvesting and delivery to the processing plant. Other important considerations are - transportation of the finished product, site suitability (as regards foundation conditions), availability and cost of water supply, electric power, fuel, telecommunications and other supporting facilities. For the purpose of this study, grove-to-factory and outshipment roads, settler accommodations and amenities will have been provided and their cost is not included in the project investment.

B. Processing

1. Technical Process The processing plant considered herein uses the latest developments in technology consistent with initial and future expanded capacity, the consequent capital and operating costs, management and labor skills. The rapid increase in world-wide palm oil production requires that producers make a determined effort to supply their customers with a standard product of high quality as regards ffa content and easy bleachability.

Generally the more synchronized the harvesting operation and the less variation in ffb supply flow, the more efficient the extraction method becomes. To produce high quality oil at low cost requires good management and well-maintained transportation networks. In this study, a fully integrated factory for the production of high-grade oil is contemplated.

Extraction of oil from the bunch requires five basic operations which are common to all processing methods. These include: (1) sterilization of the bunches; (2) stripping the fruitlets from the bunch; (3) maceration of the fruitlets; (4) oil extraction, and (5) purification. The various methods differ in scale of operation, extraction efficiency, and the ratio of capital to labor usage. (Palm oil processing is more capital than labor intensive).

Palm oil tends to be semi-liquid at room temperature and separates on standing into a deep-red liquid and a yellow solid of about equal volumes. The end-product of the processing will be in an unfractionated, semi-solid form of oil which is the oil sold in international trade.

For domestic use as a replacement for seed oils, the end-product oil through a fractionating process is separated into a liquid, unsaturated oil portion and a saturated solid fat portion. The liquid portion is marketed as a table oil and the solid portion is used in the manufacture of soaps and hard cooking fats. This process has not yet found acceptance in the United States and in European markets.

Palm kernels yield an oil which is very similar to coconut oil and the two virtually are interchangeable. The oil primarily is used in the manufacture of margarine and cooking fats with further applications in high-quality soaps and cosmetics.

2. Equipment and Facilities - Production

Processing is done in six principal stages, each stage having machinery and equipment assembled as a "station".

The first process to which the ffb are subjected to after reception is sterilization which inactivates the fruit enzyme, coagulates extraneous matter to prevent the formation of emulsions during purification, to facilitate stripping of the fruit by loosening the fruitlets from the stalk, and to break up the oil-carrying cells of the mesocarp.

Sterilization normally is carried out in horizontal or vertical vessels constructed to withstand a working steam pressure of three atmospheres (3 kg/cm^2). It is the only part of the process that is not continuous.

In the horizontal sterilizer, ffb are contained in steel cages holding 1.5 to 2.5 tons which are placed in the vessel and subjected to the temperature corresponding to the steam pressure for a period of up to one hour. The vertical sterilizer works on the same principle and is used for smaller factory throughput.

The second treatment is stripping the fruitlets from the bunch, an operation that takes place in a drum threshing machine having a diameter of about two meters and revolving at 23 revolutions per minute.

The stripped bunches represent approximately 25% by weight of the incoming ffb which presents a disposal problem that is dealt with in either of two ways:

(a) The empty bunches are returned to the groves where they are distributed between the rows of palms. The mulching effect is beneficial and can last over a period of years;

(b) The empty bunches can be conveyed to an incinerator where a slow and controlled fire burns them to ash. The ash is a valuable fertilizer which contains a significant amount of potash. The ash is distributed in the groves where it is absorbed readily by the palms.

Extraction of oil is the next processing stage. Since the palm fruit contains two widely different oils, solvent extraction presents problems both mechanical and economic that exclude that method from commercial use. The continuous screw press (expeller) is now the most frequently used means in the industry. Efficiency of the extraction unit largely depends upon the process of digesting; the breaking up of the oil-carrying cells by means of rotating stirring arms while being heated. The digester is an integral part of the extraction station.

Efficient kernel recovery begins at sterilization, at which time nuts can be preconditioned for cracking at a later stage. Separation of the nuts from the press residue begins at the steam-heated press cake conveyor whose purpose is to condition the press residue for separation of the nuts from the fiber in the de-pericarper. Several types of the machines are in use, ranging from open mechanical screens to pneumatic separating columns, or a combination of the pneumatic column and a cleaning drum. After having their moisture content reduced, the nuts are cracked, the kernels separated from the shells, dried and stored. Extraction of oil is not contemplated in the proposed factory.

The need for quality products and efficiency has led to various solutions for the quick recovery of pure oil from the crude expelled by the extractor units. Purification begins by screening the crude immediately, thereby removing the major part of the fiber and other residue leaving the press. Further purification is obtained by several separating processes; a widely used one is patented in Denmark. After purification, moisture is removed by vacuum to a level below

0.1%. The oil is cooled to about 45°C and pumped to a storage tank where it remains at ambient temperature until shipped, which takes place at about 55°C.

In the event that oil is conveyed to a bulking depot by road, modern factories have relatively small storage tanks; normally two of 50 tons each. The oil is discharged directly into a road tanker by gravity without further heating.

Capital and operating costs of the proposed factory are predicated upon the use of modern machines to carry out the processes outlined above.

A range of outputs of oil, kernels and wastes from the described processing, based on the throughput of ffb, are:

Oil and Kernels	Percent on ffb
Crude oil from extractor	28-32
Purified oil	
From Dura	17-18
From Tenera	22-26
Nuts	
From Dura	23-25
From Tenera	12-15
Kernels	3.6-4.5
Wastes	
Empty bunches	22-25
Incinerator potash	0.3-0.5
Wet fiber from de-pericarping (35-40% moisture)	11-15
Shell from nut cracking	
From Dura	16-20
From Tenera	6-9

3. Equipment and Facilities - Support

Palm oil processing being thermo-mechanical, the factory consumes relatively large amounts of steam for both motive power and thermal treatment. The power plant, next to the transportation system, is the most important supporting service. Fiber from the screw press and shells from the nut cracker provide fuel. Boilers and motive power units, the latter principally for electricity generation, are designed to serve full output of each factory development phase. It is evident that at early stages of operation when boilers and generating units are oversized, there may be insufficient waste for fuel. Waste for fuel is approximately 18% of the ffb throughput. The deficiency may be made up by firewood from land clearing operations. A standby diesel-engine powered generator is included in capital cost for use during construction and for periods when the factory is shut down. (Table 13 shows fixed asset costs).

An adequate water supply is of paramount importance in determining the site of a processing facility. About 1.5 tons of water are required per ton of ffb processed and a significant quantity is required for human consumption, sanitation and other factory needs. The Ta Pi river flows through the intended settlement area. There are no stream flow data available which would indicate year-round water availability. There are sites along the banks, and if investigation finds an inadequate flow in any period of the year, ground water sources can be developed by drilling. An estimated sum has been included in capital cost for the provision and treatment of water.

Effluent disposal creates a difficult problem in the area. Many palm oil factories are so situated that their sludge can be discharged into large rivers. Fouling the streams in the area would create considerable resentment. No attempt herein is made to solve the problem; perhaps, by the time final factory design is made, there may have been some developments in waste disposal that may offer a better solution than is possible today.

C. Costs

1. Capital Cost The estimate of fixed asset cost shown in Table 13 is comparable to an average factory using up-to-date machinery and equipment situated in Malaysia. Estimates are subject to revision pending detailed site investigation and plant design. Final cost will depend upon both the location and nature of the selected site and on the complexity of sludge disposal.

It is envisaged that the processing facility will be constructed in two phases, each unit having an input capacity of five tons of ffb per hour. Based on peak month projections (Section IV - Optimum Project Size), single shift operation only will be necessary up to Crop Year 4 during which two shifts will be required to cope with harvests. The second phase unit will be required in Crop Year 5.

Land for the factory may be leased from the provincial government. The nominal rent, $31.25 per hectare per year, is included in production costs.

Roads and hardstands immediately adjacent to the factory buildings are included in capital costs. Access roads to the groves will be made and the cost borne by the developers of the settlement.

Cost of processing machinery is based largely on the use of continuous screw presses, the advantages of which were discussed above.

2. Production Costs

The production cost of palm oil, like those of all other primary commodities, is subject to fluctuations. The production cost estimate made herein is based on eight different levels of activity for the purpose of making a pro forma profit and loss analysis. Anticipated extraction rates and product output are shown in Table 1.

Currently (1977), the price paid to smallholders of the other settlements is $0.045/kg for ffb delivered to the roadside. Grove labor requirements are met by the smallholder whose task is completed when the ffb are delivered to a designated point for pick-up by a factory-owned vehicle operated by factory labor. With this arrangement, staffing is confined to the operation of the processing facility and to the marketing of it's products (Table 12).

An experienced factory manager and chief engineer will be required to oversee construction and operation during the first few years of the project. It may be possible to obtain the services of a qualified expatriate through overseas aid at no cost to the government if the project is a joint venture. A staffing plan, with salaries and wages, is shown in Table 12. Assessments of the labor required include all tasks for ffb collection, factory operation and shipment of oil and kernels.

The staffing plan in Table 12 estimates annual personnel costs. Since single shift operation only is required up to Crop Year 4, the staffing shown for Crop Year 2 is considered adequate up to that time. During Crop Year 4, double shifts will be necessary.

In Crop Year 5, the second five-ton per hour unit will begin single shift operation and in Crop Year 6 full operation of 400 hours per month, at 10 tons per hour, will be required to cope with the crop.

D. Distribution System

The Royal Thai Government currently is negotiating with the World Bank for financial assistance for improving the port of Songkhla in Southern Thailand to accommodate deep-draft vessels at either piers or wharfs. Shipments will be made from the factory by tank truck to storage tanks at a railway siding to be constructed along the main line of the State Railway some 24 km to the east of the factory site, thence by rail south to the port of Songkhla.

Songkhla is the largest port in Southern Thailand and up to 130,000 tons of rubber annually are shipped overseas from Songkhla by lightering to ships at anchor.

A bulk installation would be required to accumulate sufficient volume of oil for shipment by tanker.

E. Financial Projections

1. Profit and Loss A pro forma profit and loss statement is shown in Table 10 based on the following assumptions and computations. For the purpose of this analysis, it is assumed that the project will have promotional privileges and will be exempt from machinery and equipment import duties and taxes. No costs for these items are included in the profit and loss statement. Also, no costs are included for property damage, casualty or workmen's compensation insurance. Explanations to the profit and loss statement are numbered to correspond to the items in Table 10.

(i) Operating Levels

Operating levels correspond to ffb annual harvests in Years After Planting 3,5,7,9,12,15,18 and 21, as shown in Crop Projections (Table 2).

(ii) Revenue

Annual sales are based on the assumption that all products are sold within the year produced. F.o.b. selling price is the World Bank's projection in constant dollars for 1985, namely $320 per ton c.i.f. European ports for palm oil and $460 for kernels. Allowing $27 per ton average freight and insurance, the f.o.b. price is $293 for palm oil and $433 for kernels. Oil yield is taken as 22% on ffb.

Operating year	1	3	5	7	9	12	15	18
Year after planting	3	5	7	9	12	15	18	21
Operating level-ffb tons	1,700	9,700	23,400	34,400	37,700	35,200	33,100	30,900
Oil to ffb(22%)-tons	374	2,134	5,148	7,568	8,294	7,744	7,282	6,798
(a) Revenue-$ thousands	120	683	1,647	2,421	2,654	2,478	2,330	2,175
Kernels to ffb(5%)-tons	85	485	1,170	1,720	1,885	1,760	1,655	1,545
(b) Revenue-$ thousands	39	223	538	791	867	810	761	710
(c) Gross Revenue	159	906	2,185	3,212	3,521	3,288	3,091	2,885

(iii) <u>Operating costs</u> - Processing expenses

<u>Raw material</u>. Current price to farmers for ffb deposited at grove roadside is $0.045 per kg ($45 per ton). A 10% increase to $0.0495 ($49.50 per ton) is assumed for Year After Planting 7 and beyond.

Operating year	1	3	5	7	9	12	15	18	21
Year after planting	3	5	7	9	12	15	18	21	24
Operating level-tons ffb	1,700	9,700	23,400	34,400	37,700	35,200	33,100	30,900	28,700
ffb at $45/ton($000's)	76	436							
ffb at $49.50/ton($000's)			1,158	1,703	1,866	1,742	1,638	1,530	1,421

<u>Labor</u>. Fringe benefits are estimated to be 15% of the salaries and wages shown in Table 12. There are seven management personnel and the factory labor force varies from 20 initially to 56 at full production.

From Table 12	$26,000	29,400	38,100	49,800	57,000	57,000	49,800	49,800	49,800
Fringe benefits	3,900	4,400	5,700	7,500	8,600	8,600	7,500	7,500	7,500
	29,900	33,800	43,800	57,300	65,600	65,600	57,300	57,300	57,300

Maintenance. Average annual cost, $17,600, consisting of the depreciation on the spare parts inventory. (Table 13). Maintenance labor is not in the cost above but is included in labor cost. Labor costs for the two years prior to start-up, shown in Table 12, are included in construction cost.

Fuels. The five ton/hr plant uses about 60,000 kwh/month of which 85% is steam generated, 15% by stand-by diesel generator or 9,000 kwh. At an output of 2.6 kwh/liter of fuel, about 3,500 liters per month will be required. At $0.12/liter, the cost is $5,000 annually. Gasoline and diesel fuels for vehicles is estimated to be $5,000 per year for the first two years and $6,000 per year for the remainder.

Water. Approximately 1.5 tons of water per ton of ffb are required. Pumping cost is included in power generation; capital cost is included in depreciation.

Processing expenses recapitulation (rounded)

Operating year	3	5	7	9	12	15	18	21
Output-tons of oil	374	2,134	5,148	7,568	8,294	7,744	7,282	6,798
Raw material-($000's)	77	437	1,158	1,703	1,866	1,742	1,638	1,330
Labor-($000's)	30	30	44	57	66	66	57	57
Maintenance-($000's)	18	17	17	17	17	17	17	17
Fuels-($000's)	10	11	11	11	11	11	11	11
Total processing expenses	135	495	1,230	1,788	1,960	1,836	1,723	1,615

(iv) Administrative expenses (fixed)

Management salaries will average $40,000 per year after the factory begins operation. (Table 12).

Office supplies and miscellaneous expenses are estimated to average $5,000 annually.

(v) Distribution and Marketing

On the basis of average Malaysian costs, forwarding and other related expenses are at $6.80/ton of oil.

Operating year	3	5	7	9	12	15	18	21
Oil sold-tons	374	2,134	5,148	7,568	8,294	7,744	7,282	6,798
Dist.& Marketing (Rounded to nearest $)	2,500	14,500	35,000	51,500	56,400	52,700	49,500	46,200

(vi) Start-up expenses (non-recurring)

Management expenses for two years prior to start of operations is $47,800. Additional start-up expenses for miscellaneous items is estimated at $10,000, or a total of $57,800 rounded to $58,000.

(vii) Depreciation

The useful life of the factory for the purpose of project evaluation is 18 years, which is a straight line rate of 5.3%.

Depreciation on fixed assets is $79,000 annually (Table 13) for the first phase. On the second phase, $11,800 annually. The total after operating year 5 is $91,000 (rounded).

(viii) Interest on capital

Working capital is represented by cash, finished inventory and accounts receivable. For the first phase of operation, working capital is based on sales of $260,000 and 60-day collection and is estimated at 75%. For the second phase, with sales at $2 million and over, working capital will reduce to 25%.

	First Phase	Second Phase
Cost of fixed assets	$ 1,307,000	$ 415,000
Working capital	175,000	502,000
All capital	1,482,000	917,000
Interest at 8%	118,500	73,400

2. Sensitivity

The interaction of the factors of revenue and cost are examined at the production level attained by full operation of the first phase of the project. This is the so-called "break-even" point (BEP) analysis which determines the minimum level of profitable operation. For this analysis, amounts that are not influenced materially by production level are termed fixed costs and those that are a function of activity are termed variable costs.

The break-even point (BEP), actually an area of minimum profitable operations, may be estimated in terms of sales revenue, fixed and variable costs for a given period. In this computation, sales revenue is that accruing from the first five-ton per hour units' annual output. Fixed charges are based on capital cost and variable cost on the operating expenses shown in the financial projections.

The BEP area may be determined by a simple formula:

$$\text{BEP} = \frac{\text{Fixed cost}}{1 - \dfrac{\text{variable cost}}{\text{sales revenue}}} = \frac{243{,}400}{1 - \dfrac{1{,}285{,}000}{2{,}242{,}000}} = \$566{,}000$$

Figures entered in the above formula are derived as follows:

Sales revenue

Annual input: 5 ton ffb per hour x 400 hours/month x 12 = 24,000 ffb/year.

Oil output:	At 22% extraction rate x 24,000 ton ffb is equal to 5,280 tons of oil.
Sales revenue:	5,280 tons x $320/ton = $1,690,000.
Kernel recovery:	5% extraction rate x 24,000 = 1,200 tons.
Sales:	1,200 tons x $460/ton = $552,000.
Total sales:	$2,242,000.

Fixed costs

Depreciation (Table 13)	$ 79,900
Administrative costs (Table 12)	40,000
Miscellaneous Administrative costs	5,000
Interest	118,500
	$ 243,400

Variable costs (operating)

Raw material	$1,188,000
Labor (*)	55,200
Distribution and marketing (**)	35,900
Fuel	6,000
TOTAL	$1,285,100

The break-even point for the second phase is not :imated at this time but the ratios of profit on sales and :urn on investment are shown below in Section VI-F.

Cost calculated as 29,400/23,400 (fifth year of operation) = 1.26 x $43,800 = $55,200 (See Financial Projection).

') Cost calculated as $6.80/ton x 5,280 tons of oil = $35,900.

F. Conclusions Regarding Feasibility

1. Ratios

The ratios used herein for evaluating the worth of the proposed investment are profits as percentages of sales and of investment.

The ratios are:

Year after planting	3	5	7	9	12	15	18	21
Operating year	1	3	5	7	9	12	15	18
Profit/Sales-%	Nil	17	31	32	33	33	32	31
Profit/Investment--%*	Nil	14	52	86	114	118	252	424

* Investment is asset cost less depreciation by year shown.

2. Other Factors

The pay-back period ends approximately in the sixth year of operation. This is considered normal for the subject industry.

Average annual profit over the life of the project is about $829,000 before taxes, which results in an annual rate of return on investment of 48%.

Value added by processing is $82 per ton of oil. This value was arrived at by subtracting the cost of raw material from the ex-factory production cost of a ton of oil.

3. Conclusions

Expectedly, as in most other agro-industry processing facilities, there is a period of no profit or return during the first year or two of operation. The life of machinery and equipment is easily 20 years; the life of the groves is indefinite because the trees can be replaced as they reach the end of their yielding and the long-term outlook for a generous return on investment is very favorable.

G. Down-Stream Products of Palm Oil and Palm Kernel Oil

1. Palm Oil Products

Once Thailand is producing palm oil in greater volume than at present, there are various products that can be derived from the oil, such as: (1) magarine, as a butter substitute, (2) hydrogenated oil, used as a shortening for cooking and food preparation such as "Crisco", (3) soaps, (4) plasticizers for plastics, especially in PVC products, and (5) as a food emulsifier. Palm oil is also used in cosmetics, pharmaceuticals, salad oil, mayonaise, and as a fluxing dip in the manufacture of tin plate. The principal down-stream products are described below.

a. Magarine One of the principal reasons for the rapidly growing imports of palm oil by the European Community is the widening use of palm oil in the manufacture of magarine. Margarine in the United States is made of a mixture of 80% vegetable oils and 20% milk, but elsewhere milk is often omitted. The melting point of maragarine and the degree of saturation of the fatty acids can be regulated by hydrogenation of the oils. Margarine, having a 22^{o} C melting point, is used in the bakery industry and margarine with a higher melting point, about 27^{o} C, is for table use.

Large volumes of margarine do not move in international trade. This is because margarine must be refrigerated and it is usually cheaper from nearby, local margarine producers. The 1975 imports of margarine by the industrialised countries are shown in the Table below. The large imports by the European Community are accounted for by intra-European trade where the margarine has to move only short distances.

Imports of Margarine by
Industrialized Countries
(Plus Hong Kong, Singapore) - 1975

	Quantity (MT)	Value $000's	Unit Value (per Ton)
Europe	43,534	$35,345	$ 812
Japan	311	337	$1,086
Hong Kong	3,634	2,614	$ 719
Singapore	2,092	1,370	$ 655
United States	negligible, less than $100,000		

The Hong Kong and Singapore markets may be accessible to Thailand if margarine is produced in Thailand in future years. The Hong Kong market for margarine grew from 2,436 tons in 1970 to 3,634 tons in 1975, valued respectively at U.S. $858,000 in 1970 and U.S. $2,614,000 in 1975. The Singapore imports from 1970 to 1975 grew in value from $828,000 to $1,370,000, but declined slightly in quantity.

The margarine price, landed in Hong Kong in 1975, was $719.

b. Hydrogenated oil Hydrogenated oils are vegetable or fish oils that have been hardened or solidified by the addition of hydrogen using a catalytic agent. In the hydrogenation process, the fatty acids, such as the unsaturated oleic (about 43% of palm oil by weight) are converted to unsaturates, such as stearic acid.

Hydrogenated oils do not require refrigeration and therefore tend to move in international trade. For example, U.S. imports in 1975 came to 3,703 tons valued at $3.6 million. The average unit value was $971, or about three times the c.i.f. value of palm oil.

U.S. Imports of Hydrogenated
Oils, Lard Substitutes -- 1974
(TSUSA No. 1781000)

	Quantity(MT)	Value ($000's)
Canada	306	$ 297
Brazil	987	833
United Kingdom	198	264
Netherlands	285	417
Switzerland	1,866	1,639
Greece	37	72
Other	25	76
TOTAL	3,703	$3,597

c. Soap Soap is the sodium or potassium salt of fatty acid. Metals also form compounds with fatty acid, for example, aluminum, calcium and lithium, but these compounds are insoluble.

Soap is made by the action of a warm caustic solution on fatty oils or tallows with the simultaneous formation of glycerin which may be left in the soap or separated and recovered, thereby becoming a valuable by-product. Soap may also be made by the action of an alkali (usually caustic soda) and fatty acid, in which case no glycerin is produced. The raw materials usually used in the manufacture of soap are listed below. Soap manufacturers throughout the world have their own formulae for products sold under their trade names.

FATS, OILS AND ROSIN USED IN THE MANUFACTURE OF SOAP

Hard oils, slow lathering

inedible tallow, animal greases, fish oils, palm oil, lard, olestearines

Hard oils, quick lathering

coconut oil, palm kernel oil, babassu oil

Soft oils

inedible and sulphured olive oil, soybean oil, cotton seed oil, corn oil, castor oil, other oils in lesser quantity

Rosin

Tall oil

This is the alkaline black liquor obtained in pulping resinous wood and contains sodium salts which are separated as a soap. On decomposition with acids, "tall oil" is combined with other ingredients in the finished soap. Tall oil contains 45 to 50% fatty acids, and is one of the lowest priced fatty materials.

The best seed oils for making these products are those which have a high content of saturated fatty acids or saturates. Table 15 shows the "moiety" of six selected seed oils; moiety is the percentage of various acids of which the seed oil is composed. The four saturates are: palmitic, stearic, myristic and lauric acid. Table 15 shows that some seed oils are much better for soap manufacture than others, as seen by the high percentage of saturated fatty acid below:

Type of Seed Oil	Percentage of Saturated Fatty Acid
Coconut oil	76.3%
Palm kernel oil	76.0%
Palm oil	47.5%
Corn oil	10.9%
Soy bean oil	10.7%
Peanut oil	10.7%

Thailand's soap and detergent manufacturers (Colgate Palm-Olive, Lever Brothers, Wan Far Long, Co.) are operating below capacity because of a shortage of coconut and palm oil suited to their operations. Nevertheless, the industry exported 79 tons of soap valued at ฿2.3 million ($114,267) or $1,432 per ton. Thailand, also in 1975, imported 528.4 tons valued at ฿13.2 million ($660,850) or $1,250 per ton. Domestic production was 8,815 tons in 1975, worth about ฿176 million ($8.8 million).

d. Plasticizer for Plastics The fatty acids in palm oil (palmitic, stearic, myristic and lauric) can be used as a plasticizer in the manufacture of Polyvinyl Chloride (PVC) products. A plasticizer is needed to make PVC products flexible and pliant under various use conditions (heat and cold tolerance). There are two broad classes of flexible vinyls, the PVC and PVAc (Polyvinyl Acetate). The fatty acids from palm oil are widely used in making flexible PVC, and used in lower volumes in making flexible PVAc. The PVC products can be subdivided into two groups (1) flexible and (2) rigid.

Palm oil fatty acid, chiefly palmitic acid (see Table 15) is an important plasticizer. Flexible PVC is sometimes called the "work horse" of the plastics' industry because it is consumed in such large volumes (U.S. consumption was about 450,000 tons in 1970), and has been approved as a food wrap material by the food, drug and sanitation authorities in the United States, Europe and Japan. Flaxible PVC is also used because of it's superior properties (low oxygen permeability) as a wrapping material for edible products. Flexible PVC is superior to it's competitive oil-based wrapping materials (derived from ethylene and propylene) in the sense that flexible PVC is less permaable by air and water vapor and can be imprinted with labelling inks.

Up to 30% by weight of the flexible PVC consists of plasticizer. The most important product used for plasticizers in certain flexible PVCs is fatty acid-phthalic annhydride ester. The fatty acids in plasticizer are derived from various seed oils and were, until recently, under strong competitive pressure by similar materials from the petrochemical industry.

Palm oil (as well as other seed oil) fatty acids that can be used as plasticizers are as follows (with their carbon chain length in parentheses): stearic acid (18), palmitic (16), myristic (14) and lauric acid (14-12).

In the industrialized countries, the users of plasticizers prefer to purchase seed oil in bulk and to handle the separation of acids in their own facilities.

Palm oil can also be used as the source of fatty acid for the plasticizer used in manufacturing Polyvinyl Acetate (PVAc). PVAc is a material noted for its transluscence. brilliance, and toughness. It is used to make disposable glassware, costume jewelry, and as a coating for paper (for example, playing card). In the composition of PVAc, 5 to 7% by weight consists of a fatty acid type plasticizer. The plasticizer in turn consists of phthalic annhydride - fatty acid diesters. From 50 to 70% of the weight of the plasticizer comes from the fatty acid such as from palm oil.

e. Food Emulsifiers Food emulsifiers are used to make a blend in food products of the water and oily particles. Such emulsifiers can be made from palm oil as well as from other oils. In one example, the palm oil must be modified, by a process called inter-esterification using acetic acid; these food emulsifiers are called Acetoglycerides. Food emulsifiers are used in food processing, including the manufacture of bakery products.

2. Palm Kernel Oil Products

Palm kernel oil is usually more valuable than palm oil. For example, the unit prices per ton of palm oil imported into the European Community compared with the prices of palm kernel oil were as follows in 1970, 1973 and 1975:

	C.I.F. Average Price of Palm Oil per Ton Imported into the EC (Industrial Use)	C.I.F. Average Price of Palm Kernel Oil per Ton Imported into the EC (Industrial Use)
1970	$207	$299
1973	216	240
1975	211	341

The reason for the price difference is that palm kernel oil has high value as a raw material for superior grade soaps. As shown in Table 15, the lauric acid content is 51%

and this means that palm kernel oil is useful as a lathering agent. Palm kernel oil and coconut oil have very similar properties in terms of their acid content (Table 15) and in terms of other indexes, as follows:

Physical Properties	Palm Kernel Oil	Coconut Oil
Iodine Number	14/23 a/	10
Saponification Value	244/255 a/	252/260 a/
Titre in degrees, Centigrade (melting point)	20/25 a/	20/23 a/
Unsaponifiable content (%)	0.6	0.4

a/ Denotes range

Because of the growing world scarcity of coconut oil, palm kernel oil is becoming increasingly sought after for high grade soaps and hair lotions.

The processing facilities for palm kernel oil are almost invariably sited in the industrialized countries to which the palm kernels are exported. Unless there are some facilities of very recent origin, even Malaysia, the world's largest producer of kernel oil, does not have its own processing facilities. This is because the kernels are processed on a large scale with capital-intensive equipment.

LIST OF TABLES

TABLE 1

Estimated Yields From
Settlement Groves - Southern Thailand*

Years After Planting	ffb ton/ ha	Oil in ffb %	Oil ton/ ha	Kernel in ffb %	Kernel ton/ha	Kernel oil 1/ ton/ha	Total oil ton/ha	Kernel Cake2/ ton/ha
3	4.3	15.0	0.64	3.6	0.155	0.071	0.711	0.076
4	8.7	16.5	1.44	3.9	0.339	0.159	1.600	0.166
5	14.0	17.7	2.48	4.2	0.588	0.275	2.755	0.288
6	16.2	19.0	3.00	4.5	0.729	0.333	3.333	0.357
7	18.0	20.0	3.60	4.5	0.810	0.640	3.640	0.397
8	19.5	21.5	4.19	4.5	0.877	0.465	4.655	0.430
9	19.5	22.0	4.29	4.5	0.877	0.476	4.766	0.430
10	18.6	22.0	4.09	4.5	0.837	0.454	4.544	0.410
11	18.3	22.0	4.02	4.5	0.823	0.446	4.466	0.403
12	17.9	22.0	3.93	4.5	0.805	0.436	4.366	0.394
13	17.5	22.0	3.85	4.5	0.788	0.427	4.277	0.386
14	17.2	22.0	3.78	4.5	0.774	0.420	4.200	0.379
15	16.8	22.0	3.69	4.5	0.756	0.410	4.100	0.370
16	16.5	22.0	3.63	4.5	0.743	0.403	4.033	0.364
17	16.1	22.0	3.54	4.5	0.724	0.393	3.933	0.355
18	15.7	22.0	3.45	4.5	0.706	0.383	3.833	0.346
19	15.4	22.0	3.39	4.5	0.693	0.376	3.766	0.340
20	15.0	22.0	3.30	4.5	0.675	0.366	3.666	0.331
21	14.7	22.0	3.23	4.5	0.662	0.359	3.589	0.324
22	14.3	22.0	3.15	4.5	0.644	0.350	3.500	0.316
23	13.9	22.0	3.06	4.5	0.626	0.340	3.400	0.307
24	13.6	22.0	2.99	4.5	0.612	0.443	3.433	0.300
25	13.2	22.0	2.90	4.5	0.594	0.322	3.222	0.291

* Yields are based on groves of DXP palms, 148 trees per hectare.

1/Assuming kernel oil is 46% of kernel weight.

2/Assuming cake is 48.5% of kernel weight.

Source: Checchi & Co. based on Prospects for Palm Oil. IBRD July 1976 and average Malaysian yield data.

TABLE 2

Crop Projections and Peak Month Harvests over 18 year Factory Useful Life

ars ter nting	Planting Year First 400 ha	Second 250 ha	Third 450 ha	Fourth 450 ha	Fifth 450 ha	Annual Total*	Peak Month*
3	1,720					1,700	200
4	3,480	1,075				4,500	500
5	5,600	2,175	1,925			9,700	1,200
6	6,480	3,500	3,915	1,925		15,800	1,900
7	7,200	4,050	6,300	3,915	1,925	23.400	2,800
8	7,800	4,500	7,290	6,300	3,915	29,800	3,600
9	7,800	4,875	8,100	7,290	6,300	34,400	4,100
10	7,440	4,875	8,775	8,100	7,290	36,500	4,400
11	7,320	4,650	8,775	8,775	8,100	37,600	4,500
12**	7,160	4,575	8,370	8,775	8,775	37,700	4,500
13	7,000	4,475	8,235	8,370	8,775	36,800	4,400
14	6,880	4,375	8,055	8,235	8,370	35,900	4,300
15	6,720	4,300	7,875	8,055	8,235	35,200	4,200
16	6,600	4,200	7,740	7,875	8,055	34,500	4,100
17	6,440	4,125	7,560	7,740	7,875	33,700	4,000
18	6,280	4,025	7,425	7,560	7,740	33,100	4,000
19	6,160	3,925	7,245	7,425	7,560	32,400	3,900
20	6,000	3,850	7,065	7,245	7,425	31,500	3,800
21	5,880	3,750	6,930	7,065	7,245	30,900	3,700

Figures rounded

Maximum harvest

TABLE 3

Planting Costs for One Settlement Plot (2.87ha)
1977 1/

Item	Year 1	2	3	4	5	6	Total
Clearing and burning @ $109/ha for 2.87 ha	315	-	-	-	-	-	$ 315
Plot leveling	37	15	-	70	-	-	122
Plowing & planting	50	-	-	-	-	-	50
Fertilizer & other inputs for 1.59 ha	100	150	150	150	-	-	550
Seedlings @ $1.25, 150/ha	300	-	-	-	-	-	300
Extra seedlings	-	62	-	-	-	-	62
Seeds for cash crops	100						100
Farmer's living expenses, 4 years	200	200	200	150			750
	$1,102	427	350	370			$2,249

1/ Plot consists of 1.59 ha of oil palm, .96 ha of cash crops and .32 ha of subsistence crops.

TABLE 4

Palm Oil: Thailand's Imports and Exports, 1970-1976

	Imports Volume ton 1/	Imports Value (cif) U.S.$(000)	Imports Cost $/ton	Exports Volume ton	Exports Value (fob) U.S.$(000)	Exports Price $/ton
1970	417	175	420	Nil	Nil	Nil
1971	431	171	397	Nil	Nil	Nil
1972	520	194	373	Nil	Nil	Nil
1973	475	274	577	Nil	Nil	Nil
1974	205	157	766	229	146	637
1975	422	272	645	1,942	673	347
1976	6,151	2,091	340	1,524	609	400

1/ Assumed sp.gr 0.9

Source: Foreign Trade Statistics of Thailand Department of Customs.

TABLE 5

World Production of Palm Oil -- 1970-74 Actual Averages and Projections to 1980 and 1985

(000 tons)

	1970-74		1980		1985	
	Production	Per Cent	Production	Per Cent	Production	Per Cent
Malaysia	728	(31)	2,350	(52)	3,900	(66)
Nigeria	533	(23)	500	(11)	400	(7)
Indonesia	274	(12)	411	(9)	548	(9)
Zaire	180	(8)	200	(4)	200	(3)
Ivory Coast	91	(4)	168	(4)	250	(4)
Others	507	(22)	891	(20)	602	(11)
Total	2,313	(100)	4,520	(100)	5,900	(100)

Source: World Bank, Prospects for Palm Oil, July 1976.

TABLE 6

Projection of Palm Oil Imports by Region, 1975 Actual, 1980 and 1985 Projected

(Unit: Thousands of MT)

	1975	(%)	1980	(%)	1985	(%)
European Common Market	744	(42)	1,231	(40)	1,727	(37)
U.S.	436	(25)	872	(28)	1,281	(27)
Japan	103	(6)	206	(7)	276	(6)
Singapore	128	(7)	100	(3)	--	-
Others (Developing Countries)	362	(20)	691	(22)	1,406	(30)
	1,773	(100)	3,100	(100)	4,690	(100)

Sources: Foreign trade data of the EC, U.S., Japan, Singapore compiled by Checchi and Company. World Bank: Prospects for Palm Oil, July 1976; regional allocations in 1980 and 1985 by Checchi and Company.

TABLE 7

Imports of Palm Oil by Quantity and Country, 1970, 1973, 1975

(Unit: MT)

	1970	1973	1975
U.S.	63,885	175,575	435,560
EC	314,558	449,358	743,605
Japan	40,292	100,316	102,505
Hong Kong	--	169	929
Singapore	140,830	253,836	127,704
Total	559,565	979,254	1,410,303

Source: Compiled by Checchi and Co. from official trade statistics.

TABLE 8

Imports of Palm Oil by Value and Country, 1970, 1973, 1975

(Unit: U.S. Dollars thousands)

	1970	1973	1975
U.S.	$ 14,506	$ 44,238	$201,732
EC	77,307	126,808	372,484
Japan	9,778	28,286	48,067
Hong Kong	--	75	427
Singapore	29,652	54,555	66,573
Total	$131,243	$253,962	$639,283

Source: Compiled by Checchi and Co. from official trade statistics.

TABLE 9

Demand Supply Balance of Fats and Oils, 1974 and 1975 Actual, 1976-85 Projected

(Unit: millions of metric tons)

	1974	1975	1976	1977	1980	1985
A. World Production of Oils and Fats a/	47.4	46.2	48.7	48.2	55.4	60.7
B. Less inedible oils and fats	-2.4	-2.3	-2.4	-2.4	-2.2	-2.4
C. Edible supply (A-B) b/	45.0	43.9	46.3	44.9	53.2	58.3
D. Edible demand	46.4	44.5	45.4	46.3	51.8	57.5
E. Surplus/Deficit (+/-)	-1.4	-0.6	+0.9	-1.4	+1.4	+0.8

a/ USDA, Foreign Agriculture, December 13, 1976 for 1974-77 (See Table 7).

b/ World Bank, Prospects for Palm Oil, July 1976.

TABLE 10

Pro Forma Profit and Loss Statement

	Operating year	1	3	5	7	9	12	15	18
	Year after planting	3	5	7	9	12	15	18	21
(i)	Operating level- ffb ton/year	1,700	9,700	23,400	34,430	37,700	35,200	33,100	30,900
(ii)	Revenue								
	Annual sales								
	Palm oil -	119,700	682,900	1,647,000	2,421,000	2,654,000	2,478,000	2,330,000	2,175,000
	Kernels -	39,000	223,000	538,000	791,000	867,000	810,000	761,000	710,000
	Gross revenue (rounded)	159,000	906,000	2,185,000	3,212,000	3,521,000	3,288,000	3,091,000	2,885,000
(iii)	Operating costs								
	Processing expense	135,000	495,000	1,230,000	1,788,000	1,960,000	1,830,000	1,723,000	1,615,000
(iv)	Administration	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
(v)	Dist. & Marketing	2,500	14,500	35,000	51,500	56,400	52,700	49,500	46,200
(vi)	Start-up expense	58,000	Nil	Nil	Nil	Nil			
(vii)	Depreciation	79,000	79,000	79,000	91,000	91,000	91,000	91,000	91,000
(viii)	Interest	118,500	118,500	118,000	192,000	192,000	192,000	192,000	192,000
	Total operating cost	438,000	752,000	1,507,000	2,167,000	2,344,000	2,210,000	2,100,000	1,989,000
	Profit or (loss) before taxes	(279,000)	154,000	678,000	1,045,000	1,177,000	1,078,000	991,000	896,000
	Cash flow								
	Net profit + depreciation	(200,000)	233,000	990,000	1,124,000	1,256,000	1,157,000	1,070,000	975,000

TABLE 11

Prices and Price Index of Palm Oil and Kernels CIF Europe, 1960-1980 and 1985

Year	In US dollars/ton Palm Oil	Kernel	Index	In constant US dollars/ton Palm Oil	Kernel	Index
1960	228	317	33.5	450.9	626.9	66.3
1961	232	263	33.1	565.3	640.8	80.8
1962	216	255	30.5	424.2	500.8	59.8
1963	222	287	32.3	432.9	559.7	62.9
1964	240	299	34.1	464.8	579.0	66.1
1965	273	353	38.2	520.8	673.4	72.9
1966	236	271	34.9	440.2	505.5	65.0
1967	224	249	31.2	414.6	460.9	57.8
1968	169	367	28.6	314.5	683.0	53.2
1969	181	306	32.2	324.7	548.9	57.7
1970	260	429	41.0	436.0	719.4	68.7
1971	261	335	43.6	412.1	529.0	68.8
1972	217	244	37.3	315.1	354.3	54.1
1973	378	491	59.1	462.7	601.1	72.3
1974	669	1,010	100.0	669.0	1,010.0	100.0
1975	433	439	75.5	378.2	383.4	66.0
1976	370	360	62.4	303.4	295.2	51.2
1977	397	423	64.5	300.3	320.0	48.0
1978	433	485	68.0	303.3	339.8	47.6
1979	471	568	72.6	307.0	370.2	47.3
1980	509	657	76.3	310.0	400.1	46.5
1985	737	1,060	120.2	320.0	460.3	52.2

Source: IBRD, Prospects for Palm Oil, July 1976.

TABLE 12

Staffing Plan
Salaries, Wages and Number of Employees by Grade

Title	Dollars/yr[1/]	-2*	-1*	3	5	7	9	12+
		Year after Planting						
MANAGEMENT (Administration)								
General manager	12,000	1-$12,000	1-12,000	1-12,000	1-12,000	1-12,000		
Deputy manager	10,000		1-10,000	1-10,000	1-10,000	1-10,000		
Chief engineer	6,000		1- 6,000	1- 6,000	1- 6,000	1- 6,000		
Deputy engineer	5,400			1- 5,400	1- 5,400	1- 5,400		
Chief clerk	1,800			1- 1,800	1- 1,800	1- 1,800		
Secretary (stenographer)	3,000	1- 3,000	1- 3,000	1- 3,000	1- 3,000	1- 3,000		
Book-keeper	1,800		1- 1,800	1- 1,800	1- 1,800	1- 1,800		
		2- 15,000	5-32,800	7-40,000	7-40,000	7-40,000	7-40,000	7-40,000
FACTORY								
Assistant engineer	3,600			1- 3,500	1- 3,600	1- 3,600	1- 3,600	2- 7,200
Chief clerk	1,800			1- 1,800	1- 1,800	1- 1,800	1- 1,800	1- 1,800
Laboratory assistant	1,200			1- 1,200	1- 1,200	1- 1,200	2- 2,400	2- 2,400
Boiler operators	1,800		1- 1,800	1- 1,800	1- 1,800	2- 3,600	2- 3,600	2- 3,600
Electrician	1,200			1- 1,200	1- 1,200	2- 2,400	2- 2,400	2- 2,400
Maintenance foreman	1,200			1- 1,200	1- 1,200	1- 1,200	1- 1,200	1- 1,200
Workshop mechanic	1,200		1- 1,200	1- 1,200	1- 1,200	[illegible] 1,200	2- 2,400	2- [illegible],400
Mechanic's helper	600			1- 600	1- 600	2- 1,200	3- 1,800	[illegible] 1,800
Assist. foreman-maintenance	1,000			Nil	1- 600	1- 600	1- 600	1- 600
Weighbridgeman	1,200			1- 1,200	1- 1,200	1- 1,200	2- 2,400	[illegible] 2,400
Power plant operator	1,200		1- 1,200	1- 1,200	1- 1,200	2- 2,400	[illegible] 2,400	3- 3,600
Laborers-unskilled	600			1- 600	2- 1,200	4- 2,400	6- 3,600	8- 4,[illegible]
Watchman	600		2- 1,200	3- 1,800	3- 1,800	3- 1,800	3- 1,800	3- 1,800
Gardeners	600			1- 600	1- 600	1- 600	2- 1,200	2- 1,200
			5- 5,400	15-18,000	17-19,200	23-25,200	30-31,200	34-38,400
TRANSPORT								
Supervisor	3,600			1- 3,600	1- 3,600	1- 3,600	1- 3,600	
Motor mechanic	1,800			1- 1,800	1- 1,800	1- 1,800	2- 3,600	
Mechanic's helper	900				1- 900	2- 1,800	3- 2,700	
Foreman	1,200				1- 1,200	2- 1,200	2- 2,400	
Driver	900		2- 1,800	3- 2,700	3- 2,700	5- 4,500	7- 6,300	
			1,800	5- 8,100	7-10,200	11-12,900	15-18,600	15-18,600
Annual total		2-$15,000	12-39,200	27-66,100	31-69,400	41-78,100	52-89,800	56-97,000

* Years before first crop

1/ Overtime and fringe benefits not included.

TABLE 13

Capital Cost of Fixed Assets
(U.S.$000's CIF at Thai border or port)

	First phase 5-ton ($000)	Annual Depreciation Amount %	Annual Depreciation Amount $	Second phase 5-ton ($000)	Annual Depreciation Amount $
Land (20,000M²) leased	0			0	
Site improvements - roads, drainage, etc.	29	5.0	1,450	0	
Factory building, foundations and erection (700M²)	210	3.3	6,930	0	
Office building - (60M²)	15	3.3	495	0	
Sub-total	254		8,875	0	
Weighbridge	14			0	
Sterilising	48			37	
Threshing	47			21	
Extraction	79			77	
Purification	33			14	
De-pericarping	44			0	
Kernel recovery	103			25	
Electric wiring	15			10	
Piping, steam and process lines	22			12	
Sub-total	405	5.5	22,275	196	10,780
Boiler/Power plant	182	5.5	10,010	128	7,040
Sub-total	587		32,285	324	17,820
Spare parts inventory (15% x 573; 10% x 324)	88	20 0	17,600	32	6,400
Installation of plant	49	5 5	2,695	15	825
Machinery foundations	32	3 3	1,056	0	0
Auxiliaries					
Bunch reception & storage	43	5 5	2,365	22	1,210
Workshop	52	5 5	2,860	0	
Water supply & treatment	35	3.3	1,155	0	
Bulk oil storage (500 tons)	17	3 3	561	0	
Vehicles	15	20.0	3,000	15	3,000
Engineering Services	110	5 5	6,090	0	
Inland transportation to site	25	5 5	1,375	7	385
Capital cost per phase	1,307			415	
Annual depreciation			79,900		11,800
Total capital cost	1,722				
Total annual depreciation			91,700	5.3% average	

TABLE 14

Rates of Duty in Export Markets for Palm Oil and Palm Kernel Oil -- 1977

	Palm Oil	Palm Kernel Oil
Canada	Free	Free
EC	4%	2.5%
Japan	4%	4%
Norway	Free	Free
Sweden	Free	Free
Switzerland	Free	Free
U.S.S.R.	Free	Free
U.S.	Free	Free

Source: F.A.O. Bulletin (CCP of 77/4), January, 1977.

TABLE 15

Moiety of Selected Seed Oils a/
(Unit: Percent)

Type of Acid *Denotes Saturates	Corn	Soy	Peanut	Palm	Palm Kernel	Coconut
Palmitic*	7.4	6.5	7.0	42.5	7.5	8.8
Stearic*	3.5	4.2	5.0	4.0	2.5	2.0
Arachdic	0.6	0.7	4.0			
Lignoceric	0.2	-	3.0	0.1		
Oleic	46.0	28.0	60.0	43.0	16.0	6.0
Linoleic	42.3	52.6	21.0	9.4		2.5
Linolenic		8.0 b/			1.0	
Arachidonic		0.05				
Myristic*				1.0	15.0	17.3
Caprylic					3.0	
Capric					4.0	7.0
Lauric*					51.0	48.2
Caproic						0.02
Total	100.0	100.0	100.0	100.0	100.0	100.0
Saturate Sub-Total	10.9	10.7	10.7	47.5	76.0	76.3

a/ These data are average contents of selected fatty acids in some commercial seed oils. The source is E.F. Drew & Co. Inc. Technical Products Division, New York City.

b/ This may be in error; original document not legible.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

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