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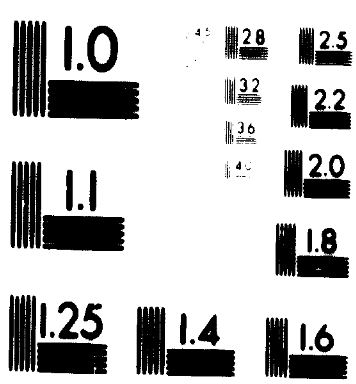

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FEASIBILITY STUDY OF A REGIONAL PLAN FOR THE PRODUCTION OF NITROGEN AND PHOSPHATE FERTILIZERS IN THE ASEAN COUNTRIES

by

Taylor Darden

and

Stephen Merrett

Bangkok
July 1972

1972

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INTRODUCTION

Since the ASEAN Declaration was first made in 1967, extensive discussions and investigations have taken place on what might be the form of economic co-operation between Indonesia, Malaysia, the Philippines, Singapore and Thailand. Much of the technical work was carried out in the period March 1970-July 1972 by the United Nations ASEAN Team.

Three specific forms of co-operative effort have been reviewed at considerable length: trade liberalization, complementarity agreements and 'package deals'. The last technique envisages the selection of a number of industrial projects which would be allocated amongst the ASEAN countries in an efficient and equitable manner and each of which would serve the entire ASEAN market without the hindrance of trade barriers.

To provide a concrete basis for discussion, the U.N. Team carried out 13 studies on possible projects suitable to the package deal technique and the results of these have been presented in the Team's Final Report: "Economic Co-operation for ASEAN".

The following document, "Feasibility Study of a Regional Plan for the Production of Nitrogen and Phosphate Fertilizers in the ASEAN Countries" continues the work of project definition and is the first in-depth feasibility report on a possible ASEAN package deal project. The study has been carried out by a chemical engineer, Mr. Taylor Darden, and an industrial economist, Mr. Stephen Merrett, and was financed under the Special Industrial Services of the United Nations Industrial Development Organization.

SECTION I

SUMMARY AND CONCLUSIONS

Market Forecast

1. The study begins with the market. An estimate is made for 1980/81 of the consumption of the nitrogen and phosphorus pentoxide nutrients for each of the ASEAN countries. The results are:

Country	1980/81 Consumption in tons N	P_2O_5
Indonesia	540,000	220,000
Malaysia	148,000	120,000
Philippines	172,000	80,000
Singapore	negligible	negligible
Thailand	178,000	136,000

The aggregate rate of growth in demand in the twelve years from the end of the 1960's up to 1980-81 will be approximately 10.1 per cent for nitrogen and 9.5 per cent for P_2O_5.

The total ASEAN consumption in tons of nutrient after excluding supplies expected to come from ground rock phosphate, that is to say the total ASEAN effective demand for chemical fertilizer nutrient is forecast for 1980/81 as:

N	P_2O_5
1,038,000	434,000

2. **Present and Planned Supply**

Information was collected on all units at present manufacturing nitrogen and phosphate fertilizers in the ASEAN countries. Adding up these quantities plus that of the Indonesian Pusri II complex, which has now been approved and financed, gives total capacity output in the region. The gap between 1980/81 consumption and this total of existing and assured additional capacity is the forecast **nutrient shortfall** which equals:

ASEAN Nutrient shortfall in 1980/81 in tons

N	P_2O_5
595,000	368,000

3. Product choice and plan alternatives

In order to eliminate this nutrient shortfall, alternative plans were drawn up, all of which are based on the production of two fertilizers: prilled urea and a complex fertilizer with an N P K analysis of 23-23-9.5. The choice of urea and a complex fertilizer was made because:

a) supplying the farmer with complex fertilizers permits a balanced application of nutrients much more easily;
b) investment costs can be reduced by producing complex fertilizers rather than two or more straight (single nutrient) fertilizers;
c) mixing some straight fertilizers, e.g. urea and triple superphosphate, presents technical difficulties;
d) urea and the complex fertilizer chosen in this study each have a high nutrient percentage thereby reducing the cost of distribution of each ton of plant food with consequently lower prices to the farmer.

Three alternative plans were drawn up. Regional Plan I (R.P.I) has two independent complexes, both based on natural gas, both producing urea and the complex fertilizer, and with a total capacity matching the ASEAN nutrient shortfall. Regional Plan II (R.P.II) has three complexes. Only one of the complexes has phosphoric acid production facilities, but the same complex produces no ammonia. Therefore each complex exports or imports intermediate products to one of the other two complexes. Total output in terms of nutrient is the same as in R.P.I. With such large tonnages of end-product and intermediate products requiring transport in the regional alternatives, we recommend that the regional complexes each be located at a large port and each should have its own loading and unloading facilities. The National Plan (N.P.), the third alternative, has two independent complexes. Both complexes produce urea and the complex fertilizer. One is based on natural gas and the other on naphtha. Total nutrient capacity is sufficient to eliminate the forecast nutrient shortfall in the two largest consuming countries in the region.

4. Economic viability of the three alternatives

The main economic indicators of the three plans are given below:

		R.P.I	R.P.II	N.P.
Volume of output in tons per year	N	597,000	597,000	426,000
	P_2O_5	370,000	370,000	338,000
	K_2O	153,000	153,000	140,000
Annual value of output ($m)		152	152	124
Total investment ($m)		211	214	174
Annual operating surplus ($m)		73.4	71.4	63.7
Average rate of return on capital		24%	23%	25%
Total foreign exchange savings ($m)		1045	1030	829

In terms of all of the economic indicators, R.P.I and R.P.II are very similar in magnitude. In terms of volume and value of output, total investment and total foreign exchange savings, N.P. is approximately 81 per cent of the magnitude of the regional plans, whilst the proportional annual operating surplus is higher, at 87 per cent; and the average rate of return on capital is of the same magnitude as the Regional Plans. The return on capital in all three plans is encouragingly high.

In Section VI of this study we show in detail that in every respect R.P.I is either as good as or better than R.P.II, even though the differences are not large. The chief comparison made, therefore, is between Regional Plan I and the National Plan.

Because N.P. is designed to meet the consumption requirements of the two largest consuming nations in 1980/81, its scale of output is sufficient to reap substantial economies of scale of manufacturing. However, one of the complexes is based on naphtha - less efficient than the same process using natural gas - and it also has a smaller ammonia capacity than the R.P.I complexes. As a result the efficiency of R.P.I is greater than that of N.P. in terms of investment costs and operating costs. But the transport costs incurred in the regional solution tell against it for there are none in the national solution.

The choice between R.P.I and N.P. should be based on the cost of finance of the plans using the most modern of project appraisal techniques, discounted cash flow. In Section VI we show precisely under what circumstances which plan is preferable in economic terms.

The final result is:

Cost of plan finance in per cent per annum	Plan choice
Below 19%	R.P.I preferred
19%	no difference
20 - 25%	N.P. preferred
Above 25%	Neither plan viable

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NOTE ON UNITS OF MEASUREMENT AND TIME-HORIZON, ABBREVIATIONS

NOTE

Throughout this study the basic units of measurement are metric tons and U.S. Dollars. 1980/81 has been chosen as the time-horizon for estimated consumption and the plan alternatives. This gives sufficient time for: thorough review by the ASEAN countries of the alternative techniques of economic co-operation; taking a decision (if so made) to go ahead with the package deal technique; selection of projects; project report; calling of tenders and allocation of contracts; construction of the manufacturing complexes.

Abbreviations

M^3	Cubic meters
MT	Metric tons
ST	Short ton
Kwh	Kilowatt hour
MAP	Monoammonium phosphate
P_2O_5	Phosphorus pentoxide
N	Nitrogen
K_2O	Potassium Oxide
dN	Billion
MN	Million
M	Thousand

Section II: The Effective Demand for Nitrogen and Phosphate Fertilizers in the ASEAN Countries

The starting point of any plan of production must be the estimation of the effective demand for the end-products manufactured. As we are dealing with the feasibility of a regional plan, then naturally we examine in turn the situation in each of the ASEAN member countries in terms of past and present consumption and the prospects for change in the future. This Section in which we forecast the effective demand for nitrogen and phosphate fertilizers is composed therefore of a series of country studies.

A. Indonesia

1. The available statistics indicate that the import and consumption of fertilizer nutrients in Indonesia have fluctuated sharply from year to year during the 1960s. Throughout the period there have also been very large stocks in the warehouses, never less than one year's sales. In spite of this it is clear that there has been a strong growth trend in the consumption of nitrogen from very low base period tonnages, whilst the growth rate in the demand for phosphorus pentoxide has been rather modest.

Table II.1 presents the time-series of distribution of the NP nutrients by major sector. Taking the years 1964-65 and 1969-70 as base and end-periods, the annual rate of growth of distribution has been 12.4 per cent for nitrogen and 4.3 per cent for P_2C_5.1/

/Table II.1:

1/ Throughout this Section we have used as the measure of annual consumption in the base and end-periods an average taken over three years. We do not do so in this case because of the abnormally low figure for P_2O_5 in 1966. Here, a base-period of 1964-66 gives a misleadingly high growth rate because of the misleadingly low base.

Table II.1: Nutrient distribution in Indonesia by sector by year in tons

Nutrient	Sector	1964	1965	1966	1967	1968	1969	1970
N	Food crop	87,600	58,900	61,000	43,000	95,000	155,200	162,100
	Estate	20,600	31,100	34,900	24,200	6,200	16,100	21,800
	Total	108,200	90,000	95,900	67,200	101,200	171,300	183,900
P_2O_5	Food crop	17,000	27,900	18,800	5,400	24,400	36,300	31,600
	Estate	9,100	17,500	6,800	3,000	8,100	6,500	13,800
	Total	26,100	45,400	25,600	8,400	32,500	42,800	45,400

2. No comprehensive nation-wide statistics at present exist for Indonesia, either on the proportion of nutrient going to specific crops or on the relative shares of harvested area fertilized. The best estimates which exist are the results of a recent farm survey. Table II.2 shows estimated proportionate nutrient consumption.

Table II.2: Nutrient consumption in Indonesia in 1969 by crop/sector in percentages

Crop/Sector	N	P_2O_5
Rice	[illegible]	38
Secondary food crops	15	15
Smallholder cash crops	8	12
Estates	17	35
Total	100	100

/Rice

Rice is the most important consumer and the estates run second. The chief estate crops are rubber, oil palm, sugarcane and tea; for secondary food crops, maize and vegetables are more significant. The nutrient ratio, as can be seen, varies widely between the four categories. In the smallholder sector the predominance of rice in nutrient consumption is established by the much bigger area harvested. In fact, for the main foodcrops, in Java at least, there is little difference between the proportion of harvested area fertilized: for rice, maize and vegetables it lies in the range 27-30 per cent. Tobacco, on the other hand, is 64 per cent fertilized, whilst all other smallholder cash crops together receive a negligible amount of fertilizer.

With respect to area-wise consumption, the 1968-70 shares in total foodcrop NPK consumption by main region were:

East Java	36%
West Java	28%
Central Java	23%
Sumatra	11%
Other islands	2%

High distribution costs in the outer islands is the most serious constraint to an increase in fertilizer demand in these areas. Whilst the average distribution margin for Java is Rp. 8,400 per ton, that for the outer islands is Rp. 12,900 per ton.

3. In terms of end-product the foodcrop sector has come to rely less and less on ammonium sulphate, substituting urea. Triple superphosphate has become the dominant source of P_2O_5. This standardization has been largely determined by official policies which subsidize urea and TSP on rice and maize, although it is in line with the relative profitability of different nutrient sources. As yet there has been little significant development in the use of compounds. The trend over time on the estates is not clear but we do know that there has been traditionally a greater reliance on ammonium sulphate and compounds such as nitrophosphate than in the foodcrop sector. The Indonesian estate sector at present uses about 20,000 tons per annum of ground rock phosphate as a P_2O_5 source. Table II.3 shows the 1970 end-product shares in total nutrient distributed.

/Table II.3

Table II.3: End-product shares of nutrient distributed in Indonesia in 1970 in percentages

	Food Crop Sector		Estate Sector	
	N	P_2O_5	N	P_2O_5
Urea	96.0	-	10.0	-
Ammonium Sulphate	1.5	-	61.0	-
Other N straights	-	-	1.0	-
Triple superphosphate	-	83.0	-	25.0
Other P straights	-	1.5	-	31.0
Compounds	2.5	15.5	28.0	44.0
Total	100	100	100	100

4. In 1970 the area of cultivated land in Indonesia totalled approximately 18 million hectares. From Table II.1 we see that in the same year distribution of the nitrogen and P_2O_5 nutrients totalled some 230,000 tons. On this basis the average application rate to agricultural land in the country is 12.8 kg./ha. This is very much lower than the rates in South Korea, Japan and Taiwan, the most intensive fertilizer consumers in Asia, whose rates lie in the range 195 to 283 kg./ha. It is therefore worthwhile to sketch in what have been some of the constraints on expansion in fertilizer demand in Indonesia in the past.

5. The first constraint we begin with is value-cost ratios where most of the work has been done on the nitrogen-rice relationship. Experiments by the Central Research Institute of Agriculture which have been conducted on the response rates of paddy to N show good results when controls are maintained for all other variables. The average value-cost ratio was 5.5:1. However, fertilisation of most traditional Indonesian varieties is not recommended because of the likelihood of lodging. Another data source is a recent farm survey of the rice sector which showed that

/when

when other inputs were allowed to vary the ratio of the values of the incremental yield expected by farmers to additional nitrogen nutrient lay predominantly in the range of 2-4:1 for high yielding varieties and 1-3:1 for non-HYVs.

However, the results from a survey of crop-cuttings give a more pessimistic picture. These bring out not merely the average rate for a crop or region but also the frequency distribution of the outcomes. Only this measure provides evidence on the risk element the farmer faces in the decision to invest in fertilizers and associated inputs. The data suggest that amongst every 100 farmers in West and Central Java, where the cuttings were taken, about 22 will find that the value of the incremental yield was actually lower than the cost of the input package which included the fertilizer; about 37 will find that the value approximately equalled the cost; and only 41 will find a **clearly high value-cost** ratio, with an average equal to 3:1. The last group is the only one to have gained from the investment. Low yields were principally due to inadequate water supply, insufficient water control, pest attacks and nutrient application to unresponsive plant varieties.

The latest evidence from crop cuttings brings together some of all these points. The highest yields come, not surprisingly, from the HYVs, but these also have the widest yield distribution and therefore a very appreciable element of risk. This is due to their greater sensitivity to non-optimality in other inputs, e.g. pesticides and water. The evidence shows, then, that much higher nutrient application rates can be expected in the future with the spread of HYVs provided the farmer can be sure of getting the right fertilizer at the right time, with assured supplies of water and pesticides.

This raises the problem of the HYV seeds. In the past many farmers have been disappointed by them. This is due to the fact that in many cases they have been using degenerated seed which was less fertiliser responsive and had a lower incremental yield than local improved varieties. The farmers felt, however, that the "extension seed" was even worse than their own. At the same time village seed farms have faced a very bad marketing situation, primarily due to the very poor quality of

/their

their product. However, in the last two years a number of new projects have been started both for seed farms and seed distribution and improvements in the situation are already apparent giving much more hope for the future.

6. The second constraint concerns the extension service. In the past the Indonesian extension service has suffered from two basic weaknesses: extension officers have had very little contact with the individual farmer and extension has been largely limited to the information phase - radio, handouts, lectures and field-days. This is now frankly recognised and over the last 18 months the situation has definitely begun to change. Also there has been an attempt to formulate clear work programmes and BIMAS during the last season showed it was willing to pursue a more flexible policy on the supply of inputs to the farmer.

7. The third constraint on nutrient demand we wish to mention has been that the majority of farmers with one hectare or less of land have been unable to repay or only partly able to repay credit issued for fertiliser purchases. Of total rural credit extended in Indonesia from 1965-66 to 1970 only one fifth was repaid. Whilst the marginal value-cost ratio for fertilizer application is believed to be relatively high on these farms, the fact remains that a good part of additional production is in practice allocated to the most immediate consumption needs. The new credit policy introduced since 1970 will channel the majority of loans to the richer farmers and already repayment rates have improved significantly. However, it does mean that the very small farmers are unlikely to constitute a growth sector for fertiliser consumption.

The improved seed supply and extension service changes mentioned above will themselves improve credit repayment rates by raising yields, and thereby ensure a greater supply of 'recycled' credit for fertiliser purchase.

8. In the light of these comments on past demand constraints and current changes in the situation for the better we feel that the rounded

1964-70 growth rate of 12 per cent for nitrogen will be maintained during the 1970s. This in spite of the fact that the base period tonnages are now, of course, much much higher. As the new base we use the average N consumption of 1969 and 1970; consumption in these two years was 142,000 and 166,000 tons respectively.1/ Application of a 12% growth rate to this base gives estimated N consumption in 1980/81 as 540,000 tons.

Rice will remain the predominant fertilizer user, with perhaps as much as 90 per cent of rice demand coming from the HYVs. It is grown mainly under submerged conditions and N losses in gaseous form from nitrates may be heavy. N should therefore be provided in the ammoniacal form.

9. With respect to phosphorus pentoxide we are driven to speculation. There is little information in Indonesia on the use of P_2O_5 - either on value-cost ratios or on physical response rates. This is in part due to the fact that very little experimental or research work has been done where P_2O_5 was the principal variable. The lack of data may account for the large errors (in an upward direction) in earlier projections of demand for this nutrient, a rather discouraging precedent for the forecaster.

Undismayed by past experiences of unjustified optimism, we feel sure that during the 1970s the consumption of P_2O_5 will grow at a markedly faster rate than the 4.3 per cent of 1964-70. In the first place there has been very recently a clear quickening of interest in Indonesia amongst experimental workers, extension officers and farmers. Second, the year-by-year increase in nitrogen application - and nitrogen demand will increase by a factor of 3 in the 1970s - should begin to

/reveal

1/ These are the best available estimates. They differ from the <u>distribution</u> figures for 1969 and 1970 in Table II.1 because of year-to-year stock changes and stock run-down caused not by demand but by product deterioration.

reveal P_2O_5 (and K_2O) deficiencies in the soil as these nutrients too are taken out of the soil by increased food a d cash crop production. A related point is that in 1969-70 the $N:P_2O_5$ consumption ratio was 2.7:1. The optimal ratio for Indonesia is not known but it probably does lie between 2 and 3 to 1. However, the continued maintenance of a ratio of this order would not be consistent with a continuation of the 1964-70 experience of the ratio of growth rates of demand for N and P_2O_5 diverging in the ratio of approximately three-to-one.

Our final reason for expecting an increase in the P_2O_5 growth rate is that the future is likely to bring with it the production and marketing of complex fertilizers in Indonesia. The greatlv increased availability of NP fertilizers and the ability to apply both nutrients at the same time is certain to raise the farmer's outlays on P_2O_5.

We assume that the $N:P_2O_5$ consumption ratio in 1980-81 will be of the order of 2.5:1. This implies a demand for P_2O_5 of some 220,000 tons and an implicit average growth rate from the 1969-70 annual average consumption, equal to 57,000 tons[1/], of 13 per cent.

Of the 1980 total about one-fifth will be consumed by the estates. We assume ground rock phosphate will provide approximately 20,000 tons of total nutrient consumed. For rice the end-product source is more or less immaterial, in the plant biological sense; for upland crops the information is not yet available.

1/ Different from Table II.1 for the same reasons as stated for nitrogen.

/B. Malaysia

B. Malaysia

1. Agriculture and forestry continue to-day to be Malaysia's most important economic sector. Fifty per cent of the country's present 12 million population work in agriculture where approximately 30 per cent of gross domestic product is produced, half of which come from rubber alone. In 1970 rubber supplied 34 per cent of total export receipts. Malaysia is also the world's largest producer of tropical hardwoods and palm oil.

In estimating future nutrient consumption we shall, following Kemmler's analysis, adopt a product-by-product approach for West Malaysia alone, returning to the needs of Sabah and Sarawak in a separate paragraph. (Kemmler 1970)

2. Rubber. Of West Malaysia's 2.7 million hectares of agricultural land, 2.2 million is devoted to plantation crops and 0.5 million to food crops. Rubber dominates the plantation sector with a 1968 total of 1.8 million hectares of which 1.1 million were in small-holdings and 0.7 million in estates. The estates' rubber area is decreasing in favour of oil palms whilst the smallholding rubber area is increasing due to encouragement from government-supported schemes. To meet the serious competition from synthetics the rubber sector is replanting on a consistent basis with new high-yielding clones developed by the Rubber Research Institute of Malaya and private research institutes.

These institutes provide an excellent fertiliser advisory service with detailed schedules for newly-planted and mature trees. Formerly, the main emphasis was laid on phosphorus pentoxide particularly for establishing a leguminous cover crop in immature rubber plantations. At present the recommended average $N:P_2O_5$ nutrient ratio for rubber trees is 1:1.1 and for a substantial part of inland soils nitrogen in fact outweighs P_2O_5 in the ratio 1:0.7.

Most estate fertiliser programmes are well organised and their 1969 consumption was already very close to the recommended rate. The future growth rate will therefore be rather low, of the order of five

/per cent

per cent per annum with an unchanged nutrient ratio. The smallholdings rubber area will increase by about 3 per cent per annum and fertilizer consumption can be expected to increase at a corresponding rate. After 1975 the annual rate of growth of total consumption of nitrogen and P_2O_5 will be at the average, let us say, of the two rates up to 1975. 1969 consumption and the 1975 and 1980 projections are given in Table II.4.

Table II.4: Nutrient consumption on rubber estates and smallholdings in West Malaysia in 1969, 1975 and 1980 in tons

Year	Total rubber area in million ha.	Fertilizer consumption in tons of nutrient: N Estates	N Small-holdings	N Total	P_2O_5 Estates	P_2O_5 Small-holdings	P_2O_5 Total
1969	1.79	12,500	9,300	21,800	14,000	10,800	24,800
1975	1.87	16,700	11,700	28,400	18,800	13,700	32,500
1980	1.90	...	...	35,000	...	...	40,000

Ammonium sulphate and ammonium nitrate are both widely used. The usual P_2O_5 form, in straights or mixtures, is ground rock phosphate from Christmas Island. In fertiliser experiments it has given satisfactory results under the prevailing climatic and soil conditions. By 1968 compounds accounted for about 50 per cent of total consumption for rubber.

3. <u>Oil palm</u>. Since the early 1950s the oil palm acreage has increased five-fold to 200,000 hectares in 1969 and is still expanding. Both the smallholding sector and the rubber estates have been diversifying their output by moving into this crop. Nutrient requirements for the palm for vegetative growth and fruit bunch production are very high and adequate fertiliser application is essential. Eight-year old palms can in a single year take up from the soil 128 kilogrammes of nitrogen and 39 kilogrammes of P_2O_5 per hectare. The Department of Agriculture and private research stations have now established a well-organised fertilizer advisory service on the basis of numerous experiments.

/In Table II.5

In Table II.5 the 1969 consumption of fertilizer for oil palm production and Kemmler's projections for 1975 and 1980 are given. The average growth rate of nitrogen and P_2O_5 nutrient consumption over the 1969-80 period is 8.1 per cent and 11.3 per cent respectively. Fertilizers used for oil palms are the same as those applied to rubber.

Table II.5: Nutrient consumption for oil palm production on estates and smallholdings in West Malaysia in 1969, 1975 and 1980

	Total oil palm area in ha.	Application rate in kg./ha.		Fertilizer consumption in tons	
		N	P_2O_5	N	P_2O_5
1969	211,000	52	38	11,000	8,000
1975	332,000	60	60	20,000	20,000
1980	400,000	65	65	26,000	26,000

4. Rice. It is now an objective of Malaysian government policy to make the country self-sufficient in rice. A number of measures have been adopted to achieve this such as a minimum price for paddy, a 30 per cent subsidy for fertiliser used on paddy and the introduction of high-yielding varieties. Since 1968 a sister variety of the International Rice Research Institute's IR5 known as Bahagia has been introduced and it is believed will become the major variety used in double-cropping areas. The present recommended nutrient application in kilogrammes/hectare is 67-100 N, 34-45 P_2O_5 and 17-34 K_2O. This is estimated to give a 4:1 value-cost ratio.

Table II.6 presents the consumption of nutrient by paddy in 1969/70 on the single-cropped and double-cropped acreage. The 1975 figures are Kemmler's projections of acreage, application rates and consequent nutrient consumption. The 1975-1980 growth rates for nitrogen and phosphorus are 11.4 per cent and 12.5 per cent respectively. End-products used are ammonium sulphate, urea, ground rock phosphate and compound fertilizers.

/Table II.6

Table II.6: Nutrient consumption for rice production in West Malaysia in 1969/70, 1975 and 1980

Year	Crop	Area planted in '000 ha. First crop	Second crop	Total	Average application kg./ha. N	P_2O_5	Consumption in tons N	P_2O_5
1969/70	Single	255	-	255	16	16	4,100	4,100
	Double	101	101	202	30	20	6,100	4,000
1975	Single	162	-	162	16	16	2,600	2,600
	Double	243	243	486	60	40	29,200	19,400
1980		...	...	...	..	..	50,000	35,000

5. Other crops. This includes cassava, sweet potatoes, groundnuts, maise, green vegetables, pepper, sugarcane, coconuts, pineapples, bananas and other fruit. Pineapples and pepper already receive heavy applications but the acreage is small. If present private enterprise plans for the expansion of sugarcane production are realized, this crop could become the largest single nutrient consumer in the "other crops" category. In 1969 consumption by "other crops" of nitrogen and P_2O_5 stood at 12,000 tons and 2,000 tons respectively. By 1980 this could increase to 27,000 tons and 9,000 tons respectively.

6. East Malaysia. Sarawak and Sabah together cover 60 per cent of the territory of the Federation of Malaya. In terms of agricultural area the figure is much lower, at 36 per cent. East Malaysia takes up about 10 per cent of the total fertilizer consumption of the Federation.

Measured by area cultivated Sarawak's cropping pattern is mainly given over to rubber and rice. But it is pepper which accounts for over half the territory's fertiliser consumption. Fertiliser end-products used are similar to West Malaysia. Sabah's main crops in acreage terms are rubber, coconuts, rice and oil palm. Most of fertiliser imports go to this last crop.

In table II.7 East Malaysia's 1968 consumption of nitrogen and P_2O_5 are set out with projections for 1975 and 1980.

Table II.7: Nutrient consumption in East Malaysia in 1968, 1975 and 1980

	1968		1975		1980	
	N	P_2O_5	N	P_2O_5	N	P_2O_5
Sarawak	3,100	3,200	...	...	...	...
Sabah	400	700	...	...	...	...
East Malaysia	3,500	3,900	7,000	7,000	10,000	10,000

7. Table II.8 brings together the nutrient consumption projections for each crop and for East Malaysia. In 1969 the total nutrient consumption was 56,000 tons of nitrogen and 46,000 tons of P_2O_5 for the Federation of Malaysia as a whole. Thus the implicit growth rate for nitrogen and P_2O_5 in the period 1969-1980 is 9.2 per cent and 9.1 per cent respectively. P_2O_5 will continue to be supplied in the form of ground phosphate rock. If the percentage of nutrient supplied in rock form remains the same as it was at the end of the 1960s, that is 85 per cent, then the P_2O_5 nutrient requirement in the form of chemical fertilizers will be only 18,000 tons out of the 1980 120,000 tons total.

Table II.8: Estimated nutrient consumption in Malaysia in 1980

	Fertilizer consumption in 1980 in tons	
	N	P_2O_5
Rubber	35,000	40,000
Oil palm	26,000	26,000
Rice	50,000	35,000
Other crops	27,000	9,000
East Malaysia	10,000	10,000
Total	148,000	120,000

/C. The Philippines

C. The Philippines

1. The importance of agriculture to the Philippines is well-recognized. Agriculture and forestry contributed one-third of gross national product in 1970 and the proportion was actually increasing in the late sixties. Some sixty per cent of the labour force work in agriculture. Four-fifths of total export earnings come from the sale of agricultural products, the most important of which are copra, sugar, abaca, pineapples, forest products, vegetable oils, and seeds.

2. A time-series of nutrient consumption is difficult to construct with complete accuracy because of the uncertainty in year-to-year stock changes, the incompleteness of import statistics and the likely double-counting of imported materials used for domestic production of compounds. It is accepted that the FAO data are the best available and these are given in Table II.9.

Table II.9: Nutrient consumption in the Philippines by year in tons

Year	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70
N	48,000	52,000	53,000	58,000	66,000	64,000	63,000	71,000
P_2O_5	25,000	22,000	23,000	25,000	28,000	24,000	45,000	64,000

Source: FAO Annual Fertiliser Review.

Using the annual average of 1962/63 - 1964/65 as base and 1967/68 - 1969/70 as the end-period, the rate of growth of nitrogen was very modest at 5.3 per cent per annum. The corresponding growth rate of phosphorus pentoxide was 13.7 per cent, all of the advance being registered by the quantum leaps of the last two years of our time-series.

The devaluation of the peso in February 1970 from P 3.90 to the dollar to a floating rate which in 1971 was some P 6.40 meant a

/severe

severe increase in the price of fertilizers. Between September 1969 and March 1970 end-product prices rose by 41 - 73 per cent (TVA 1971). As a result consumption in 1970/71 and 1971/72 has probably not increased on the 1969/70 figure and may well have fallen back.

3. In geographic terms nutrient consumption is highly concentrated Regional estimates for 1970 to the nearest percentage point were:

Region	% of nutrient consumed
Southern Tagalog	38
Western Visayas	23
Central Luzon	18
Ilocos	8
All other regions	13
TOTAL	100

In Southern Tagalog, particularly Batangas and Cavite provinces, application rates are very heavy compared with the rest of the country. Western Visayas is an important sugar-cane producing region. Central Luzon has priority rice programmes and is also a sugar producer. (TVA 1971)

4. Consumption is also concentrated in terms of its distribution amongst crops. According to ESFAC 1/ estimates for 1967, shown in Table II.10, sugarcane and rice between them took up more than three-quarters of total consumption of each nutrient, nitrogen and P_2O_5. Kemmler has suggested that in 1975 these two crops will continue to dominate effective demand, joined by maize: the three together will consume 81 per cent of all nitrogen and 73 per cent of all P_2O_5. A more detailed study of these three crops is therefore justified.

/Table II.10

1/ Esso Standard Fertiliser and Agricultural Chemicals Company. Since these estimates were made Esso has sold its fertilizer business.

Table II.10: Nutrient consumption in the Philippines by crop in 1967 and 1975 in percentages

Crop	1967		1975	
	N	P_2O_5	N	P_2O_5
Sugar-cane	48	57	41	41
Rice	30	23	28	17
Maize	4	2	12	15
All others	18	18	19	27
Total	100	100	100	100

Source: 1967 ESFAC. 1975 Kemmler.

5. **Sugarcane**. Table II.11 shows that only 4 per cent of all harvested land is given over to sugar-cane. But it consumed 48 per cent of all nitrogen in 1967. Therefore sugar-cane uses about 27 times more nitrogen per hectare than the average for all other crops. The ratio of P_2O_5 is even higher.

Table II.11: 1970 area harvested by major crops in the Philippines in '000 hectares and percentages

Crop	Area harvested ('000 ha.)	%
Rice	3,113	37
Maize	2,420	29
Coconut	1,884	22
Sugar-cane	366	4
Banana	235	3
Abaca	173	2
All others	285	3
Total	8,476	100

Source: TVA 1971

/Sugar-cane

Sugar-cane acreage has almost doubled since the early fifties but from the beginning of the sixties yields have decreased and the trend rate of growth in production for the last two decades has been negligibly different from zero. The Philippines did not fill its export quota to the United States in the late sixties and its quota was accordingly cut in 1971 by the U.S. Congress. The Philippines special ambassador to the United States predicted in May 1972 a further cut when the new quotas are established in 1974.

With these points in mind our projection for fertilizer demand in 1980 takes the rather conservative ESFAC estimate for 1975 raised by ten per cent. This gives 1980 consumption as 52,000 tons of nitrogen and 26,000 tons of P_2O_5. A low estimate is strongly confirmed by the fact that 1967 data show that the average recommended rate for nitrogen was exceeded by actual applications whilst P_2O_5 use was as high as 83 per cent of the recommended rate.

Nitrogen is used to an increasing extent in the form of urea but many growers insist on applying part of it as ammonium sulphate. Other N sources are mono- and di-ammonium phosphate which, with NPK compounds, supplies virtually all the P_2O_5 uptake.

6. <u>Rice</u>. As we can see from Tables II.10 and II.11 rice is the second most important consumer of fertilizer nutrients and the most important of all crops in terms of acreage harvested. Acreage has remained fairly stable in recent years. The remarkable increase in output since 1966 is mainly due to the successful introduction of the new HYVs produced by the International Rice Research Institute and the Bureau of the Plant Industry. The acreage under HYVs has increased from a negligible amount in 1965 to about 30 per cent of the total in 1968/69.

In 1968 the Philippines achieved self-sufficiency in rice production for the first time, although in 1970 and 1971 there were large-scale imports because of damage to crops by typhoons and the ravaging effects of disease on one of the new HYVs. These set-backs appear to be of a temporary nature and we can expect total production to equal or be very close to total consumption throughout the 1970s. Possibilities for export seem very limited.

Accordingly we expect rice acreage to change little over the coming years. Paddy output may rise at a rate slightly above the rate of growth of population, say four per cent per annum. Present rates of application are definitely below the recommended rates of approximately 60 kg. nitrogen and 40 kg. of P_2O_5 per hectare. Room for growth in fertilizer demand exists. Furthermore, new strains developed by the IRRI and BPI with a better taste and higher disease resistance may also encourage increased acreage intensity of nutrient use. On this basis the effective demand for nitrogen on paddy could rise each year by say 6 per cent and for P_2O_5 at a higher rate. Nitrogen consumption in 1980/81 we project to be 50,000 tons against 20,000 tons of P_2O_5, a nutrient ratio of 2.5:1.

7. Maize. Maize is the most important food crop in the Philippines after rice. Average yields per hectare have been very low. In order to meet the growth in demand, but with total acreage little changed, the government has been promoting HYVs. The target number of hectares under these new varieties has been set at 500,000, which is about one-fifth of present total acreage harvested. In 1967 maize accounted for only 4 per cent of total nitrogen consumed and 2 per cent of total P_2O_5. But the government's HYV programme will boost these proportions.

The Rice and Corn Production Co-ordinating Council's recommendations are 90 kg. N and 45 kg. P_2O_5 per hectare. If 90 per cent of total fertiliser consumption in 1980 is on HYVs and if these cover the planned 500,000 ha., using fertilizer at say 60 per cent of the recommended rate then the effective demand for nutrients for maize in 1980/81 will be 30,000 tons of N and 15,000 tons of P_2O_5.

8. Other crops. The most important of these are coconuts, pineapples, bananas, vegetables, abaca and tobacco. Coconuts are the Philippines biggest export earner in the form of copra, coconut oil and dessicated coconut. Experiments on fertiliser response rates have begun in the last few years and rates of 80 kg. N and 60 kg. P_2O_5 per hectare have been recommended by the Bureau of Soils. Coconut could become a very considerable user of fertilizers but a number of problems such as

/land

land tenure, lack of capital, small farm size, etc. are holding demand in check. 1980 consumption may be of the order of 5,000 tons of nitrogen and 4,000 tons of P_2O_5. All other crops may generate a demand in the projection year for say 35,000 tons of nitrogen and 15,000 tons of P_2O_5.

9. Table II.12 brings together the crop-based consumption estimates. Using 1967/68 - 1969/70 as base-period, the rate of growth of effective demand averaged over all products in the twelve years up to 1980/81 is 8.4 per cent for nitrogen and 5.0 per cent for P_2O_5.

In terms of the crop-wise distribution of nitrogen, sugarcane's share falls from 48% in 1967 to 30% in 1980/81. On the other hand the share of maize rises from 4% to 17%. The same shift in relative weights is even more marked in the case of P_2O_5. It is the relative stagnation in the growth of fertiliser demand from the sugarcane sector which explains the slow rate of growth of demand for P_2O_5.

Table II.12: Estimated nutrient consumption in the Philippines in 1980/81 by crop in tons

Crop	Estimated 1980/81 consumption			
	N	%	P_2O_5	%
Sugar-cane	52,000	30	26,000	32
Rice	[illegible]0,000	29	20,000	25
Maize	30,000	17	15,000	19
Coconut	5,000	3	4,000	5
Other crops	35,000	21	15,000	19
Total	172,000	100	80,000	100

/D. Thailand

D. Thailand

1. Agriculture is far and away the dominant sector in the economy of Thailand in terms of employment and value of exports. Three-quarters of the labour force work in agriculture and in 1969 74 per cent of the country's exports originated in this sector, the most important products being rice, rubber, maise and tapioca in that order. With the rate of growth of the Thai population at present exceeding 3 per cent and with the largest increases in foreign exchange earnings projected still to come from primary products, the agricultural sector can be expected to maintain its dominant position throughout the 1970s.

About 80 different crops are grown in the country of which 40 are of commercial importance. These can be broken down into seven major categories:

Rice
Grains and forage (maise and sorghum)
Fibre (jute, kenaf, cotton)
Oil (caster beans, peanuts, soya beans, coconut)
Fruit and vegetables
Tree crops (deciduous, citrus, banana, coffee, rubber)
Others (including tapioca, sugarcane and tobacco)

Rice is and always has been the most important crop and some two-thirds of the country's 11 million hectares of cultivated land are devoted to it. The major rice cultivation area is the alluvial Central Plain.

Chemical fertiliser was first imported into Thailand in the early years after the Second World War, in the form of white ammonium sulphate. This product became the accepted nutrient source amongst farmers. As a result during the early 1950s Thailand was basically a nitrogen-using country. In the late 1950s a gray 16:20:0 compound was introduced and also met wide acceptability. The spread of fertiliser usage in the years up to 1960 was very modest and in that year the country consumed a total of only 12,000 tons of nitrogen and phosphorus pentoxide.

Table II.13 shows the growth of the main products during the period 1961/62 - 1969/70. The first point to note is the high rate of

/growth

growth in effective demand for both nutrients from a low base-period tonnage. Taking as base and end periods the three year averages of 1962/3 - 1964/5 and 1967/8 - 1969/70 respectively, the annual rate of growth over the intervening five years was 27 per cent in the case of nitrogen and even higher at 34 per cent in the case of P_2O_5.

These aggregate growth rates hide a pronounced shift in the type of end-product purchased. Dividing the products into two groups, low analysis straight fertilizers (ammonium sulphate, ammonium nitrate, other nitrogen fertilizers, superphosphate and other phosphate fertilizers) and high analysis and complex fertilisers (urea, ammonium phosphate and other complex fertilizers) we can deduce from Table II.13 that whilst in 1961/62 the relative shares in total consumption of the first and second groups was 51 per cent and 49 per cent respectively, by 1967/68, the last year for which we have the product break-down, the relative shares had changed to 22 per cent and 78 per cent. This is effectively symbolised by the displacement of ammonium sulphate by ammonium phosphate as the No. 1 nutrient provider to Thai agriculture.[1/]

2. For many years fertiliser use was mostly confined to fruit and vegetable cultivation in the Central Plain for the Bangkok market. Accurate statistics do not exist on fertilizer use broken down by area or by crop. But it appears that some 60 per cent of total fertilizer consumption is taken up within a 100 kilometre radius of Bangkok. It was

/the fruit

1/ One uncertainty in the data sources is the quantity of urea used in agriculture. Mueller has suggested that as much as 80-90 per cent of the urea produced in Thailand or imported goes to industrial uses such as glue, monosodium glutamate and various fermentation processes. /̅Mueller 1971_7 If this were true it would tend to diminish the rate of growth of consumption of fertiliser nitrogen because urea makes up an increasing proportion over time of total nutrient consumed in Table II.13; but even with 90 per cent industrial usage the rate of growth would not fall below 25 per cent.

Table II.13: Consumption of nitrogen and phosphate fertilizers in Thailand by product in tons of nutrient, 1961/62 - 1969/70

Nutrient	Product	1961/62	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70
N	Ammonium sulphate	6,464	6,825	8,316	6,838	6,034	11,066	14,468	...	...
	Ammonium nitrate	138	66	650	516	1,203	1,861	3,286	...	...
	Urea	482	675	486	581	1,079	1,900	4,849	...	...
	Ammonium phosphate	2,133	2,720	5,364	4,450	5,401	12,436	18,549	...	...
	Other nitrogen fertilizers	591	500	512	482	470	364	257	...	...
	Other complex fertilizers	1,200	1,560	3,036	3,335	3,730	7,166	10,784	...	...
	TOTAL	11,058	12,346	18,364	16,202	17,917	34,793	52,193	51,000	51,000
P_2O_5	Super phosphate	606	768	840	585	660	974	754	...	...
	Ammonium phosphate	2,729	3,400	6,705	5,563	6,751	15,545	23,187	...	...
	Other phosphate fertilizers	185	750	483	457	134	570	942	...	...
	Other complex fertilizers	1,200	1,560	3,036	3,335	3,730	7,166	10,784	...	...
	TOTAL	4,720	6,478	11,364	9,940	11,275	24,255	35,667	38,100	45,300
$N+P_2O_5$	Grand Total	15,778	18,824	29,428	26,142	29,192	59,048	87,860	89,100	96,300

Source: FAO Annual Fertilizer Review. ... not available.

Note: ground rock phosphate excluded.

the fruit and vegetable growers who pioneered the use of compounds on a significant scale. These farmers are regarded as the most progressive of all due to their educational levels and financial status. (Cavusoglu 1970). Complex fertilizers and mixtures have been preferred because they are less bulky than straight fertilizers. They also combine the NP and NPK nutrients homogeneously enabling farmers to apply them more accurately and easily than combining straights. Vegetables in particular are said to show a remarkable response to fertilizer use. 13:13:13 mixtures are widely used.

During the 1950s and early 1960s there was widespread pessimism on the likelihood of rice farmers using fertilizer. Since then there has been a remarkable change in the situation and now it is estimated that about one-half of total consumption on N and P_2O_5 goes on paddy. In 1970 Kemmler pointed out that in the case of a farmer following the fertilizer recommendations of the Department of Agriculture the value-cost ratio of fertilizer use was as high as 3.3 - 6.7:1. (Kemmler 1970) Ammonium phosphate has been particularly popular amongst rice farmers.

Thus rice, vegetables and fruit, dominate the consumption of fertiliser in Thailand. After these three the most important crops are probably tobacco, rubber, maise and sugar-cane.

3. We now look at the main determinants of the changes in aggregate and product-wise consumption described in paragraph 2 above.

__Prices__. Table II.14 shows the prices Thai farmers had to pay in 1965 and 1969 for nine different fertilizers when purchased on credit. The price reductions have been very large, in all cases but one they lie in the 14-25 per cent range. This fall played a major role in the large expansion of demand over this four-year period. (See Table II.13.) There is no clear correlation between the magnitude of the fall in price and the magnitude of expansion in volume demanded: for example, the price of ammonium sulphate fell more rapidly than that of ammonium phosphate, but as we have seen the volume of ammonium phosphate consumed increased much more rapidly in the second half of the sixties than did ammonium sulphate.

/Table II.14

Table II.14: Fertiliser prices on credit to Thai farmers 1965-69 in baht per ton

Product	Analysis	Price to farmer		Change	1969 price per nutrient
		1965	1969	1965-69	ton
Potassium chloride	0:0:60	2,000	1,510	-24	2,520
Compound	12:24:12	2,900	2,800	- 4	5,840
Compound	13:13:21	2,800	2,300	-18	4,900
Urea*	46:0:0	2,800	2,400	-14	5,220
Compound	14:14:14	3,200	2,400	-25	5,720
Compound	13:13:13	3,200	2,600	-18	6,660
Ammonium phosphate	16:20:0	2,800	2,300	-18	6,400
Ammonium sulphate	21:0:0	1,700	1,300	-23	6,200
Superphosphate	0:20:0	1,600	1,360	-15	6,800

*Cash prices.

Source: prices from Cavusoglu 1970.

Table II.14 also shows that a correlation exists between price per ton of nutrient and the percentage of nutrient in each ton of fertiliser. The products in the table have been ranked in terms of their analysis. Potassium chloride, for example, has the highest analysis and the lowest price per nutrient ton. Superphosphate has the lowest analysis and the highest price per nutrient ton. The fit is not perfect: the 12:24:12 compound, in particular, seems to be considerably over-priced.

It is not only fertilizer prices which effect consumption, but crop prices too, because for the farmer the relative price of fertiliser and crop plus their agronomic yield relationship is what determines his value/cost ratio upon fertiliser application. Unfortunately we do not have time-series data on crop-prices received by the farmer. But we do know that the farmer is price-sensitive. For example, whilst the area devoted to kenaf, or Thai jute, increased rapidly in the decade of the sixties, present usage of fertiliser is very low. One of the reasons

/cited

cited by Kemmler is the price fluctuation of the crop. In other cases fertilizer use followed by higher yields has had the result of a fall in price received for the crop. This is a clear example of inelastic demand for the crop checking expansion in the derived demand for fertilizer.

4. Import policy. Up to the mid-1960s there were no quantitative restrictions on the import into Thailand of fertilizers. A charge of approximately 7 per cent of the c.i.f. price was imposed in transferring the product from steamer to godown to cover a government ad valorem tax and the transportation charges of the government-owned Express Transportation Organization. /TVA 1966 7

In 1967 Thailand's first chemical fertilizer plant came on-stream at Mae Mo near Lampang, producing ammonium sulphate and urea. It is owned by the Chemical Fertiliser Company Limited. At the end of the previous year ammonium sulphate imported from Japan was sold at 1,250 baht per ton. Mae Mo marketed its output at the same price in 1967. Within 8 months the price of imported ammonium sulphate had been slashed twice by the Japanese to 900 baht, a 28 per cent cut. This was lower than the production cost of the indigenous product. Furthermore, profit margins and credit terms offered by importers to dealers were more favourable than those offered by Chemferco.

By June 1968 Mae Mo's unsold stocks exceeded 35,000 tons and the factory ceased production. In the same month the government banned the import of ammonium sulphate and urea. Excess stocks were slowly liquidated and production was restarted at the beginning of 1970. (Cavusoglu 1970) After the import ban importers increased tremendously their import of nitrogen fertilisers other than ammonium sulphate and urea and in January 1970 the government imposed a ban on other nitrogen fertilisers.

The situation then has been complex. The appearance of Mae Mo led to a fierce price war and considerable price reductions for the farmer in 1966-68. Thereafter, the ammonium sulphate and urea ban led to importers switching into other nitrogen products in 1969. Finally the total nitrogen fertiliser ban in 1970 held back the consumption of all these products. This analysis is confirmed in aggregate terms by Table II.13 where we see a strong surge in nitrogen consumption up to 1967/68 which is checked thereafter. P_2O_5 consumption continues to grow after 1967/68 but at a much slower rate.

The import legislation still permits Chemferco itself to import ammonium sulphate and urea. In Table II.15 we show the 1971 pricing system. The c.i.f. to wholesaler price increase is very high indeed, 92 per cent and 121 per cent in the case of ammonium sulphate and urea respectively. These mark-ups alone constitute 40 per cent and 46 per cent of the price to the farmer on the respective products.

Table II.15: Post-1969 pricing system for ammonium sulphate and urea in baht per ton

	Ammonium sulphate	Price increase	Urea	Price increase
FOB Japan	500	-	960	-
Freight	150	-	150	-
CIF Bangkok	650	30%	1,110	16%
Chemferco price to wholesaler*	1,250	92%	2,450	121%
Price to farmer	1,500	20%	2,940	20%

* Domestically produced or imported.

Source: Mueller 1971.

5. Credit. In 1966 the Thai government launched a project aimed at providing credit to farmers for purchasing fertilizer. Later the credit was distributed primarily through agricultural co-operatives. This led to co-operatives bulk-purchasing from wholesalers at cheaper prices. About 6-10 per cent of total fertilizer consumption in 1969 was financed in this way. It is of considerable interest to note that in that year only 34 per cent of total credit applications were granted. The lesson is clear. Greater availability of credit could lead to a vigorous expansion of fertilizer consumption.

/Confirmation

Confirmation can be found for this in the case of tobacco. The Tobacco Monopoly of Thailand ensures the fertilization of almost the entire crop by providing credit to the growers.

However, the credit situation in Thailand at present is not good. Indeed, Donner has said that it is on the verge of collapse. Distributors hesitate to establish new dealers because they are not interested in expanding their volume of fertilizer credit and thus acquiring additional bad credit risks. (TVA 1966) The farmers themselves are deep in debt, an average of 8,000 baht per family and the average interest on this debt is at a rate of 28 per cent per annum. (Donner 1971). Donner estimates that present credit needs for fertilizer alone are 500-600 million baht. If these views are correct then clearly the continuing progress of Thai agriculture depends on resolution of the credit problem.

6. Enough has been said in the previous paragraphs to demonstrate that it would be quite invalid to estimate consumption in 1980 on the basis of projecting the growth rates of the 1960s. As we have seen they were 27 per cent per annum for nitrogen and 34 per cent per annum for P_2O_5.

Taking the 1967/68 - 1969/70 annual average as base, we can foresee only a very modest growth in the short-term primarily because of uncertainties in the import position. However, if this problem is dealt with in a way which is satisfactory to the domestic producer but which permits unrestricted entry of imports once again, the situation will be most encouraging. The present c.i.f. - domestic wholesaler mark-up is sufficiently high that resolution of the import problem would probably permit price cuts for nitrogen of up to 35 per cent to the farmer and smaller reductions in the price of P_2O_5. This will bring about a large, once-for-all surge in the demand for both products. Thereafter the growth rate of consumption will settle down to a somewhat lower but steadier rate, the maintenance of which will necessitate the provision of an adequate agricultural credit system.

The underlying situation, then, is excellent. In terms of crops, one can foresee that NP compounds will continue to spread amongst rice farmers, with nitrogen supplied in the ammonium, not the nitrate form. However, Thai rice which is of the tall Indica variety, will never become an intensive fertilizer user as it is liable to lodge with heavy nutrient application. Only if there were a shift into high yielding varieties would this change. At present this seems unlikely since the success of the country's export trade in rice is founded on the excellent taste and cooking qualities of the present Indica grains.

Maize is likely to continue at least its modest expansion in demand for compounds as exports rise. Tobacco, of the local not the Virginia variety, has first-class export prospects and is already an NPK user. The credit system here is particularly encouraging. Rubber, too, is a good potential user and fertilizer recommendations for it are particularly heavy. Fruit and vegetables will maintain and increase their demand for compounds.

There is a continuing need to educate the farmer whose understanding today is based on colour and brand with little knowledge of analysis variation. There is a need for improved extension services. The 1970s will also bring a closer understanding of the agronomic yield relationship as a result of long-term experiments at present being conducted by the Department of Agriculture and the UNDP Soil Fertility Programme. Finally, consumption will undoubtedly be encouraged by the fulfilment of the present plans for irrigation, flood control and drainage projects.

7. Table II.16 sets out the assumed growth rate for nitrogen and P_2O_5 up to 1980-81.

Table II.16 - Forecast rate of Growth of Nutrient Consumption in Thailand 1968/69 - 1980/81 in per cent per annum

Year		1968/69-1972/73	1972/73-1974/75	1974/75-1980/81	1968/69-1980/81 *
Growth rate	N	5%	20%	12%	10.9 %
	P_2O_5	7%	15%	12%	10.8 %

* The equivalent over 12 years of the three component growth rates.

The equivalent of the three component growth rates in the case of both nitrogen and P_2O_5 is a little short of 11 per cent per annum. Projected consumption in 1980/81 of nitrogen is 178,000 tons, and 136,000 tons of P_2O_5. Of this total we can speculate that 15 per cent or less will be applied as straight fertilizers. The rest will be applied in the form of complex or blended fertilizers.

E. ASEAN

Now we have all the information necessary to estimate the 1980/81 nutrient demand for ASEAN as a whole. It will be noticed that Singapore has so far been left out of account. The Singaporean agricultural sector is extremely small in absolute size because of the island's limited total area. Market gardening and orchid growing are the most important agricultural activities with farmers using organic fertilizers such as pig and chicken manure and prawn dust. Chemical fertilizer use is predominantly for the Garden City Programme on public parks, gardens, flower beds and so forth. Total consumption of fertilizer materials is at present only about 40 tons.

In Table II.17 we bring together the demand forecasts for each of the ASEAN countries.

TABLE II.17 - Estimated Nutrient Consumption in the ASEAN Countries in 1980/81 in tons

Estimated nutrient consumption in 1980/81 in tons

Country[1]	N	%	P_2O_5	%	P_2O_5 ex GRP[2]	%[2]
Indonesia	540,000	52	220,000	40	200,000	46
Malaysia	148,000	14	120,000	22	18,000	4
Philippines	172,000	17	80,000	14	80,000	18
Thailand	178,000	17	136,000	24	136,000	32
ASEAN	1,038,000	100	556,000	100	434,000	100

1. Singapore's consumption is and will continue to be negligible
2. Excluding ground rock phosphate (GRP) as a nutrient source, that is, including only manufactured chemical fertilizer sources of P_2O_5.

The two most distinctive features of the table are that Indonesia is estimated to be the dominant fertilizer consumer of the ASEAN countries in 1980/81. Second, that in the same year Malaysia will be the smallest consumer, by a considerable margin, when ground rock phosphate supplies are excluded, that is when only manufactured chemical fertilizers are counted. This is the most appropriate figure from the point of view of the requirements for expansion of fertilizer production in the area.

In each of the country studies we used base-period consumption estimates to calculate the rate of growth of demand for nitrogen and for phosphorus pentoxide from all sources, i.e. including ground rock phosphate supplies. Using the same base-period data summed for the ASEAN region as a whole, it can be calculated that the rate of growth of consumption of nitrogen in the twelve years from the end of the 1960's up to 1980/81 will be approximately 10.1 per cent. The corresponding figure for P_2O_5 is 9.5 per cent.

SECTION III

PRESENT AND PLANNED SUPPLY OF FERTILIZER IN THE ASEAN COUNTRIES

The existing and planned capacity of the ASEAN countries in terms of plant nutrients, N & P_2O_5 - is summarized in Table III-1. This Table also gives the estimated consumption of fertilizers for the year 1980 and the shortfall between consumption and production for that year.

In considering future capacity, it was assumed that all existing and proposed plants in the ASEAN area would be operated at rated capacity, and the 52,000 metric tons of N capacity, as ammonia in the Philippines, would be converted to fertilizer use.

Only the Pusri II project, which has been approved and financed, was considered as being assured future production. The proposed N expansion in Malaysia and the completion of the superphosphate plant in Indonesia, are very much in doubt, so they are not included. In any event, the Malaysian N expansion would have to be based on imported ammonia which could be supplied from regional production.

The capacity of the fertilizer plants in the ASEAN countries as the situation now stands, can only supply 43.3% of the nitrogen and 16.2% of the phosphate requirements of the ASEAN countries in 1980.

In terms of plant nutrients, additional production facilities should be constructed between now and 1980 to produce 595,000 metric tons per year (2190 metric tons of ammonia per day) of nitrogen, and 368,000 metric tons per year (1115 metric tons of P_2O_5 per day) of P_2O_5 as phosphoric acid, with conversion facilities to produce solid straight and compound fertilizers in order to satisfy the needs of the ASEAN countries.

The projected supply-demand relationships clearly indicate that by 1980 new facilities of adequate size to be economically competitive with imports from any part of the world, could be established in the ASEAN area. This is particularly true because of the availability of a most important raw material, natural gas, at a low cost in Indonesia.

ASEAN COUNTRIES

DEMAND AND SUPPLY OF NITROGEN AND PHOSPHATE FERTILIZERS

YEAR 1980

TABLE III-1

QUANTITIES - 1000 MT

YEAR - 1980

COUNTRY	INDONESIA		MALAYSIA		PHILIPPINES		THAILAND		SINGAPORE		TOTAL	
PLANT NUTRIENT	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5
ESTIMATED CONSUMPTION	540	200	148	18	172	80	178	136	12	5	1050	439
PRODUCTION BY COMPANY												
PUSRI I & II	216	-	-	-	-	-	-	-	-	-	216	-
PETROKIMIA	52	-	-	-	-	-	-	-	-	-	52	-
CHEM. Co. OF MALAYSIA	-	-	33	-	-	-	-	-	-	-	33	-
FEDERAL FERTILIZER Co.	-	-	5	-	-	-	-	-	-	-	5	-
MARIA CRISTINA	-	-	-	-	11	-	-	-	-	-	11	-
ATLAS FERTILIZER CORP.	-	-	-	-	15	12	-	-	-	-	15	12
CHEMPHIT	-	-	-	-	11	3	-	-	-	-	11	3
SUGAR PROD. COOP	-	-	-	-	34	56	-	-	-	-	34	56
EXCESS AMMONIA CAPACITY	-	-	-	-	52	-	-	-	-	-	52	-
CHEMICAL FERTILIZER CO.	-	-	-	-	-	-	26	-	-	-	26	-
TOTAL CAPACITY	268		38	-	123	71	26	-	-	-	455	71
REQUIRED 1980	272	200	110	18	49	9	152	136	12	5	595	368

SECTION IV

SUGGESTED REGIONAL PLANS FOR CO-OPERATION IN THE FERTILIZER INDUSTRY

A. Introduction

A review of previous reports and consumption figures of fertilizers in the Asian countries shows a very marked trend towards the use of granular compound fertilizer of N-P and N-P-K grades.

Developing countries often establish a nitrogen industry first, followed by a phosphate industry, and finally a mixed fertilizer industry. This is what is happening in most of the ASEAN countries except the Philippines. The above sequence has disadvantages since it is likely to make the installation of total industry more expensive, and it makes it more difficult to give the farmer the balanced fertilizer that he needs.

Also, farmers are often illiterate, well-trained advisors few and soil analysis laboratories may be lacking. It would seem best to provide the farmer with mixed fertilizers, compounded on the basis of the best information available for the crops and soils of the area, with due regard to costs.

When nitrogen and phosphate fertilizer facilities are planned separately, problems may arise that could be avoided by a more integrated approach. For instance, if urea is chosen for the nitrogen fertilizer and triple superphosphate for the phosphorous fertilizer, any attempt to mix these two materials except by special techniques of ammoniating the superphosphate and granulating the mixture simultaneously, results in a wet, sticky mixture that is unusable.

Also, money may be wasted in granulating two materials in separate plants when the two could be combined and granulated in a single plant. This is very true in the case of compound fertilizers containing urea, since all of the concentrating and prilling equipment for the urea plant is eliminated at a very large investment savings.

A matter of prime importance is the cost of the finished fertilizers delivered to the farmer. The actual manufacturing costs are often no more than half of the final cost. Handling, bagging, transport, storage and distribution costs make up a large percentage of the final cost, and for these reasons an economic evaluation usually favours high analysis fertilizers. While only the CIF cost is used in evaluating the various schemes in this report, the above has influenced the thinking in selection of products and processes.

For the above reasons, the technology of providing high analysis N-P and N-P-K granulated fertilizers or intermediate products for producing this type of fertilizer in well-integrated plants has been chosen as the basis for this report.

The inclusion of potash in the compound fertilizers has only been included to the extent that the addition of potash to the granulation plant affects the capacity of the plant.

The production of nitrophosphates, produced by the acidulation of phosphate rock with nitric acid, was considered because of the possible saving on sulfur imports, but has not been included because they are not suitable for paddy rice, there being some danger of spontaneous combustion of nitrophosphates during storage and shipping when they include potasium chloride. There are strong indications that in the wet fields of warm climates they are inferior to the non-nitrate fertilizers, and they are a relatively low-grade fertilizer.

For reasons similar to the above, the production of ammonium nitrate has not been included in this study.

Ammonium sulfate, while considered a "has-been" fertilizer due to its low analysis, still remains a "tradition fertilizer" for use on paddy rice although it is rapidly being replaced by urea. More than adequate supplies of by-product ammonium sulfate are available on the world market at prices that make local production uneconomical (1).

(1) National Fertilizer Study - Indonesia - Annex V page 14

In view of the above, urea has been selected as the nitrogen compound for both straight nitrogen fertilizers and the predominant nitrogen carrier used in compound fertilizers in this study.

For fertilizer compounds containing N-P and/or N-P-K mixtures of urea, ammonium phosphate, and potash and mixtures of urea, triple superphosphate, ammonia, and potash were considered with the former being selected as the optimum to present in the study because the ammonium phosphate based compound fertilizer gives the highest analysis. The cost per unit of plant food, bulk, ex-factory for monoammonium phosphate based fertilizer is only about $0.10 higher, and the water solubility of the phosphate content is higher. The $0.10 per unit of plant food higher cost of this fertilizer disappears by the time bagging, distribution, freight and sales cost are added to each product, making the triple superphosphate based material more expensive to the farmer.

A very wide variety of N-P and N-P-K ratios in the compound fertilizers used in the area exist today with the pattern changing yearly as the fertilizer market grows and develops. It is impossible to determine the average grade of fertilizers in use in the area today or what it will be eight years hence, so prilled urea and a 23-23-9.5 granular fertilizer were selected being a close representative of the average analysis of fertilizers produced by the fertilizer complex plants covered in this report.

B. Proposed ASEAN Regional Fertilizer Complexes

The proposed solution for providing production facilities to supply the ASEAN area with fertilizers (based on availability of raw materials and consumption patterns) has resolved into the two plans which follow:-

1. ASEAN Regional Plan I

In Plan No. 1, both nitrogen and phosphate production facilities are integrated into a fertilizer complex producing prilled urea and granular compound fertilizer.

Nitrogen production is based on the use and availability of cheap Indonesian natural gas which results in two plant complexes at different locations. Phosphate production is also split equally between the two complexes. The following production units at indicated capacities comprise the plant complexes:

TABLE IV - 1	Complex JI Metric tons/day	Complex SI Metric tons/day
Ammonia Plant	950	1250
Urea Plants - 83% solution	950	950
Prills	470	1020
Sulfuric Acid Plant	1500	1500
Phosphoric Acid Plant	560	560
Monoammonium Phosphate Plant	1080	1080
Granulation Plant	2440	2440

ASEAN Regional Plan I is shown schematically in block flow Diagram No. 1

2. ASEAN Regional Plan II

In Plan No. II, nitrogen and phosphate production are separated, however, the production of granular compound fertilizers is produced in the phosphate plant complex and also in one of the nitrogen plant complexes. Phosphate is shipped as monoammonium phosphate (powder) from the phosphate complex to a nitrogen plant complex, and a very low-vapour pressure urea-ammonia solution (5psig at 105 degrees F) is shipped from one of the nitrogen plant complexes to the phosphate plant complex where the ammonia is stripped from the solution and used to make monoammonium phosphate. The remaining urea is concentrated and used in combination with solid urea to produce granular compound fertilizers. Nitrogen production is again based on the use and availability of cheap Indonesian natural gas.

The following production units with their capacities comprise the plant complexes:

TABLE IV - 2	Complex JII Metric Tons day	Complex SII Metric Tons day	Complex BII Metric Tons day
Ammonia Plant	950	1250	-
Urea Plants 83% Solution	1020	565	-
Prills	650	1120	-
Ammonia-Urea Solutions Plant	-	1510	-
Sulfuric Acid Plant	-	-	3000
Phosphoric Acid Plant	-	-	1120
Monoammonium Phosphate Plant	-	-	2160
Granulation Plant	2660	-	2220

ASEAN Regional Plan II is shown schematically in block flow diagram no.2

C. Process Plants

A brief description of the process plant used in the study is given below:

1. Ammonia Plants (NH_3)

The ammonia plant is based on a unit utilizing high pressure reforming of natural gas, or naptha reforming, desulfurization, CO_2 removal by M.E.A. methanation, compression, and ammonia synthesis using centrifugal compressors and steam turbine.

2. Urea Plants $(NH_2)_2CO$

a) 83% Solution Plants

The urea solutions plant is based on a total recycle plant producing an 83% solution of urea which is used in the granulation plant to produce compound fertilizers. No facilities are provided with this unit for concentrating and prilling urea.

b) Prilled Urea Plants

The prilled urea plant is based on a total recycle plant and includes all facilities for concentrating and finishing the urea into a usable fertilizer.

3. Sulfuric Acid Plants (H_2SO_4)

The sulfuric acid plants are based on the burning of elemental sulphur to produce sulfuric acid.

4. Phosphoric Acid Plant (H_3PO_4)

The phosphoric acid plants are based on the reaction of sulphuric acid with phosphate rock to produce phosphoric acid and gypsum (calcium sulfate dihydrate) with the gypsum being separated from the acid by vacuum filter. The resultant acid is concentrated to 45% P_2O_5 strength for use in making monoammonium phosphate powder. The plant includes all rock processes facilities and gypsum disposal.

5. Monoammonium Phosphate Plant (Powdered) (11-52-0)

The monoammonium phosphate plant is based on recent process developments where ammonia is reacted with phosphoric acid at elevated temperatures and pressures and the product of reaction is sprayed in a tower where the water in the solution is flashed and a dry powder is produced in the process.

The average analysis of the monoammonium phosphate powder is: N-11.0%; P_2O_5-52.0%, H_2O - 6.0%. Although the moisture content is relatively high, the material is dry in appearance, can easily be granulated with other fertilizer materials or ammoniated to diammonium phosphate and granulated, and has excellent handling, storage, and shipping qualities. Capital investment for the process is low.

6. Granulation Plants

The process proposed to be used is based on the TVA ammoniator - granulator process using powdered (fine) dry feeds as opposed to the Dorr-Oliver slurry process. This process has the advantage that the "recycle" requirements are at least one half of that required by the slurry process, making the capital investment lower in proportion. Much larger capacity units can also be built due to the fact that the capacity of the materials handling equipment required for the "recycle" is the limiting factor. Feeds to the granulation plant would be monoammonium phosphate (powdered), ammonia, phosphoric acid, urea solution and potash. While a single product analysis of 23-23-9.5 is used in this study for cost comparison purposes, the granulation plant proposed is extremely versatile and depending on the raw materials fed to the plant, can produce almost any combination of N-P and N-P-K ratios desired, including granular fertilizer containing Magnesium. Some examples of possible N-P and N-P-K ratios are: 27-27-0, 19-19-19, 19-48, 12-50 and 22-22-11.

D. Estimate of Capital Requirement for Regional Fertilizer Complexes.

While there are a variety of methods, processes and raw materials which can be used in the production of ammonia, urea and granular compound fertilizers, this study has evolved to a presentation of those unit operation and raw materials which appear to have economic justification under the conditions which exist in the ASEAN area.

The estimated investment cost for the proposed fertilizer plant complexes for ASEAN regional plans I and II, are given in Tables IV - 3 & 4.

A brief explanation of the items that make up the investment cost follows:

1. Battery Limits Plant

A complete operating unit which when supplied with adequate quantities of specified raw materials and utilities at its battery limits is capable of producing the products specified at the rated capacity. Battery limit investment costs were taken from IV - figures 1, 2 & 3, which were prepared from published cost ratio figures referred to under Section I, which have been adjusted to ASEAN conditions.

2. Offsites

Offsites are the necessary ancillary and support facilities required to keep the battery limit units operating efficiently at rated capacity. They include such items as the power distribution system, water systems, laboratories, shops, offices, steam generation, raw material and product storage etc.

3. Spare Parts

The requirement number and kind of spare parts or complete items of equipment required to place each unit in operation and cover operations for a period of two years.

4. Start-Up Expenses

Include all pre-operational expenses including training and schooling of personnel, expatriate start-up personnel and other costs prior to production. It also includes expatriate personnel through the first year of operation.

5. Interest During Construction

The interest on borrowed capital for a 30 month design and construction schedule is assumed to be as follows:

10%	x 2.5 years -	0.250
10%	x 2.0 years -	0.200
20%	x 1.5 years -	0.300
10%	x 1.25 years-	0.125
20%	x 1.00 years-	0.200
20%	x 0.75 years-	0.150
10%	x 0.50 years-	0.050
100%		1.275 equivalent years

Interest during construction is 1.275 x 8% of construction loan, or 10.2%. The construction loan includes the delivered and erected cost of all battery limit plants, offsites and spare parts.

6. Fixed Investment

The sum of Item 1 through 5 above.

7. Working Capital

Working Capital includes 30 days production of product, 30 days supply of raw materials and 10 days production of intermediate product.

8. Total Investment

The sum of Item 6 and 7 above.

E. Estimated Cost of Production - Regional Fertilizer Complexes

The following is a brief explanation of the elements of cost that make up the cost of production.

A summary of the Estimated Cost of Production for ASEAN Regional Plans I and II is given in Tables IV - 5,6,7,8 and 9.

1. Raw Materials

a) Natural Gas

Indonesia has known reserves of natural gas amounting to 72.9 bn cubic metres with additional reserves being proven currently. The present price being paid for this raw material to produce ammonia, is about $0.0066 per cubic metre. Additional consumption over and above that presently planned is expected to cause a rise in the cost of gas to about $0.0088 per cubic metre.

b) Sulfur

There are no known deposits of sulfur which are of commercial value at the present time in the ASEAN area. There are large deposits of volcanic sulfur on the Island of Negros in the Philippines, but they are not commercially attractive at present. A large scale venture to produce 2000 tons of sulfur from these ores has been abandoned due to the current sulfur market. Sulfur is expected to be in long supply for an indefinite time in the future. The Philippines also have a considerable supply of Pyrites from which sulfur can be made, but the capital investment requirement for a plant to use either Pyrites or volcanic ores is twice that of a sulfur-burning plant, and only in special cases would the choice of these raw materials be economical.

The reported C.I.F. price for sulfur is $22.50 to $26.50 per ton for the Philippines from the Near East, and $30.00 per ton for Indonesia (source unknown). In view of the fact that the supply of sulfur will be plentiful for many years to come and that the proposed consumption for the ASEAN area would amount to about 332,000 tons per year, current or lower prices for sulfur will prevail for the proposed operation.

Estimated cost of sulfur from the most logical sources delivered to the plant, is as follows:

Source	F.O.B. $	Freight $	Port and Handling $	Total Cost $
Canada	15.00	12.50	1.50	29.00
Near East	15.00	8.00	1.50	24.50

C. Phosphate Rock

There are no known deposits of phosphate rock of commercial value located in the ASEAN countries.

(1) Pacific Islands

The Paracel Islands, which are situated approximately six hundred miles to the west of Manila, contain some 9,500,000 million tons of phosphate rock estimated to average over 20% P_2O_5. From available analysis, the grade could be increased by calcining to 30% P_2O_5, but the Ca O/P_2O_5 ratio would make the rock require about 30% more sulfuric acid, making its use uneconomical. The deposits area is not being mined at the present time.

Christmas, Naura and Ocean Islands

While there are adequate reserves of phosphate rock on these islands (82 million tons of about 85% BPL), with the exception of Naura, all of this phosphate is under the control of the British Phosphate Commission who allocate most of the rock to New Zealand and Australia. However, some bagged phosphate dust is sold to Indonesia and Malaysia. Naura is expected to continue to sell its rock to New Zealand and Australia, plus Japan.

(2) Australia

Large deposits of phosphate rock have been recently discovered in Australia. One company, Broken Hills South Ltd., is in the process of developing a large deposit and expects to begin to produce 4,000,000 tons per year of phosphate rock in the late 1970's. What effect this will have on the phosphate rock situation in the ASEAN area, is unknown. The price of the Australian rock will be competitive with rock from other distant areas.

(3) Israel and Jordan

Adequate supplies of phosphate rock are available from these sources, however, it is only 67 BPL. An economic analysis of using this rock as opposed to 73% BPL Florida rock shows that it results in a cost of about \$3.00/MT P_2O_5 as 54% P_2O_5 phosphoric acid higher than Florida rock. Both Israel and Jordan rock have a high chloride content which presents technical problems when producing phosphoric acid.

The following is the estimated cost of phosphate rock delivered to the plant:

	BPL	F.O.B.$	Freight $	Port & Handling $	Total $
Florida	73	7.00	12.50	2.00	19.50
Morocco	75	12.50	13.00	2.00	27.50
Israel/Jordan	67	8.00	7.25	2.00	17.50
Pacific Islands	85	-	-	2.00	15.50

D. Potash

There are no known deposits of potash of commercial value in the ASEAN countries. Adequate supplies of potash are available from the following sources at the estimated delivered prices shown:

Source	F.O.B. $	Freight $	Port and Handling $	Total $
Canada	36.00	12.50	2.00	50.50
Israel	12.25	7.25	2.00	21.50

An average of these prices was used in cost calculation.

UTILITIES

Power

While in all probability each fertilizer plant complex will generate its own power using natural gas, the capital investment and fuel requirements for in-plant power generation were not available, so a power rate of $0.02 per kilowatt hour was used which is believed to be adequate.

Steam, Water and Fuel

Normal consumption rates for each battery limit plant were used. Standard unit costs were also used.

Catalyst and Chemicals

Normal consumption rates and ASEAN area prices were used to determine this expense.

Labour

Operating labour was calculated on a 4 shift basis at the rate of $5.00 per man per shift, and supervision at the rate of $75.00 per man per shift.

Overhead

Calculated to be 1% of fixed investment.

Taxes and Insurance

Calculated to be 1% of fixed investment.

Maintenance

Calculated on the basis of 5% of the investment cost of battery limit units plus 1% of offsites for all plants except phosphoric acid and granulation, where a rate of 7% was used.

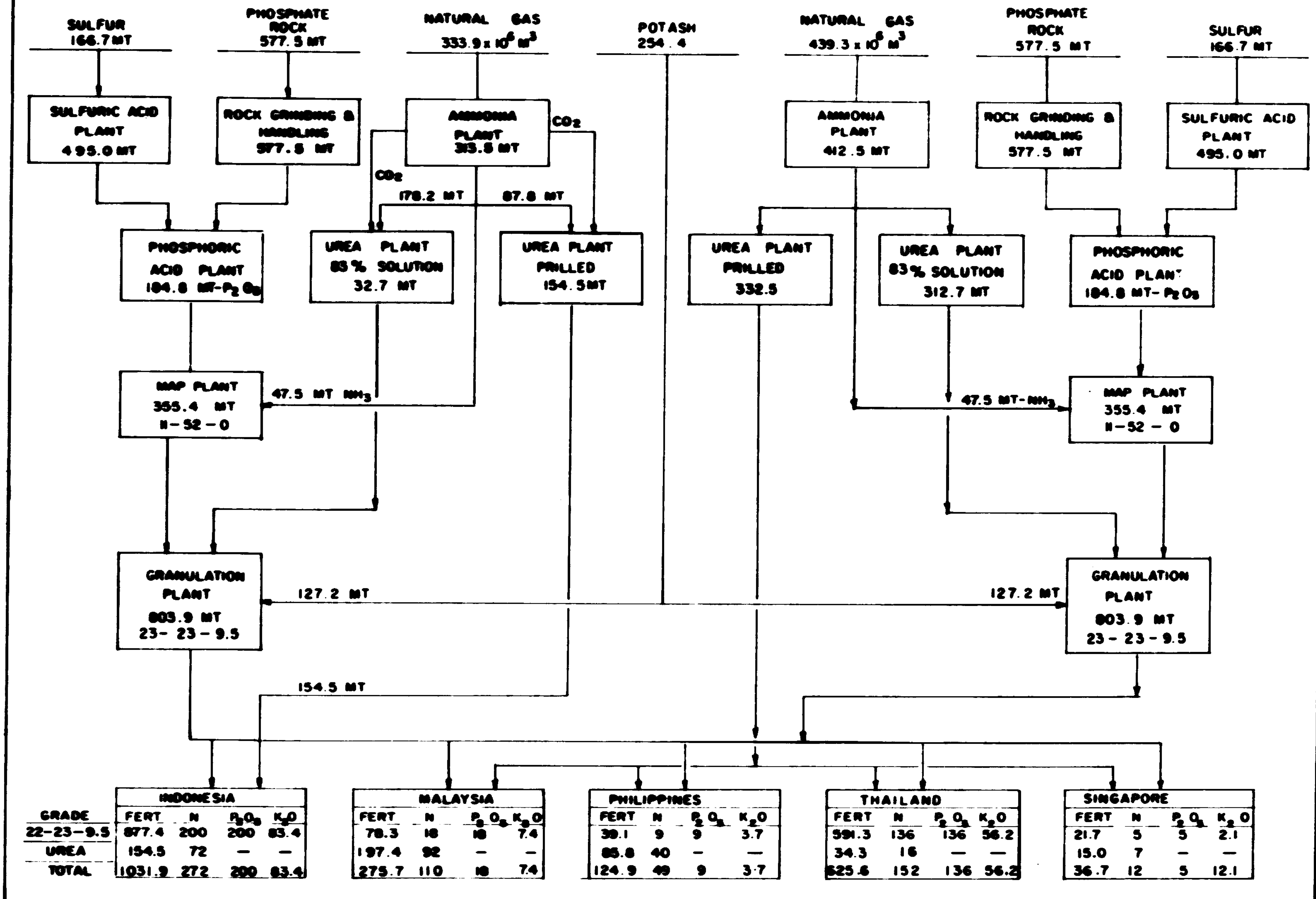
Depreciation

Calculated on a 12.5 year plant life, or 8% of fixed investment.

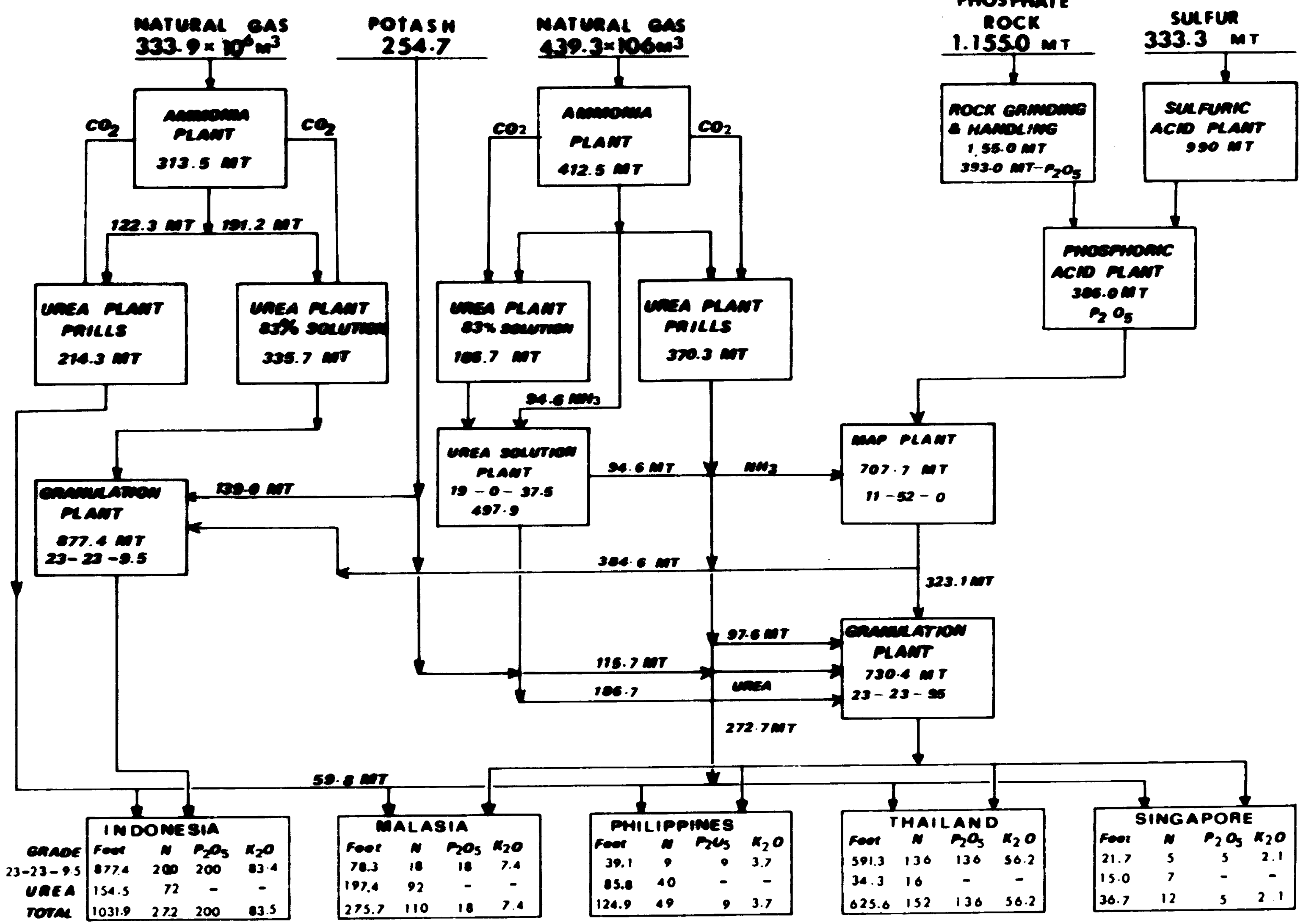
Interest on Investment

Calculated at the rate of 8% of the total investment.

REGIONAL PLAN I FLOW DIAGRAM IV-I 1,000 MTS



REGIONAL PLAN II-1 FLOW DIGRAM IV-2



ESTIMATED INVESTMENT COST SUMMARY

REGIONAL PLAN I
Millions of U.S. Dollars

TABLE IV-3

COMPLEX NO. I I

PLANT	AMMONIA	UREA 83% SOL.	UREA PRILLS	SULFURIC ACID	PHOSPHURIC ACID	MAP POWDER	GRANULATED FERTILIZER	TOTAL
CAPACITY MT/D	950	950	470	1500	560	1080	2440	
B. L. PLANT	16.60	6.10	6.40	5.40	7.55	1.50	5.22	50.77
OFFSITES	11.60	1.83	3.84	2.16	4.53	0.38	3.73	28.07
SPARE PARTS	1.80	1.00	0.60	0.60	0.40	0.15	0.50	5.05
START UP EXP.	2.00	1.00	0.80	0.75	0.50	0.20	0.50	5.75
CONSTR. INT.	3.47	1.01	1.19	0.91	1.32	0.23	1.01	9.14
FIXED INVESTMENT	37.47	10.94	12.83	9.82	14.30	2.46	10.96	98.78
WORKING CAPITAL	1.13	0.86	0.50	0.62	1.75	0.80	3.70	9.36
TOTAL INVESTMENT	38.60	11.80	13.33	10.44	16.05	3.26	14.66	108.14
NOTES	82.3%N	100%Urea	46.6%N	100%	45%P_2O_5	11-52-0	23-23-9.5	

COMPLEX NO. S I

PLANT	AMMONIA	UREA 83% SOL.	UREA PRILLS	SULFURIC ACID	PHOSPHURIC ACID	MAP POWDER	GRANULATED FERTILIZER	TOTAL
CAPACITY MT/D	1250	950	1020	1500	560	1080	2440	
B.L. PLANT	21.20	6.10	10.00	5.40	7.55	1.50	5.22	56.97
OFFSITES	12.72	1.83	6.00	2.16	4.53	0.38	3.73	31.35
SPARE PARTS	2.00	1.00	1.30	0.60	0.40	0.15	0.50	5.95
START UP EXP.	2.50	1.00	1.60	0.75	0.50	0.20	0.50	7.05
CONST. INT.	3.92	1.01	1.93	0.91	1.32	0.23	1.01	10.33
FIXED INVESTMENT	42.34	10.94	20.83	9.82	14.30	2.46	10.96	111.65
WORKING CAPITAL	1.50	0.86	1.10	0.62	1.75	0.80	3.70	10.33
TOTAL INVESTMENT	43.84	11.80	21.93	10.44	16.05	3.26	14.66	121.98
NOTES	82.3%N	100%Urea	46.6%N	100%	45%P_2O_5	11.52-0	23-23-9.5	
TOTAL I + II	82.44	23.60	35.26	20.88	32.10	6.52	29.32	230.12

ESTIMATED INVESTMENT COST SUMMARY

REGIONAL PLAN II

Millions of U.S. Dollars

TABLE IV-4

Complex JII

PLANT	AMMONIA	UREA 83% SOL.	UREA PRILLS	GRANULAR FERTILIZER	TOTAL
CAPACITY MT/D	950	1020	650	2660	
B.L. PLANT	18.60	6.40	9.90	5.67	40.57
OFFSITES	11.60	1.92	5.94	3.40	22.86
SPARE PARTS	1.80	1.00	1.30	0.50	5.10
START UP EXPENSES	2.00	1.00	1.60	0.50	4.60
CONSTRUCTION INT.	3.47	1.05	1.91	1.03	7.46
FIXED INVESTMENT	37.47	11.37	20.65	11.10	80.59
WORKING CAPITAL	1.13	0.90	1.50	4.00	7.53
TOTAL INVESTMENT	38.60	12.27	22.15	15.10	88.12
NOTES	82.3%N	100%Urea	46.6%N	23-23-9.5	

Complex S II

PLANT	AMMONIA	UREA 83% SOL.	UREA PRILLS	UREA AMMONIA SOLUTION	TOTAL
CAPACITY MT/D	1250	565	1120	1510	
B.L. PLANT	21.20	4.75	10.90	0.15	37.00
OFFSITES	12.72	1.43	6.54	0.06	20.75
SPARE PARTS	2.00	0.70	1.30	-	4.00
START UP EXPENSES	2.50	0.70	1.60	-	4.80
CONSTRUCTION INT.	3.92	0.77	2.07	0.02	6.78
FIXED INVESTMENT	42.34	8.35	22.47	0.23	73.33
WORKING CAPITAL	1.50	0.60	1.20	-	3.30
TOTAL INVESTMENT	43.84	8.95	23.67	0.23	76.63
NOTES	82.3%N	100% Urea	46.6%N	19-0-37.5	

Complex BII

PLANT	SULFURIC ACID	PHOSPHORIC ACID	MAP (POW)	GRANULATED FERTILIZER	TOTAL
CAPACITY MT/D	3000	1120	2160	2220	
B.L. PLANT	9.72	13.59	2.70	6.95	32.96
OFFSITES	3.40	6.80	0.54	4.17	14.91
SPARE PARTS	1.00	0.75	0.25	0.60	2.60
START UP EXPENSES	1.25	0.80	0.30	0.75	3.10
CONSTRUCTION INT.	1.57	2.24	0.39	1.27	5.47
FIXED INVESTMENT	16.94	24.18	4.18	13.24	59.04
WORKING CAPITAL	1.20	3.50	1.60	4.00	10.30
TOTAL INVESTMENT	18.14	27.68	5.78	17.74	69.34

REGIONAL PLANT I

TABLE IV - 5

COMPLEX JI	Units	Units Per MT	$ Per Unit	$1000 per YR	$ Per MT	Units Per MT	$ Per Unit	$1000 per YR	$ Per MT
VARIABLE COSTS									
Raw Materials									
Natural Gas	M^3	298	0.0088	2109.3	2.62	607	0.0088	828.7	5.34
Sulfur	MT	0.2070	24.50	4088.7	5.07				
Phosphate Rock	MT	0.7170	19.50	11278.3	13.99				
Potash	MT	0.1585	36.00	4597.7	5.71				
CO_2	MT	0.2930	-	-	-	0.760			
Utilities									
Power	Kwh	123.0	0.02	1977.3	2.46	128.0	0.020	397.1	2.56
Fuel	Gal	6	0.10	483.1	0.60				
Boiler Feed Water	M^3	1.3	0.0670	71.3	0.09	1.0	0.0670	10.9	0.07
Cooling Water	M^3	148.0	0.0052	615.6	0.77	196	0.0052	158.2	1.02
Process Water	M^3	1.2	0.0670	62.8	0.08				
Steam (Net)	MT	0.214	1.1000	192.4	0.24	0.70	1.1000	119.4	0.77
Other									
Catalyst & Chemicals				135.4	1.17			52.7	0.34
Operating Supplies				616.4	0.77			62.0	0.40
TOTAL VARIABLE COST				26228.3	32.58			1628.5	10.50
DIRECT COST									
Operating Labour				163.8	0.20			34.8	0.22
Direct Supervision				290.0	0.36			61.0	0.39
Maintenance				2473.9	3.07			656.1	4.24
Overhead				752.0	0.93			234.0	1.51
Taxes & Insurance				752.0	0.93			234.0	1.51
Depreciation				5964.0	7.42			1876.0	12.10
Interest				6705.8	8.33			1944.2	12.54
TOTAL DIRECT COST				17101.5	21.24			5040.0	32.51
COST OF PRODUCTION				43329.8	53.82			6668.5	43.01

REGIONAL PLAN I

TABLE IV - 6

COMPLEX SI	Units	333,300 MT/YR Prilled Urea: Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT	805,200 MT/YR Granular 23-23-9.5 Fertilizer: Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT
VARIABLE COST									
Raw Materials									
Natural Gas	M^3	607.0	0.0088	1,780.0	5.34	298.0	0.0088	2,109.3	2.62
Sulfur	MT	-	-	-	-	0.2070	24.50	4,088.7	5.07
Phosphate Rock	MT	-	-	-	-	0.7170	19.50	11,278.3	13.99
Potash	MT	-	-	-	-	0.1585	36.00	4,597.7	5.71
CO_2	MT	0.76	-	-	-	0.2927	-	-	-
Utilities									
Power	Kwh	128	0.0200	852.3	2.56	122.3	0.02	1,977.3	2.45
Fuel	Gal	-	-	-	-	6	0.10	483.1	0.60
Boiler Feed Water	M^3	1.8	0.0670	22.8	0.07	1.3	0.0670	71.3	0.09
Cooling Water	M^3	196	0.0052	239.4	1.02	148.0	0.0052	615.6	0.77
Process Water	M^3	-	-	-	-	1.2	0.0670	62.8	0.08
Steam (net)	MT	0.70	1.1000	256.6	0.77	0.214	1.1000	192.4	0.24
OTHER									
Catalyst & Chemicals				114.0	0.34			135.5	0.17
Operating Supplies				133.2	0.40			616.4	0.77
TOTAL VARIABLE COST				3,498.7	10.50			26,228.3	32.58
DIRECT COST									
Operating Labour				40.4	0.12			158.2	0.20
Direct Supervision				74.9	0.22			276.1	0.34
Maintenance				1,108.2	3.32			2,361.8	2.94
Overhead				403.3	1.21			711.4	0.88
Taxes & Insurance				403.3	1.21			711.4	0.88
Depreciation				3,231.4	9.71			5,680.0	7.05
Interest				3,366.7	10.11			6,373.3	7.92
TOTAL DIRECT COST				8,628.2	25.90			16,272.2	20.21
COST OF PRODUCTION				12,126.9	36.40			42,500.5	52.79

REGIONAL PLAN II

TABLE IV - 7

FERTILIZER PLANT COMPLEX SII

	Units	370,300 MT Per Year Prilled Urea Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT	497,900 MT Per Year Urea-Ammonium Solution 19-0-37.5 Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT
VARIABLE COST									
Raw Materials									
Natural Gas	M^3	607.0	0.0088	1978.5	5.34	431	0.0088	1,886.6	3.79
CO_2	MT	0.76							
Utilities									
Power	Kwh	128	0.020	945.1	2.56	43	0.0200	433.1	0.86
Cooling Water	M^3	1.96	0.0052	370.9	1.02	123	0.0052	316.3	0.64
Boiler Feed Water	M^3	1.8	0.0670	25.3	0.07	0.7	0.0670	24.2	0.05
Steam	MT	0.70	1.1000	284.6	0.77	0.3	1.1000	143.6	0.29
Process Water	M^3					0.4	0.0670	15.0	0.03
OTHER									
Catalyst & Chemicals				126.7	0.34			120.8	0.24
Operating Supplies				147.8	0.40			108.1	0.22
Total Variable Cost				3818.9	10.50			3,047.7	6.12
DIRECT COST									
Operating Labour				42.0	0.11			51.6	0.10
Direct Supervision				78.9	0.21			96.6	0.19
Maintenance				1219.2	3.29			837.8	1.68
Overhead				441.4	1.20			292.5	0.59
Taxes & Insurance				441.4	1.20			292.5	0.59
Depreciation				3533.3	9.54			2,324.6	4.67
Interest				3690.8	9.98			2,431.1	4.88
TOTAL DIRECT COST				9447.0	25.50			6,326.7	12.70
COST OF PRODUCTION				13,325.9	36.03			9,374.4	18.82

REGIONAL PLAN II

TABLE IV - 8

FERTILIZER PLANT COMPLEX JII

	Units	877,400 MT/YR Granular 23-23-9.5 Fert. Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT	214,300 MT/YR Prilled Urea Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT
VARIABLE COST									
Raw Materials									
Natural Gas	M^3	231.0	0.0088	1,791.9	2.04	607	0.0088	1,145.6	5.34
Monoammonium Phosphate	MT	0.442	79.03	30,661.6	34.93				
Potash	MT	0.1585	36.00	5,012.2	5.71				
CO_2	MT	0.760				0.760			
Utilities									
Power	Kwh	82.5	0.02	1,447.2	1.65	1.28	0.0200	548.5	2.56
Fuel	Gals	6	0.10	526.7	0.60				
Boiler Feed Water	M^3	0.5	0.0670	22.9	0.03	1.8	0.0670	14.7	0.07
Cooling Water	M^3	75.0	0.0052	341.9	0.39	196	0.0052	218.4	1.02
Steam	MT	0.03	1.10	285.5	0.33	0.70	1.1000	165.2	0.77
OTHER									
Catalyst & Chemicals				114.7	0.13			73.4	0.34
Operating Supplies				232.6	0.27			85.6	0.40
Total Variable Cost				40,437.2	46.08			2,251.8	10.50
DIRECT COST									
Operating Labour				108.2	0.12			37.4	
Direct Supervision				166.0	0.19			68.0	
Maintenance				1,443.1	1.64			790.9	
Overhead				458.8	0.52			302.5	
Taxes and Insurance				458.8	0.52			302.5	
Depreciation				3,676.3	4.20			2,420.7	
Interest				3,981.3	4.53			2,545.6	
TOTAL DIRECT COST				10,292.5	11.72			6,467.6	30.18
COST OF PRODUCTION				50,729.7	57.80			8,719.4	40.68

REGIONAL PLAN II

TABLE IV - 9

FERTILIZER PLANT COMPLEX BII

	Units	384,600 MT of Mono Ammonium Phosphate 11-52-0				730,400 MT of Granular Fertilizer 23-23-9.5			
		Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT	Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT
VARIABLE COST									
Raw Materials									
Phosphate Rock	MT	1.63	19.50	12,243.5	31.83	0.72	19.50	10,316.9	14.13
Sulfur	MT	0.47	24.50	4,437.9	11.54	0.21	24.50	3,739.5	5.12
Ammonia	MT	0.13	41.81	2,150.8	5.59	0.06	41.81	1,812.3	2.48
Urea	MT	-	-	-	-	0.3895	42.93	12,212.5	16.72
Potash	MT	-	-	-	-	0.1585	36.00	4,183.1	5.71
Utilities									
Power	Kwh	89.5	0.0200	689.6	1.79		0.0200	1,313.6	1.30
Fuel	Gals	-	0.100	-	-		0.1000	439.6	0.60
Cooling Water	M^3	65.0	0.0052	130.6	0.34		0.0052	110.1	0.15
Boiler Feed Water	M^3	2.0	0.0670	484	0.13		0.0670	40.8	0.06
Process Water	M^3	2.5	0.0670	68.2	0.17		0.0670	57.5	0.08
Steam	MT	-	-	-	-		1.1000	277.7	0.38
Other									
Operating Supplies				418.4	1.08			462.4	0.63
Total Variable Cost				20,181.4	52.47			34,966.0	47.86
DIRECT COST									
Operating Labour				36.7	0.10			93.3	0.13
Direct Supervision				63.5	0.16			131.5	0.18
Maintenance				965.5	2.51			1,341.5	1.83
Overhead				246.0	0.64			344.7	0.47
Taxes & Insurance				246.0	0.64			344.7	0.47
Depreciation				1,931.4	5.02			2,726.6	3.73
Interest				2,239.7	5.82			3,306.3	4.53
TOTAL DIRECT COST				5,728.8	14.89			8,288.6	11.34
COST OF PRODUCTION				25,916.2	67.38			43,254.6	59.20

SECTION V

NATIONAL FERTILIZER SOLUTION AS ALTERNATIVE TO COOPERATIVE REGIONAL FERTILIZER SOLUTION TO SOLVING 1980 FERTILIZER SHORT-FALL

A. Introduction

Due to predicted consumption patterns for fertilizers for the year 1980, the only logical national solution to providing fertilizer production facilities on a national basis, would be to provide production facilities for nitrogen and phosphorous in those countries whose consumption volume can justify an economically sized plant, and for countries whose volume is below this level, to import intermediates and convert them to a finished product, or import finished products. On this basis, the national solution would be two fertilizer complexes, each producing its own nitrogen and phosphorous fertilizers in combinations required to satisfy their market.

B. Proposed National Fertilizer Complexes

Due to consumption patterns and availability of cheap raw materials, only two countries can support a minimum economically sized fertilizer plant complex. The proposed national complexes are fully integrated, including phosphorous producing units, and are shown in Block Flow Diagram V-1. They consist of the following production units at indicated capacities:

Table V-I

	Complex JIII Metric Tons/Day	Complex BIII Metric Tons/Day
Ammonia Plant	1000	560
Urea Plants 83% Solution	1300	800
Prills	470	105
Sulfuric Acid Plant	1610	1100
Phosphoric Acid Plant	610	410
Monoammonium Phosphate Plant	1150	790
Granulation Plant	2610	1790

C. Comments

With the exception of the comments made below, all of the information given under Process Plant, Estimate of Capital Requirements and Estimated Cost of Production in Section III is applicable to the National Fertilizer Solution, Section V.

The Estimated Investment Requirements for the National Fertilizer Solution are given in Table V-2, and the Estimated Cost of Production in Table V-3 & 4.

The production of ammonia in the case of Fertilizer Plant Complex BIII is based on using naptha at a cost of 22.00 per metric ton in storage at the plant. This seems a reasonable price to use since the estimated cost of production for straight run naptha for the area is about $17.00.

The detailed cost of production for all final and intermediate products at the various rates of production is given in the Appendix Tables A - 1-40.

ESTIMATED INVESTMENT COST SUMMARY

NATIONAL PLAN
Millions of U.S. Dollars

TABLE V - 2

Complex JIII

PLANT	AMMONIA	UREA 83% SOL.	UREA PRILLS	SULFURIC ACID	PHOSPHORIC ACID	DAP POWDER	GRANULATION	TOTAL
CAPACITY MT/D	1000	1300	470	1610	610	1150	2610	
BATTERY LIMIT PLANT	19.00	7.20	6.40	5.50	7.90	1.60	5.40	53.00
OFFSITES	11.40	2.16	3.84	2.20	4.74	0.40	3.24	27.98
SPARE PARTS	1.90	1.20	0.70	0.70	0.40	0.15	0.60	5.65
START UP EXP.	2.00	1.00	1.00	0.80	0.50	0.20	0.60	6.10
INT.DURING CONS.	3.50	1.18	1.22	0.94	1.38	0.24	1.00	9.46
FIXED INVEST.	37.80	12.74	13.16	10.14	14.92	2.59	10.84	102.19
WORKING CAP.	1.20	0.96	0.50	0.70	2.00	0.80	3.80	9.96
TOTAL INV.	39.00	13.70	13.66	10.84	16.92	3.39	14.64	112.15

COMPLEX BIII

PLANT	AMMONIA	UREA 83% SOL.	UREA PRILLS	SULFURIC ACID	PHOSPHORIC ACID	DAP POWDER	GRANULATION	TOTAL
CAPACITY MT/D	560	800	105	1100	410	790	1790	
BATTERY LIMIT PLANT	14.20	5.75	0.75	4.80	6.09	1.30	4.68	37.57
OFFSITES	8.52	1.73	0.75	1.92	3.65	0.33	2.81	19.71
SPARE PARTS	0.90	1.00	0.10	0.45	0.30	0.12	0.35	3.22
START UP EXP.	1.25	1.00	0.15	0.55	0.40	0.20	0.35	3.90
INT.DURING CONS.	2.54	1.12	0.18	0.79	1.06	0.20	0.84	6.73
FIXED INV.	27.41	10.60	1.93	8.51	11.50	2.15	9.03	71.13
WORKING CAP.	0.75	0.90	0.11	0.45	1.30	0.60	2.70	6.81
TOTAL INV.	28.16	11.50	2.04	8.96	12.80	2.75	11.73	77.94

FERTILIZER PLANT COMPLEX - JIII

NATIONAL PLANT

TABLE V - 3

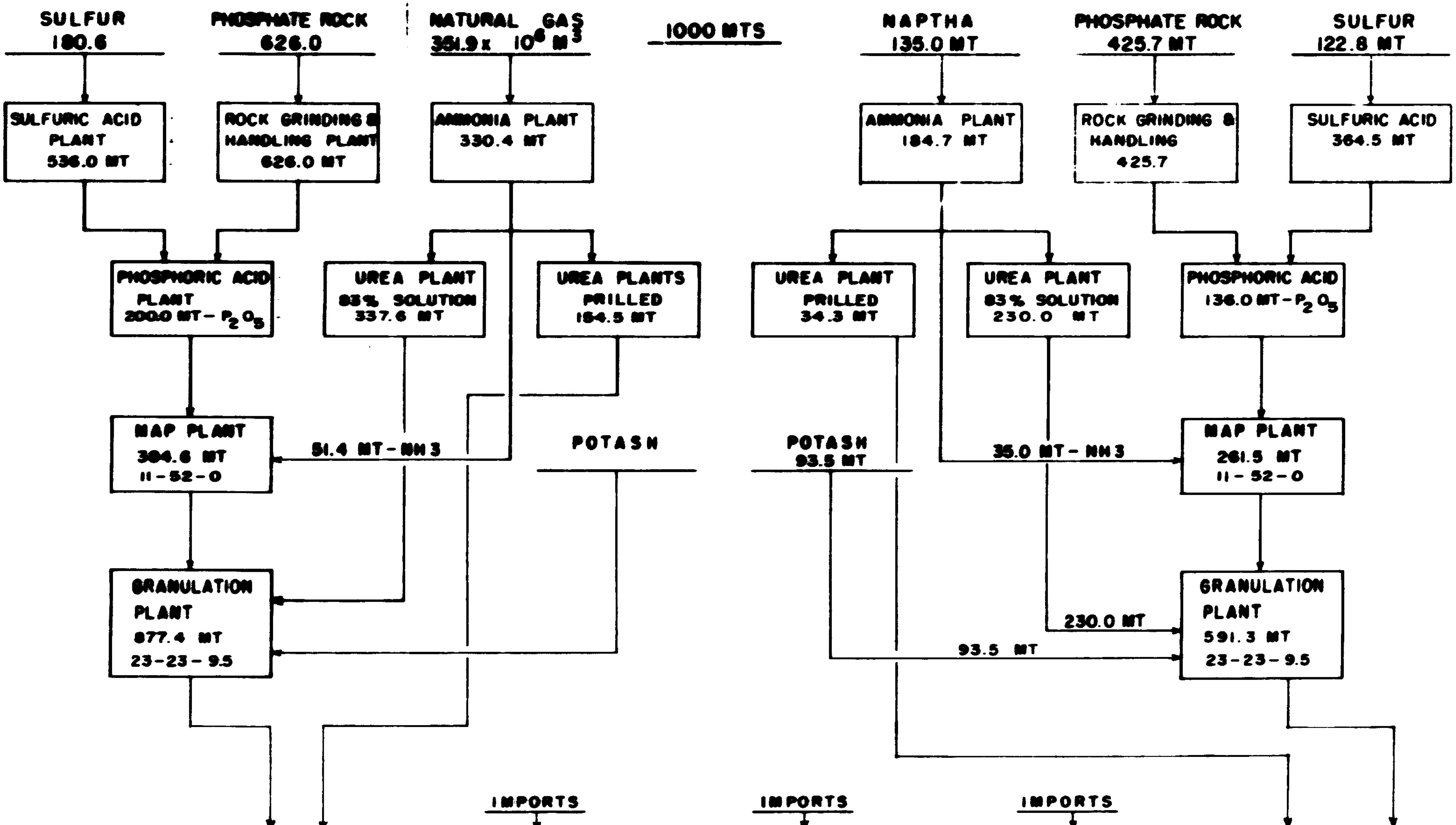
	Units	154,500 MT Per Year Prilled Urea: Units per MT	$ Per Unit	$1000 per YR	$ Per MT	877,400 MT Per Year Granulated Fertilizer 23-23-9.5: Units per MT	$ Per Unit	$1000 per YR	$ Per MT
VARIABLE COST									
Raw Materials									
Natural Gas	M^3	667	0.0080	825.0	5.34	298		229.0	2.62
Co_2	MT	760	-	-	-	0.2923	-	-	-
Sulfur	MT	-	-	-	-	0.2[illegible]	-	4148.4	5.07
Phosphate Rock	MT	-	-	-	-	0.7170	-	12274.8	13.99
Potash	MT	-	-	-	-	0.1585	-	5010.0	5.71
Utilities									
Power	Kwh	128.0	0.020	395.5	2.56	123.0	0.0088	2156.4	2.46
Fuel	Gals	-	-	-	-	6	0.600	526.4	0.60
Boiler Feed Water	M^3	1.0	0.0670	10.8	0.07	1.3	0.0670	79.0	0.09
Cooling Water	M^3	196.0	0.0052	157.6	1.02	148.0	0.0052	675.6	0.77
Process Water	M^3	-	-	-	-	1.2	0.0670	70.2	0.08
Steam	MT	0.70	1.1000	119.0	0.77	0.214	1.1000	210.6	0.24
Other									
Catalyst & Chemicals				52.5	0.34			149.2	0.17
Operating Supplies				61.8	0.40			675.6	0.77
TOTAL VARIABLE COST				1622.2	10.50			28,577.0	32.58
DIRECT COST									
Operating Labour				34.3	0.22			164.3	0.19
Direct Supervision				59.8	0.39			291.2	0.33
Maintenance				614.6	3.98			2,477.4	2.82
Overhead				92.5	0.60			633.6	0.72
Taxes & Insurance				92.5	0.60			633.6	0.72
Depreciation				1860.2	12.04			6,315.0	7.20
Interest				1925.0	12.46			7,046.2	8.03
TOTAL DIRECT COST				4678.9	30.29			17,561.3	20.01
COST OF PRODUCTION				6301.1	40.79			46,138.3	52.59

FERTILIZER PLANT COMPLEX BIII
NATIONAL PLAN

TABLE V - 4

	Units	34,300 MT per Year Prilled Urea: Units Per MT	$ Per Unit	$1000 Per Year	$ Per MT	591,300 MT per Year Granulated Fertilizer 23-23-9.5: Units Per MT	$ Per Unit	$1000 Per Year	$ Per Unit
VARIABLE COST									
Raw Materials									
Naptha	MT	.417	22.0	314.5	9.17	0.204	22.00	2657.1	4.49
Sulfur	MT	-	-	-	-	0.2070	24.50	2997.9	5.07
Phosphate Rock	MT	-	-	-	-	0.7170	19.50	8272.2	13.99
Potash	MT	-	-	-	-	0.1585	36.00	3376.3	5.71
Utilities:									
Power	Kwh	128.0	0.020	87.8	2.56	123.0	0.020	1454.6	2.46
Fuel	Gals	-	-	-	-	6.0	0.1000	354.8	0.60
Boiler Feed Water	M^3	1.0	0.0670	2.4	0.07	1.3	0.0670	53.2	0.09
Cooling Water	M^3	196	0.0052	35.0	1.02	148.0	0.0052	455.3	0.77
Process Water	M^3	1.2	0.0670	2.7	0.08	-	-	-	-
Steam	MT	0.70	1.1000	26.4	0.77	0.214	1.1000	141.9	0.24
Other									
Catalyst & Chemicals				11.7	0.34			100.5	0.17
Operating Supplies				13.7	0.40			455.3	0.77
TOTAL VARIABLE COST				494.2	14.41			20,319.1	34.36
DIRECT COST									
Operating Labour				9.9	0.28			168.2	0.28
Direct Supervision				11.8	0.33			290.7	0.49
Maintenance				144.6	4.22			2,144.1	3.63
Overhead				60.7	1.77			670.0	1.13
Taxes & Insurance				60.7	1.77			670.0	1.13
Depreciation				347.0	10.12			5,151.5	8.72
Interest				356.6	10.40			5,662.0	9.58
TOTAL DIRECT COST				991.3	28.90			14,756.5	24.96
COST OF PRODUCTION				1485.5	43.31			35,075.6	59.32

NATIONAL PLAN FLOW DIAGRAM V-I



INDONESIA

GRADE	FERT	N	P_2O_5	K_2O
23-23-95	877.4	200	200	83.4
UREA	154.5	72	–	–
TOTAL	1031.9	272	200	83.4

MALASIA

FERT	N	P_2O_5	K_2O
78.3	18	18	7.4
197.4	92	–	–
275.7	110	18	7.4

PHILLIPPINES

FERT	N	P_2O_5	K_2O
39.1	9	9	3.7
85.8	40	–	–
124.9	49	9	3.7

SINGAPORE

FERT	N	P_2O_5	K_2O
21.7	5	5	2.1
15.0	7	–	–
36.7	12	5	2.1

THAILAND

FERT	N	P_2O_5	K_2O
591.3	136	136	56.2
34.3	16	–	–
625.6	152	136	56.2

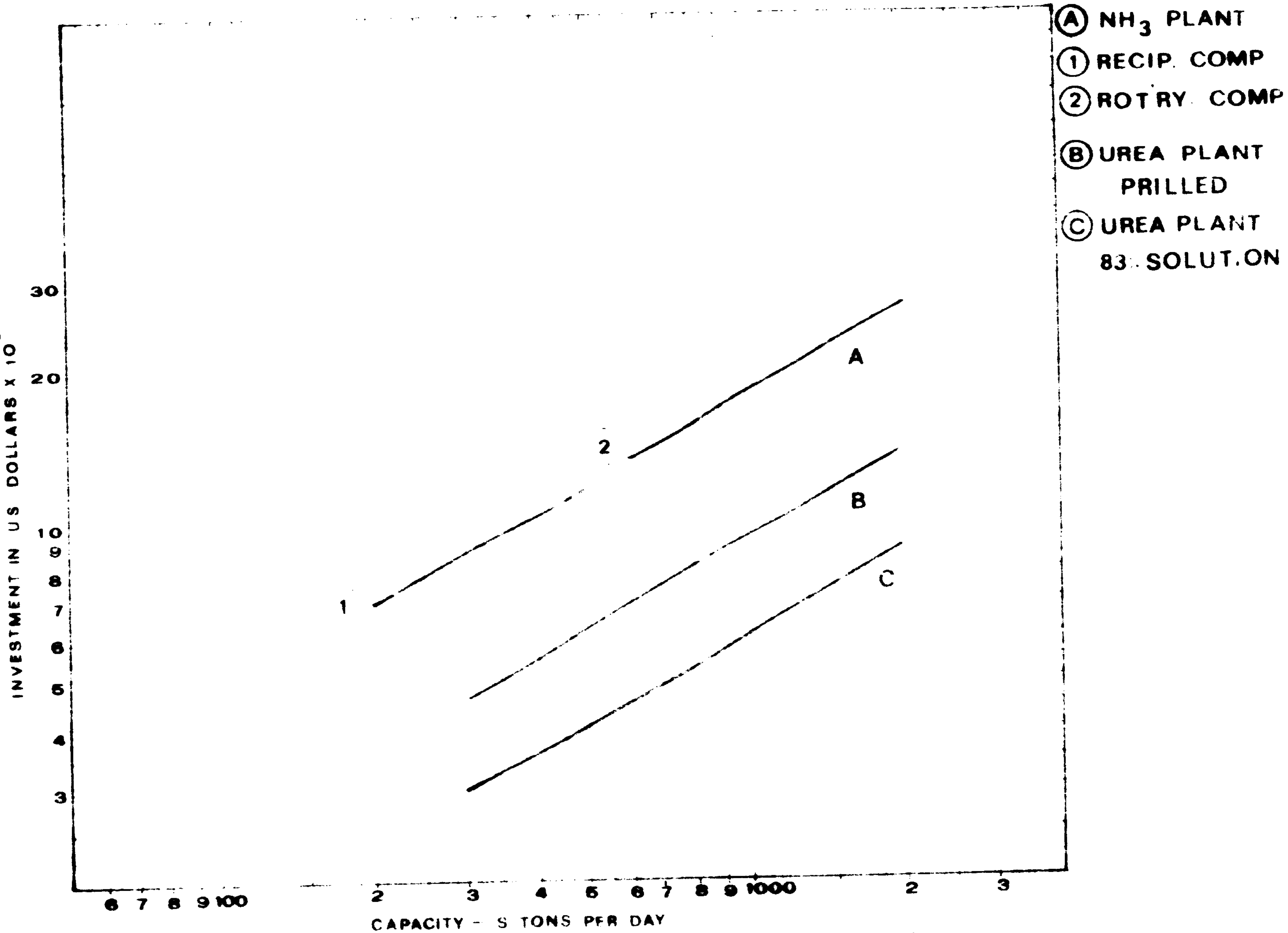


FIG 1 INVESTMENT COST NITROGEN PLANTS FAR EAST ASIA

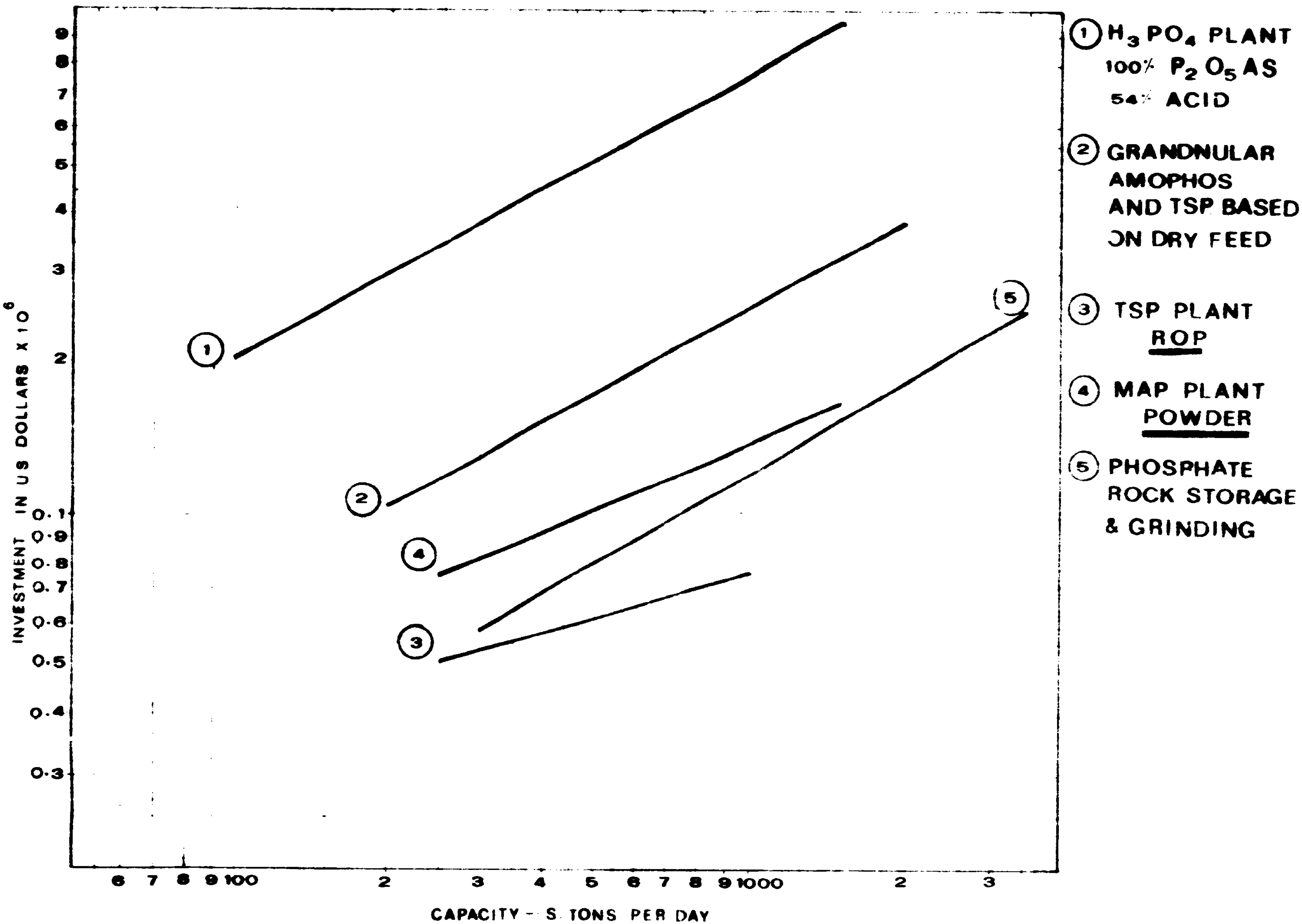


FIG 2 INVESTMENT COST PHOSPHATE PLANTS FAR EAST ASIA

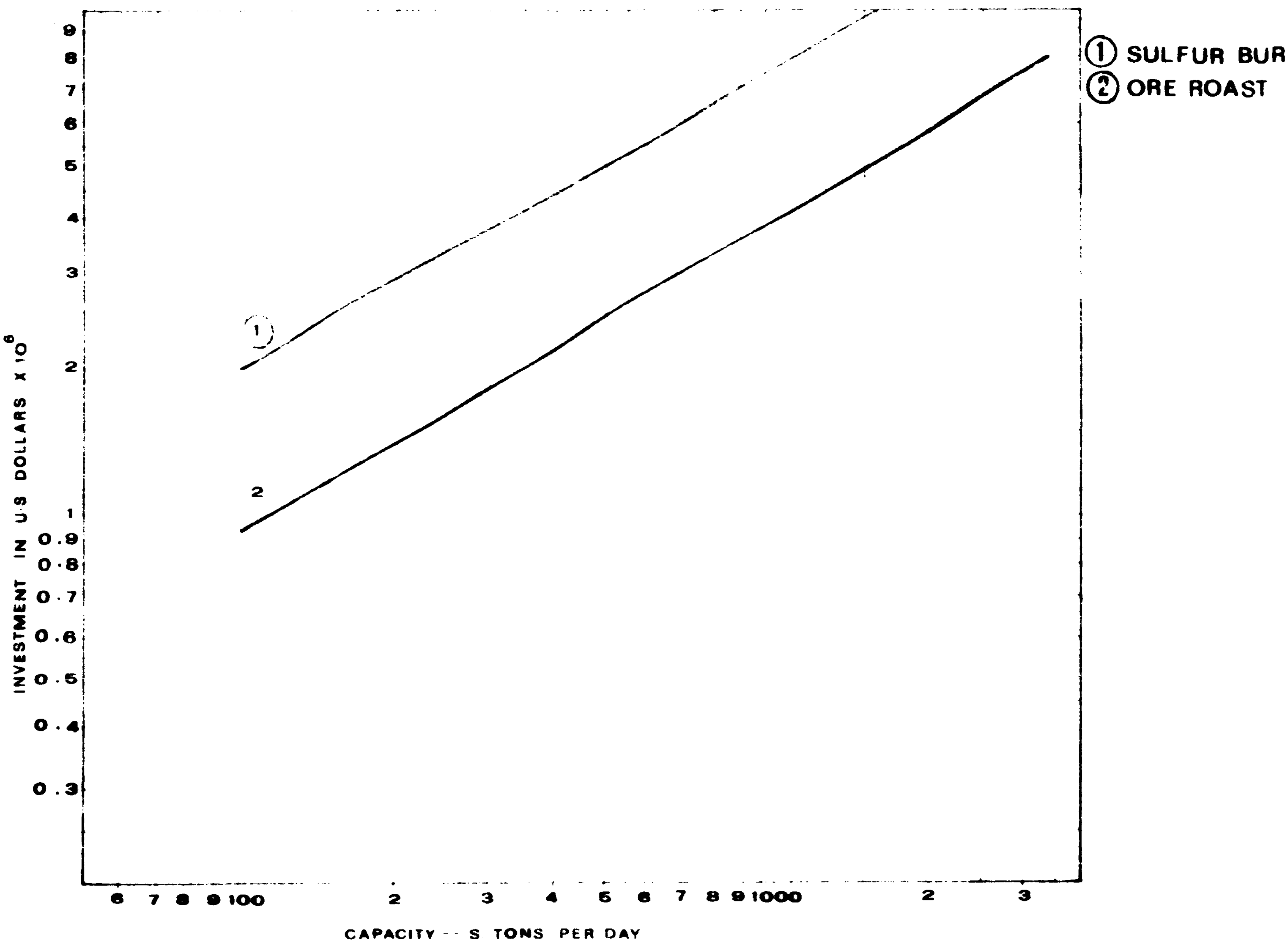


FIG 3 INVESTMENT COST SULFURIC ACID PLANT FAR EAST ASIA

SECTION VI

ECONOMIC APPRAISAL OF THE REGIONAL AND NATIONAL ALTERNATIVES

A. The Alternatives

1. We begin this Section with a brief re-statement of the alternatives which are to be appraised.

Regional Plan I envisages two complexes, SI and JI both of which are based on natural gas. Both complexes produce the same two end-products: prilled urea and a compound fertilizer with a nutrient analysis of 23-23-9.5 which for the sake of brevity is called hereafter Enphosk.

Regional Plan II envisages three complexes. SII is based on natural gas, produces prilled urea as its only end-product (that is, for direct use in agriculture) but also exports two products, prilled urea and urea-ammonia solution to BII. BII produces a single end-product, Enphosk, using its imports from SII; it also exports monoammonium phosphate to JII. Finally, JII, based on natural gas, produces two end-products: prilled urea, and Enphosk using its imports from BII. The basic structure of inter-complex imports and exports derives from the fact that only BII produces phosphoric acid and only SII and JII produce ammonia.

The National Plan envisages two complexes. JIII is based on natural gas and produces prilled urea and Enphosk for consumption within the nation. BIII is based on naphtha and produces the same end-products, again for consumption within the nation - which is assumed to be different from where JIII is located.

The three alternatives are summed up in Table VI.1.

TABLE VI.1: End-products and inter-complex imports and exports of the regional and national alternatives

Plan	Complex	End-Products	Imports	Exports
R.P.I	SI	Urea + Enphosk	-	-
	JI	Urea + Enphosk	-	-
R.P.II	SII	Urea	-	Urea+Urea-ammonia solution
	BII	Enphosk	Urea+Urea-ammonia solution	Mono-ammonium phosphate
	JII	Urea + Enphosk	Mono-ammonium phosphate	-
N.P.	JIII	Urea + Enphosk	-	-
	BIII	Urea + Enphosk	-	-

Notes: 1. Full details are given in the flow-sheets of Sections IV and V.

2. All complexes are based on natural gas except BII which does not produce its own ammonia supply, and BIII which uses naphtha.

3. Imports and exports only with reference to inter-complex movements.

B. Volume of Output

1. Volume of output will be compared in terms of end-products and of nutrient. The data are set out in Tables VI.2 and VI.3. In all three alternatives urea and Enphosk are the end-products. In Regional Plans I and II the total volume of output of end-products is identical. Nutrient production totals:

Nitrogen	597,000 tons
Phosphorus pentoxide	370,000 tons
Potassium oxide	153,000 tons

The difference is that whilst R.P.I has two complexes, R.P.II has three with a large measure of inter-complex trading in prilled urea, urea-ammonia solution and mono-ammonium phosphate.

2. As with R.P.I, the National Plan has only two complexes. Since the National Plan is capable of meeting the consumption requirements of only two nations (even though these could be the two biggest consumers of the ASEAN countries), its total output is markedly lower. Total nutrient output is equal to 81 per cent of that of the regional plans.

TABLE VI.2: Volume of output of end-products in the regional and national alternatives in tons

Plan	Complex	End-product in tons: Urea	Enphosk
R.P.I	SI	333,000	804,000
	JI	154,000	804,000
	Total	487,000	1,608,000
R.P.II	SII	273,000	-
	BII	-	730,000
	JII	214,000	878,000
	Total	487,000	1,608,000
N.P.	JIII	154,000	877,000
	BIII	34,000	591,000
	Total	188,000	1,468,000

Notes: 1. Figures rounded to the nearest 1000 tons.

TABLE VI.3: Volume of output of nutrient in the regional and national alternatives in tons

Plan	Nutrient output in tons[1]: N	P_2O_5	K_2O	Total
R.P.I	597,000	370,000	153,000	1,120,000
R.P.II	597,000	370,000	153,000	1,120,000
N.P.	426,000	338,000	140,000	904,000

Notes: 1. Figures rounded to the nearest 1000 tons.

C. Value of Output

1. The value of output is, of course, the multiple of the output volume and the selling price. During the course of a working tour of the ASEAN countries, we collected whatever data was available on present c.i.f. prices and the direction in which they are likely to move in the course of the next couple of years. The most obvious feature of the present market situation is the very tight position of triple superphosphate. Urea prices after moving down for some time, now look as if they will harden in the next couple of years.

2. We believe that the best estimate of the 1972-75 bulk prices, c.i.f. to ASEAN ports from outside the region are:

Bulk urea	$57 per ton
Bulk TSP	$85 per ton
Bulk potash	$36 per ton

These prices give the following nutrient prices, equal to the end-products prices divided by their respective percentage nutrient content:

N	$122.3
P_2O_5	$184.8
K_2O	$ 60.0

We need two end-product prices, those of urea and Enphosk. Urea is given above. For Enphosk, with its 23-23-9.5 analysis, the price is calculated by multiplying the volume of each of its nutrients by the prices per ton quoted above. This gives a bulk Enphosk price, after rounding-up, of $77.

Using these two prices and the output volume taken from Table VI.2, we can now derive the value of output c.i.f. at ASEAN ports in bulk. This is given in Table VI.4.

TABLE VI.4: Value of output c.i.f. at ASEAN ports in bulk of the regional and national alternatives in millions of dollars

Plan	Value of output[1] ($m)
R.P.I	152
R.P.II	152
N.P.	124

Note: 1. Rounded to the nearest million dollars.

Just as with output volume, the value of output of Regional Plans I and II are the same. The output value of the national plan is 82 per cent of that of the regional plans.

D. Economic Criteria of Viability

1. In the economic evaluation of mutually exclusive projects, which is the objective of this Section, we observe that the alternatives generate a flow of costs and of benefits over time and that the shape of these flows differs from project to project. Furthermore, it is a familiar result in project appraisal that for any two projects A and B, the net benefits (benefits minus costs) of A exceed those of B in some years, but fall short of those of B in other years. As we shall see, this is the case with our regional and national alternatives.

Economic evaluation therefore requires a way to compare costs and benefits accruing in different time-periods and the technique used is that of the rate of interest, otherwise referred to as the time-rate of discount.

2. In the last 15 years great progress has been made in specifying precisely how the discount rate or rates should be used in project analysis and a vast economic literature on the subject has appeared. The technique the economists have fashioned, and it is one now used extensively in government and large companies, is known as the calculation of the present value of expected earnings or the discounted cash flow. A second technique very closely related to it, is the calculation of the average rate of return on investment.

In order to use the present value technique one needs to know, amongst other things, the borrowing rate on all funds borrowed, the alternative rate of interest on all self-finance, and the rate to be earned on all cash flows generated which can be lent out at interest. In the case of this ASEAN feasibility study we do not have this information available, precisely because we are at a stage when the method of finance of 'package deal' projects is not yet agreed.

3. Therefore, in this report we use the second technique referred to above, the average rate of return. Basically this technique consists in discovering what rate of discount when applied year by year to the investment stream makes its aggregate value equal to that of the discounted stream of value of output less operating costs, i.e. the operating surplus.

Mathematically, find r, the average rate of return expressed as a percentage, such that:

$$\sum_{t=0}^{n} \left[\frac{-It}{(1+r)^t} + \frac{Vt - Ct}{(1+r)^t} \right] = 0 \qquad (1)$$

where: It = investment in year t
n = total number of plant years from first year of design and construction to the last year of production
Vt = value of output in year t
Ct = operating and transport costs in year t

If we define N, net benefits, as the value of output in any given year less total costs incurred in that year, then

$$Nt = Vt - (It + Ct)$$

and our equation can be re-written so that r, the average rate of return is such that:

$$\sum_{t=0}^{n} \frac{Nt}{(1+r)^t} = 0 \qquad (2)$$

It should be noted that costs and benefits in this context should <u>exclude</u> interest charges on borrowing (and interest earned on lending) as it is this rate or these rates of borrowing with which the average rate of return is to be compared. (Reference 21 pp.122-125). Furthermore, depreciation should also be left out otherwise we are counting the cost of capital equipment twice over.

4. <u>To sum up</u>: the technique we shall use to evaluate alternative net benefit flows will be the average rate of return. After calculating the average rate of return for each project, we can say that where this exceeds the average rate of interest at which capital can be borrowed from the sources financing the project, the project is viable on economic grounds. If a project has an average rate of return lower than the average borrowing rate, the project is not viable. Where two (or all three) of the alternatives have an average rate of return exceeding the average borrowing rate, the one with the highest discounted cash flow should be chosen and the discount rate used in this calculation should be the average borrowing rate.

<u>E. Investment costs, operating costs and transport costs</u>

1. <u>Investment costs</u>. On the basis of Sections IV and V we now bring together the cost data in the form necessary for appraisal of the regional and national alternatives. Table VI.5 shows the investment costs for the three alternatives.

TABLE VI.5: Investment costs of the regional and national alternatives in $m

Cost category	R.P.I	R.P.II	N.P.
Battery limits units	107.74	110.53	90.57
Offsites	59.42	58.52	47.69
Spare Parts	11.00	11.80	8.87
Start-up expenses	12.80	12.50	10.00
Working capital	19.69	21.13	16.77
Total [1]	210.65	214.48	173.90

Note: 1. Excludes interest during construction. See page 7

Total investment costs of the two regional plans are very similar: R.P.II is only 1.8 per cent larger than R.P.I. At first glance this might appear surprising. Are there no economies of scale to be gained by the concentration of all production in two complexes rather than three? In fact, examination of the flow-sheets shows that this concentration is more apparent than real. There are 16 chemical plants in R.P.I and 13 in R.P.II. The main reason why the two-complex plan has more plants than the three-complex plan is that the latter centres all phosphoric acid production in a single location whilst R.P.I splits it between the two complexes.

2. Investment costs of the National Plan are, of course, lower than either of the regional plans. A more interesting comparison is to look at the investment cost: value of output ratio (IVR). This shows the number of dollars of investment required to produce each dollar of annual output. The figures are:

R.P.I: 1.386 R.P.II: 1.411 N.P.: 1.405

The National Plan has an IVR only 1.4% greater than that of R.P.I and 0.4% smaller than that of R.P.II. This very small difference in capital costs per unit of output can be explained by the fact that JIII in the National Plan is actually slightly larger than JI of R.P.I. All of the increase in the National Plan's IVR, with respect to R.P.I, derives from the naphtha-based complex BIII with its relatively small ammonia unit.

3. <u>Operating costs.</u> These are summarized in Table VI.6

TABLE VI.6: Annual operating costs of the regional and national alternatives in $'000

Cost category	R.P.I	R.P.II	N.P.
Raw materials	46,756	46,738	42,475
Utilities	8,960	9,308	7,018
Catalyst, chemicals, operating supplies	1,864	1,891	1,522
Operating labour and direct supervision	1,099	985	1,030
Maintenance labour & materials	6,600	6,599	5,381
General overheads	2,100	2,087	1,458
Insurance and taxes	2,100	2,087	1,458
Transport costs[1]	-	6,940	-
Total[2]	69,479	76,635	60,342

Notes. 1. This covers only the cost of inter-complex movements see Table VI.1 The costs are based on the costs of loading and unloading and freight used in Section IV and on the tonnages shown in R.P.II's flow sheet.

2. Excludes depreciation and interest. See page 7.

With the exception of R.P.II's transport costs for the inter-complex movement of intermediates, the annual operating costs of the two regional plans are negligibly different. This was to be expected since they are based on the same raw materials, produce the same end-products, have an identical nutrient output capacity and have a very similar level of investment costs. Their main difference, the interdependence of complexes SII, BII and JII is reflected in the transport costs of $6.94 million for the movement of the intermediates, urea, urea-ammonia solution and MAP.

4. The operating costs of the National Plan are lower than those of the Regional Plans, which was to be expected since its output is lower. However, the ratio of operating costs to value of output is 45.7 per cent for R.P.I, but 48.7 per cent for the National Plan. This is in tune with our previous comparison between the plans. The ammonia plant in the BIII complex is smaller than those of the regional plans, this plus its use of naphtha rather than natural gas pushes up operating costs, although the cost increase is off-set by the large, natural gas based complex JIII.

5. <u>Transport costs</u>. The cost of transporting the fertilizer end-products within the ASEAN sub-region is determined by three factors: the location of production, the location of the markets and the loading charges and freight rates between ASEAN ports for the tonnages moved. We do not deal with the calculation of transport costs after the fertilizer has arrived by ship at its port of destination. This is consistent with our use of c.i.f. prices as a basis for the calculation of the value of output.

6. This study makes no specific recommendation about the location of the complexes in each of the three plans. This is because a regional fertilizer plan would be only one of a number of projects in an ASEAN 'package deal'. Therefore, the optimum location of any single project must be judged in terms of the agreement for the whole set of projects.

However, in this feasibility study it makes little sense to calculate transport costs for all the alternative locational decisions which, from the point of view of pure logic, could be made. This is essentially because of the theory of combinations. For example, in R.P.II the number of alternative locational outcomes is about 125.[1]

1. It is the same as the number of different ways in which one could place three balls, one black, one white and one red in 5 boxes, A,B,C,D and E, where the number of balls in any single box can vary from 0 - 3 inclusive.

7. What we do, therefore, is to use as our estimate of transport costs a single illustration of their level and to state by what proportion the maximum possible level of transport costs would exceed our illustration. The illustration on which Table VI.7 is based assumes that in each of the regional plans the J and S plants are located in Indonesia and that in R.P.II the B plant is sited in Thailand. These are the locational solutions which, from a strictly technical point of view and disregarding all the other possible projects of a package deal, are the most efficient.

TABLE VI.7: An illustration of the level of end-product transport costs for the regional solutions

Plan	Fertilizer movement From	To	Weight 000 tons	Loading Cost $ per ton	Freight Rate $ per ton	Loading & Freight $ per ton	Transport costs $000
R.P.I	Indonesia	Malaysia	276	3.0	4.97	7.97	2200
	Indonesia	Philippines	125	3.0	6.14	9.14	1143
	Indonesia	Singapore	37	3.0	2.50	5.50	204
	Indonesia	Thailand	626	3.0	5.94	8.94	5596
	TOTAL		1064				9143
R.P.II	Indonesia	Malaysia	197	3.0	4.97	7.97	1570
	Indonesia	Philippines	86	3.0	6.14	9.14	736
	Indonesia	Singapore	15	3.0	2.50	5.50	83
	Indonesia	Thailand	34	3.0	5.94	8.94	304
	Thailand	Malaysia	78	3.0	6.05	9.05	706
	Thailand	Philippines	39	3.0	6.15	9.15	357
	Thailand	Singapore	22	3.0	4.68	7.68	169
	TOTAL		471				3975

The total transport costs of R.P.I are $9.14 million and in the case of R.P.II they are $3.98 million. The difference is almost entirely accounted for by the fact that in R.P.II the transport of fertilizer from Indonesia to Thailand is reduced by almost 600,000 tons because Thailand's complex BII supplies Thai requirements. Thailand, it will be recalled from Section II, is forecast to be the sub-region's largest nutrient consumer after Indonesia. This transport cost advantage is off-set, however, by the cost of inter-complex movement of R.P.II's intermediates, which as we saw in the sub-section on operating costs above, totalled $6.94 million. The net difference between the two regional plans, when we add both sets of transport costs, is only $1.78 million, in favour of R.P.I.

8. As far as the range of transport costs is concerned, our calculations suggest that the most inefficient location from the point of view of transporting the end-product would give costs of $18 million. Therefore, we can say that whatever the location of the complexes in the two regional plans, the cost of transport from the manufacturers to the ports of destination will be between $4 million - $18 million. In the National Plan there are no transport costs incurred because all of the fertilizer produced is consumed internally.

F. Economic viability of the alternatives

1. We have now brought together virtually all the information necessary to set out the time-stream of investment costs, operating costs, transport costs, value of output and net benefits. The results are set out in Tables VI.8, 9 and 10, on page 13 of this section. They require a number of comments.

TABLE VI.8: Calculation of the flow of net benefits of Regional Plan I

	YEAR					
Costs and benefits ($m)	1	2	3	4	5	6-15[1]
1. Investment costs	42.13	147.45	21.07	-	-	-
2. Operating costs	-	-	29.17	57.96	63.72	69.48
3. Transport costs	-	-	2.74	7.31	8.23	9.14
4. Value of output	-	-	45.6	121.6	136.8	152.0
5. Net benefits[2]	-42.13	-147.45	- 7.38	56.33	64.85	73.38

Notes. 1. All figures are unchanged over the period from years 6-15 inclusive
2. Equal to (4-(1 + 2 + 3))

TABLE VI.9: Calculation of the flow of net benefits of Regional Plan II

	YEAR					
Costs and benefits ($m)	1	2	3	4	5	6-15[1]
1. Investment costs	42.9	150.14	21.44	-	-	-
2. Operating costs	-	-	31.22	63.66	70.15	76.64
3. Transport costs	-	-	1.19	3.18	3.58	3.98
4. Value of output	-	-	45.6	121.6	136.8	152
5. Net benefits[2]	- 42.9	- 150.14	- 8.25	54.76	63.07	71.38

Notes. 1. All figures are unchanged over the period from years 6-15 inclusive
2. Equal to (4- (1 + 2 + 3))

TABLE VI.10: Calculation of the flow of net benefits of the National Plan

	YEAR					
Costs and benefits ($m)	1	2	3	4	5	6-15[1]
1. Investment costs	34.78	121.72	17.39	-	-	-
2. Operating costs	-	-	24.63	50.14	55.24	60.34
3. Transport costs	-	-	-	-	-	-
4. Value of output	-	-	37.2	99.2	111.6	124
5. Net benefits[2]	- 34.78	- 121.72	- 4.82	49.06	56.36	63.66

Notes. 1. All figures are unchanged over the period from years 6-15 inclusive.
2. Equal to (4 - (1 + 2 + 3))

2. The investment time-stream is based on Table VI.5. The gestation period is expected to last 30 months and therefore terminates after the first six months of year 3. The distribution of investment costs over years 1, 2 and 3 is set at 20 per cent, 70 per cent and 10 per cent of the total respectively. The basis for this is the table from which construction interest was calculated in Section IV.

3. The value of output figures, based on Table VI.4, is set at 30 per cent of annual capacity in year 3, when only six months is available for production. In years 4 and 5 we assume 80 per cent and 90 per cent of capacity is attained. From years 6 - 15 we assume 100 per cent capacity utilization. The total number of years of production is 12½.

4. Transport costs of the end-products are based on Table VI.7 multiplied by the percentage utilization of capacity.

5. Operating costs were divided into two groups:

A. Raw materials; utilities; catalyst, chemicals and operating supplies; inter-complex transport costs.

B. Operating labour and direct supervision; maintenance labour and materials; general overheads; insurance and taxes.

A were assumed to vary directly with capacity utilization; B were assumed to be invariant with capacity. On this basis A + B were calculated for the years 3 - 5 when the complexes are assumed to run below full capacity.

6. We have already discussed all the constituent elements of net benefits, but not the net benefit series itself. These figures for each of the plans are brought together in Table VI.11.

TABLE VI.11: Net benefit stream of the regional and national alternatives in $m.

	YEAR					
Plan	1	2	3	4	5	6 - 15
R.P.I	-42.13	-147.45	-7.38	56.33	64.85	73.38
R.P. II	-42.9	- 150.14	-8.25	54.76	63.07	71.38
N.P.	-34.78	- 121.72	-4.82	49.06	56.36	63.66

Table VI.11 gives us our first clear result. In every year throughout the life of the project the net benefits of Regional Plan I are greater than those of Regional Plan II. (That is, R.P.I always has smaller negative values and higher positive values for its net benefits). In purely economic terms, therefore, R.P.I is definitely preferable to R.P.II.

Comparing the National Plan with R.P.I we see that in each of the years 1 - 3 the N.P.'s net benefits have a <u>smaller negative</u> value, but that in every year 4 - 15 the N.P.'s net benefits also have a <u>smaller positive</u> value. This is precisely what one would expect of two projects of broadly similar efficiency but where one is about 80 per cent of the size of the other.

In terms of economic viability alone, then, the crucial comparison is that between Regional Plan I and the National Plan and it is this which we shall examine most carefully. However, since R.P.II's net benefits differ from those of R.P.I by such small magnitudes, we shall continue to give the results for R.P.II as well.

7. We now present the average rate of return for each alternative using the data in Table VI.11 and equation (2) on page [illegible]. The results are:

R.P.I: 24% R.P.II: 23% N.P: 25%

All three rates are very similar and all are high.

A comment is in order here on why, in terms of the average rate of return, the National Plan beats R.P.I by a short head. Using Tables VI. 4-7 it can be shown that whilst R.P.I has a value of output 22.5 per cent greater than the National Plan, its investment costs are only 21.1 per cent greater and its operating costs are only 15.2 per cent greater than N.P. In these terms, then, R.P.I is definitely the winner. However, R.P.I incurs $9.14 million a year in transporting its end -product to ASEAN ports whilst there is no such cost in the case of the National Plan. It is this alone which pushes the N.P. ahead.

G. Plan selection and the cost of finance

1. In sub-section D we said that once the costs of plan finance are known, the plan with the highest discounted cash flow should be selected. The reason is that the ranking of projects is not necessarily the same by the discounted cash flow as by the average rate of return and the former technique can be shown to be preferable. (Reference 21 pp. 132-135). It is possible to state quite precisely which plan ranks first as a function of different costs of finance where the costs of finance are the same for each plan. The results are given in Table VI.12.

TABLE IV.12: Plan choice in relation to cost of finance for the regional and national alternatives

Cost of Finance (% p.a.)	Plan Choice
Below 19	Regional Plan I
19[1]	No difference
20 - 25	National Plan
Above 25	Neither Plan

Notes: 1. This rate of discount is known as the comparable rate of return at which the discounted cash flow of the two plans are identical.

2. The lower rates of interest favour the Regional Plan even though the National Plan has the highest average rate of return. This can be explained using the symbols of equation (1) on page 6. We see that the outlays of each plan are its investment cost, It, and the receipts are its operating surplus, (Vt - Ct). Again using Tables VI.4-7 it can be shown that whilst R.P.I's investment <u>outlays</u> are 21.1 per cent higher than N.P., its operating surplus <u>receipts</u> are only 15.3 per cent greater. Low interest rates give a greater weight to the operating surplus vis-a-vis investment, because of the discounting effect, and therefore makes R.P.I progressively more attractive as the interest rate diminishes.

H. Foreign exchange savings of the alternatives

1. In this sub-section we calculate the total foreign exchange outlay of each plan, the gross foreign exchange savings from import substitution and the difference between the two, equal to the net foreign exchange savings. We begin with total foreign exchange outlays: on investment, operating costs and transport costs. Table VI.13 shows the proportion of costs which we assume will be devoted to imports.

TABLE VI.13: Proportion of costs incurred in foreign exchange

Cost category	Proportion in foreign exchange (%)
Investment costs	80
Naphtha	80
Fuel Oil	80
Phosphate rock	100
Sulphur	100
Potash	100
Chemicals and catalyst	100
Operating supplies	50
Maintenance	50
General overheads	20
Transport costs	50

All other costs incurred are assumed to require no foreign exchange. Foreign exchange receipts from any capital inflow which might help finance the plans, and outlays in foreign exchange on the consequent return flow of interest and profits are not included as the sources of project finance are not yet known.

Using Tables VI. 5 and 13, the total foreign exchange outlays required for investment costs, in millions of dollars, are:

R.P.I: 168.52 R.F.II: 171.58 N.P: 139.12

Using the summaries of operating costs given in Sections IV and V and Tables VI.6 and 13, annual foreign exchange requirements for operation at full capacity are, in millions of dollars:

R.P:I: 46.29 R.P.II: 49.91 N.P: 43.36

Using Tables VI.7 and 13, annual foreign exchange requirements for end-product transport costs at full capacity are, in millions of dollars:

R.P.I: 4.57 R.P.II: 1.99 N.P: none

To arrive at the total foreign exchange outlay over the life of the plant we add the foreign exchange outlay on investment costs to the annual foreign exchange outlay on operating and transport costs multiplied by the number of years of production (12½) adjusted by the capacity utilization rate. This procedure gives the following table in millions of dollars:

R.P.I: 779 R.P.II: 794 N.P: 659

2. Gross foreign exchange savings through import substitution we equate simply to the total value of output over the 12½ year period of production, giving for the three plans, in millions of dollars:

R.P.I: 1824 R.P.II: 1824 N.P: 1488

3. Table VI.14 brings together these results and shows the net foreign exchange savings for each plan.

TABLE VI.14: Net foreign exchange savings of the regional and national alternatives in millions of dollars[1].

Foreign exchange outlays and savings ($m)	R.P.I	R.P.II	N.P.
Value of output	1824	1824	1488
Investment, operating & Transport costs	- 779	- 794	- 659
Net foreign exchange savings:	1045	1030	829

Notes: 1. Rounded to the nearest million dollars

The difference between the regional plans is very small indeed. The National Plan's savings are 79 per cent of those of R.P.I, very close to its proportionate output value, which we saw in sub-section C was 82 per cent.

For every unit of foreign exchange currency spent on investment the number of units of foreign exchange saved through the total operating surplus equals:

R.P.I: 7.18   R.P.II: 6.98   N.P: 6.96

The difference between the alternatives are very small: the R.P.I ratio is only 3.2 per cent greater than the N.P. ratio.

I. Employment generation

1. Our final remarks concern the employment generated by the three alternatives. The number of workers required are shown in Table VI.15.

TABLE VI.15: Number of workers required for each complex in the regional and national alternatives

	Complex J	Complex S	Complex B	Total
R.P.I	850	850	-	1700
R.P.II	850	600	600	2050
N.P.	850	-	850	1700

Using these figures and Table VI.5 it can be calculated that the size of the investment outlay per job created is:

R.P.I: $124,000   R.P.II: $105,000   N.P: $102,000

Investment outlay per job created is very high, but it is well recognized in all of the developing countries, many of which have severe problems of unemployment and under-employment, that the chemical industry is one of those industrial branches which are least capable of significant employment generation.

APPENDIX A

LETTER FROM THE BRITISH PHOSPHATE COMMISSIONERS

Twentyfour hours after completing our report we received the following letter from the British Phosphate Commissioners:

THE BRITISH PHOSPHATE COMMISSIONERS

Managing Agents for THE CHRISTMAS ISLAND PHOSPHATE COMMISSION

Dear Sir,

We refer to your letter of 10th April 1972 regarding the feasibility study you are carrying out on the production of fertilizer, particularly phosphatic fertilizer, for the region covering Indonesia, Malaysia, Philippines, Thailand and Singapore.

As the situation stands at present all phosphate rock produced at Christmas Island and Ocean Island which is suitable for acidulation is required for use in Australia and New Zealand. However, we do currently supply Malaysia and Indonesia with Christmas Island phosphate dust for direct application.

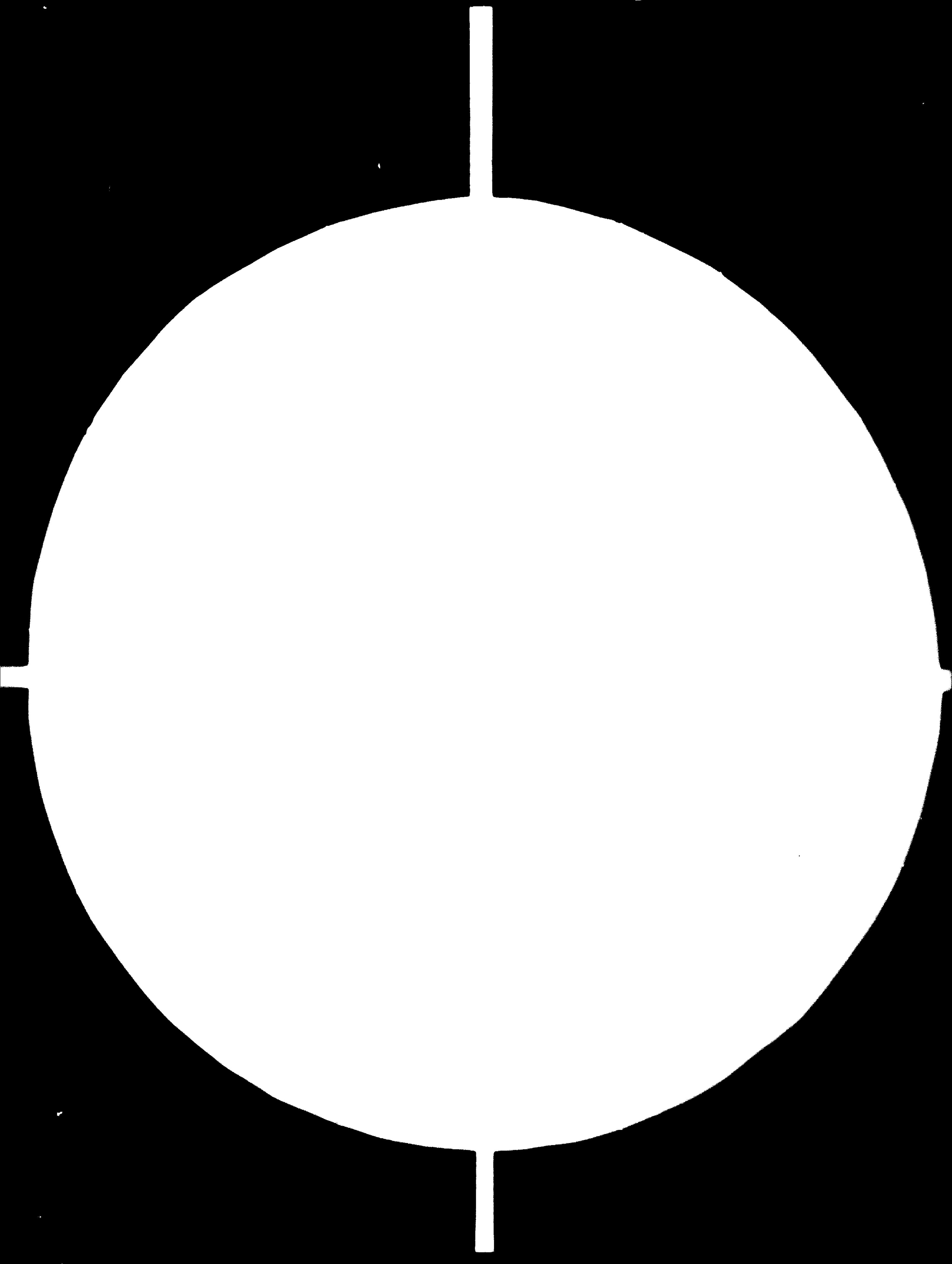
The chemical composition and other details of the two types of material sent to these areas are:-

Grade "A"

Chemical	Range	Typical
Total P_2O_5	35.0 - 37.0	36.3
P_2O_5 Sol 2% citric acid	8.2 - 9.5	-
F (fluorine)	1.5 - 2.0	1.1
CaO Total		40.0
$CaCO_3$ Free	5.5 - 6.5	3.2
H_2O	1.0	.9
Mesh	85% minus 100 mesh	70% minus 200 mesh

G-931

86.01.10
AD.87.04
ILL 5.5+10



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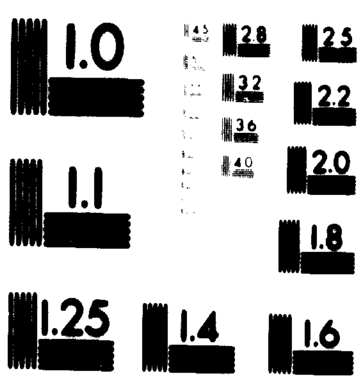

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

24x
F

Citra-Phos Grade (Calcined Product)

Chemical	Range	Typical
Total P205	30.0 - 32.0	30.5
P205 Sol citric acid	10.0 - 11.0	10.2
F (fluorine)	0.24 - 0.68	0.3
CaO Total		16.8
CaCO3 Free	1.2 - 2.3	1.8
H20	1.0 - 1.5	.9
Mesh	85% minus 100 mesh	70% minus 200 mesh

The citrate soluble P_2O_5 in a neutral ammonium citrate solution is 20% minimum.

Substantial quantities of the above material (particularly the calcined product) would be available in the late 1970's or 1980's.

We trust the foregoing information will assist you with your study.

Comment

This rock is quoted as costing $12.50 per ton in the World Bank Report. Even if only 50% of requirements would be met with this rock, it would result in a cost saving of about $9.00 per ton of P_2O_5 as phosphoric acid. As a result the average rate of return on all 3 alternatives would rise, probably by a couple of percentage points.

APPENDIX B

COST OF PRODUCTION TABLES ACCOMPANYING SECTIONS IV AND V

ESTIMATED AMMONIA PRODUCTION COST

COMPLEX B III

Plant Capacity 184,800 MT/Yr 560 MT/D 330 D/Yr

Plant Investment	MM$	27.41
Working Capital		0.75
Total		28.16

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials					
Naptha	MT	0.731	22.00	2,971.6	16.08
Utilities					
Power	Kwh	5	0.02	18.4	0.10
Cooling Water	M3	255	0.0052	245.8	1.33
Boiler Feed Water	M3	1.8	0.0670	22.2	0.12
Catalyst & Chemicals				110.9	0.60
Operating Supplies				64.7	0.35
Total Variable Cost				3,433.6	18.58
FIXED COST					
Labour					
Operators 6 men/shift				31.2	0.17
Supervision 1 man/shift				78.0	0.42
Total Labour				109.2	0.59
OTHER COSTS					
Overhead				274.1	1.48
Maintenance				795.0	4.30
Taxes and Insurance				274.1	1.48
Depreciation				2193.0	11.87
Interest on Investment				2253.0	12.19
Total Fixed Cost				5,898.4	31.91
TOTAL PRODUCTION COST				9,332.0	50.49

ESTIMATED AMMONIA PRODUCTION COST

Complex S III

Plant Capacity	257,400 MT/Yr	780 MT/D	330 D/Yr
Plant Investment	MM$ 32.74		
Working Capital	0.93		
Total	33.67		

VARIABLE COST	Units	Units/MT	$/Units	1000 $/Yr	$/MT
Raw Materials:					
Natural Gas	M^3	1065	0.0088	2,411.8	9.37
Utilities:					
Power	Kwh	5	0.02	25.7	0.10
Cooling Water	M^3	255	0.0052	342.3	1.33
Boiler Feed Water	M^3	1.8	0.0670	30.9	0.12
Catalyst and Chemicals				154.4	0.60
Operating Supplies				90.1	0.35
Total Variable Cost				3,055.2	11.87
FIXED COST					
Labour:					
Operators . 6 men/shift				31.2	0.12
Supervision 1 man/shift				78.0	0.30
Total Labour				109.2	0.42
OTHER COSTS					
Overhead				327.4	1.27
Maintenance				929.0	3.61
Taxes and Insurance				327.4	1.27
Depreciation				2,619.0	10.17
Interest on Investment				2,694.0	10.47
Total Fixed Cost				7,006.0	27.21
TOTAL PRODUCTION COST				10,061.2	39.08

ESTIMATED AMMONIA PRODUCTION COST

Complex J III

Plant Capacity	280,500 MT/Yr	850 MT/D	330	D/Yr
Plant Investment	MM$ 33.90			
Working Capital	1.00			
Total	34.90			

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Natural Gas	M^3	1065	0.0088	2,628.3	9.37
Utilities:					
Power	Kwh	5	0.02	28.1	0.10
Cooling Water	M^3	255	0.0052	373.1	1.33
Boiler Feed Water	M^3	1.8	0.0670	33.7	0.12
Catalyst and Chemicals				168.3	0.60
Operating Supplies				98.2	0.35
Total Variable Cost				3,329.7	11.87
FIXED COST					
Labour:					
Operators 6 men/shift				31.2	0.11
Supervisors 1 man/shift				78.0	0.28
Total Labour				109.2	0.39
OTHER COSTS					
Overhead				339.0	1.21
Maintenance				957.0	3.41
Taxes and Insurance				339.0	1.21
Depreciation				2,712.0	9.67
Interest on Investment				2,792.0	9.95
Total Fixed Cost				7,248.2	25.84
TOTAL PRODUCTION COST				10,577.9	37.71

ESTIMATED AMMONIA PRODUCTION COST

Complexes JI & JII

Plant Capacity 313,500 MT/Yr 950 MT/D 330 D/Yr

Plant Investment	MM$	37.47
Working Capital		1.13
Total		38.60

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Natural Gas (1)	M^3	1065	0.0088	2,937.5	9.37
Utilities:					
Power	Kwh	5	0.02	31.4	0.10
Cooling Water	M^3	255	0.0052	417.0	1.33
Boiler Feed Water	M^3	1.8	0.0670	37.6	0.12
Catalyst and Chemicals				188.1	0.60
Operating Supplies				109.7	0.35
Total Variable Cost				3,271.3	11.87
FIXED COST					
Labour:					
Operators 6 men/shift				31.2	0.10
Supervision 1 man/shift				78.0	0.25
Total Labour				109.2	0.35
OTHER COSTS					
Overhead				374.7	1.20
Maintenance				1,050.0	3.35
Taxes and Insurance				374.7	1.20
Depreciation				3,000.0	9.57
Interest on Investment				3,100.0	9.89
Total Fixed Cost				8,008.6	25.56
TOTAL PRODUCTION COST				11,729.9	37.43

ESTIMATED AMMONIA PRODUCTION COST

Complexes SI & S II

Plant Capacity	412,500 MT/Yr	1250 MT/D	330 D/Yr
Plant Investment	MM$ 42.34		
Working Capital	1.50		
Total	43.84		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Natural Gas	M^3	1065	0.0088	3,865.1	9.37
Utilities:					
Power	Kwh	5	0.02	41.3	0.10
Cooling Water	M^3	255	0.0052	548.6	1.33
Boiler Feed Water	M^3	1.8	0.0670	49.5	0.12
Catalyst and Chemicals				247.5	0.60
Operating Supplies				144.4	0.35
Total Variable Cost				4,896.4	11.87
FIXED COST					
Labour:					
Operators 6 men/shift				31.2	0.08
Supervision 1 man/shift				78.0	0.19
Total Labour				109.2	0.27
OTHER COSTS					
Overhead				423.4	1.03
Maintenance				1,190.0	2.88
Taxes and Insurance				423.4	1.03
Depreciation				3,390.0	8.22
Interest on Investment				3,510.0	8.51
Total Fixed Cost				9,046.0	21.94
TOTAL PRODUCTION COST				13,942.4	33.81

ESTIMATED UREA PRODUCTION COST

(PRILLS)

Complex B III

Plant Capacity 34,650 MT/Yr 105 MT/D 330 D/Yr

Plant Investment MM$ 1.93

Working Capital .11

Total 2.04

	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
VARIABLE COST					
Raw Materials:					
Urea	Mt	1	39.96	1,384.6	39.96
Utilities:					
Power	Kwh	25			
Cooling Water					
Steam					
Operating Supplies				3.5	0.10
Total Variable Cost				1,388.1	40.06
FIXED COST					
Labour:					
Operators 1 man/shift				5.2	0.15
Supervision					
Total Labour				5.2	0.15
OTHER COSTS					
Overhead				19.3	0.56
Maintenanee				39.0	1.13
Taxes and Insurance				19.3	0.56
Depreciation				15.0	0.43
Interest on Investment				15.0	0.43
Total Rixed Cost				112.8	3.25
TOTAL PRODUCTION COST				1,500.9	43.31

ESTIMATED UREA PRODUCTION COST

(PRILLS)

Complex J I

Plant Capacity	155,100 MT/Yr	470 MT/D	330 D/Yr
Plant Investment	MM$ 12.83		
Offsites	0.50		
Total	13.33		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	37.43	3,309.8	21.34
CO_2	MT	0.76			
Utilities:					
Power	Kwh	125	0.02	387.8	2.50
Cooling Water	M^3	49.6	0.0052	40.3	0.26
Steam	MT	0.70	1.10	119.4	0.77
Operating Supplies				31.0	.20
Total Variable Cost				3,888.3	25.07
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.17
Supervision ½ man/shift				39.0	0.25
Total Labour				65.0	0.42
OTHER COSTS					
Overhead				128.3	0.83
Maintenance				360.0	2.32
Taxes and Insurance				128.3	0.83
Depreciation				1,030.0	6.64
Interest on Investment				1,070.0	6.90
Total Fixed Cost				2,781.6	17.94
TOTAL PRODUCTION COST				6,669.9	43.01

ESTIMATED UREA PRODUCTION COST

(Prills)

Complex J II

Plant Capacity 214,500 MT/Yr 650 MT/D 330 D/Yr

Plant Investment	MM$	16.24
Offsites		0.90
Total		17.14

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	36.40	4,450.9	20.75
CO_2	MT	0.76			
Utilities:					
Power	Kwh	125	0.02	536.3	2.50
Cooling Water	M^3	49.6	0.0052	55.8	0.26
Steam	MT	0.70	1.100	165.2	0.77
Operating Supplies				42.9	0.20
Total Variable Cost				5,251.1	24.48
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.12
Supervision ½ man/shift				39.0	0.18
Total Labour				65.0	0.30
OTHER COSTS					
Overhead				162.4	0.76
Maintenance				414.0	1.93
Taxes and Insurance				162.4	0.76
Depreciation				1,299.0	6.06
Interest on Investment				1,371.0	6.39
Total Fixed Cost				3,473.8	16.20
TOTAL PRODUCTION COST				8,724.9	40.68

ESTIMATED UREA PRODUCTION COST

(PRILLS)

Complex S I

Plant Capacity	333, 300 MT/Yr	1010 MT/D	330 D/Yr
Plant Investment	MM$ 20.83		
Working Capital	1.10		
Total	21.93		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	.57	33.81	6,422.7	19.27
CO_2	MT	.76			
Utilities:					
Power	Kwh	125	0.02	833.3	2.50
Cooling Water	M^3	49.6	0.0052	86.7	0.26
Steam	MT	0.70	1.10	256.6	0.77
Operating Supplies				66.7	0.20
Total Variable Cost				7,666.0	23.00
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.08
Supervision ½ man/shift				39.0	0.12
Total Labour				65.0	0.20
OTHER COSTS					
Overhead				208.3	0.63
Maintenance				560.0	1.68
Taxes and Insurance				208.3	0.63
Depreciation				1,670.0	5.01
Interest on investment				1,750.0	15.25
Total Fixed Cost				4,461.6	13.40
TOTAL PRODUCTION COST				12,127.6	36.40

ESTIMATED UREA PRODUCTION COST
(Prills)
Complex S II

Plant Capacity	369,600 MT/Yr	1120 MT/D	330 D/Yr
Plant Investment	MM$ 22.47		
Offsites	1.20		
Total	23.67		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	33.81	7,122.2	19.27
CO_2	MT	0.76			
Utilities:					
Power	Kwh	125	0.02	924.0	2.50
Cooling Water	M^3	49.6	0.0052	96.1	0.26
Steam	MT	0.70	1.100	284.6	0.77
Operating Supplies				73.9	0.20
Total Variable Cost				8,500.8	23.00
FIXED COSTS					
Labour:					
Operators 5 men/shift				26.0	0.07
Supervision ½ man/shift				39.0	0.11
Total Labour				65.0	0.18
OTHER COSTS					
Overhead				224.7	0.61
Maintenance				610.0	1.65
Taxes and Insurance				224.7	0.61
Depreciation				1,798.0	4.86
Interest on Investment				1,894.0	5.12
Total Fixed Cost				4,816.4	13.03
TOTAL PRODUCTION COST				13,317.2	36.03

ESTIMATED UREA PRODUCTION COST
(PRILLS)
Complex S III

Plant Capacity	452,100 MT/Yr	1370 MT/D	330 D/Yr
Plant Investment	MM$ 24.51		
Working Capital	1.30		
Total	25.81		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	39.08	10,072.8	22.28
CO_2	MT	0.76			
Utilities:					
Power	Kwh	125	0.020	1,130.3	2.50
Cooling Water	M^3	49.6	0.0052	117.5	0.26
Steam	MT	0.70	1.100	348.1	0.77
Operating Supplies				90.4	0.20
Total Variable Costs				11,759.1	26.01
FIXED COSTS					
Labour:					
Operators 5 men/shift				26.0	0.06
Supervision ¼ man/shift				39.0	0.09
Total Labour				65.0	0.15
OTHER COSTS					
Overhead				245.1	0.54
Maintenance				656.0	1.45
Taxes and Insurance				245.1	0.54
Depreciation				1,961.0	4.34
Interest on Investment				2,065.0	4.57
Total Fixed Cost				5,237.2	11.59
TOTAL PRODUCTION COST				16,996.3	37.60

ESTIMATED UREA PRODUCTION COST

(83% SOL.)

Complex S II

Plant Capacity 186,450 MT/Yr 565 MT/D 330 D/Yr

Plant Investment	MM$	835
Offsites		60
Total		895

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	33.81	3,592.9	19.27
CO_2	MT	0.76			
Utilities:					
Power	Kwh	100	0.02	372.9	2.00
Cooling Water	M^3	49.6	0.0052	48.5	0.26
Steam	MT	0.7	1.10	143.6	0.77
Operating Supplies				18.6	0.10
Total Variable Cost				4,176.5	22.40
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.14
Supervision 1 man/shift				39.0	0.21
Total Labour				65.0	0.35
OTHER COSTS					
Overhead				83.5	0.45
Maintenance				252.0	1.35
Taxes and Insurance				83.5	0.45
Depreciation				668.0	3.58
Interest on Investment				716.0	3.84
Total Fixed Cost				1,868.0	10.02
TOTAL PRODUCTION COST				6,044.5	32.42

ESTIMATED UREA PRODUCTION COST

(83% SOL.)

Complex J I

Plant Capacity	313,500 MT/Yr	950 MT/D	330 D/Yr
Plant Investment	MM$ 10.94		
Working Capital	0.86		
Total	11.80		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	37.43	6,690.1	21.34
CO_2	MT	0.76			
Utilities:					
Power	Kwh	1.00	0.02	627.0	2.00
Cooling Water	M^3	49.6	0.0052	81.5	0.26
Steam	MT	0.7	1.100	241.4	0.77
Operating Supplies				31.4	0.10
Total Variable Cost				7,671.4	24.47
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.08
Supervision 1/2 man/shift				39.0	0.12
Total Labour				65.0	0.20
OTHER COSTS					
Overhead				109.4	0.35
Maintenance				320.0	1.02
Taxes and Insurance				109.4	0.35
Depreciation				880.0	2.80
Interest on Investment				940.0	3.00
Total Fixed Cost				2,423.8	7.72
TOTAL PRODUCTION COST				10,095.2	32.19

ESTIMATED UREA PRODUCTION COST - S

(83% SOL.)

Complex S I

Plant Capacity	313.50 MT/Yr	950 MT/D	330 D/Yr
Plant Investment	M$ 10.94		
Working Capital	0.86		
Total	11.80		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	.57	33.81	6,041.1	19.27
CO_2	MT	.76			
Utilities:					
Power	Kwh	100	0.02	677.0	2.00
Cooling Water	M^3	49.6	0.0052	81.5	0.26
Steam	MT	0.7	1.10	241.4	0.77
Operating Supplies				31.4	0.10
Total Variable Cost				7,022.4	22.40
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.08
Supervision 1 man/shift				39.0	0.12
Total Labour				65.0	0.20
OTHER COSTS					
Overhead				109.4	0.35
Maintenance				320.0	1.02
Taxes and Insurance				109.4	0.35
Depreciation				880.0	2.80
Interest on Investment				940.0	3.00
Total Fixed Cost				2,423.8	7.72
TOTAL PRODUCTION COST				9,446.2	30.12

ESTIMATED UREA PRODUCTION COST

(83% SOL.)

Complex B III

Plant Capacity 330,000 MT/Yr 1000 MT/D 330 D/Yr

Plant Investment MM$ 12.08

Working Capital 0.90

Total 12.98

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	50.49	9,494.1	28.77
CO_2	MT	0.76			
Utilities:					
Power	Kwh	100	0.020	660.0	2.00
Cooling Water	M^3	49.6	0.0052	85.8	0.26
Steam	MT	0.70	1.1000	254.1	0.77
Operating Supplies				33.0	0.10
Total Variable Cost				10,527.0	31.90
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.08
Supervision ½ man/shift				39.0	0.12
Total Labour				65.0	0.20
OTHER COSTS					
Overhead				120.8	0.37
Maintenance				346.0	1.05
Taxes and Insurance				120.8	0.37
Depreciation				966.0	2.92
Interest on Investment				1,038.0	3.15
Total Fixed Cost				2,656.6	8.06
TOTAL PRODUCTION COST				13,183.6	39.96

ESTIMATED UREA PRODUCTION COST

(83% SOL.)

Complex JII

Plant Capacity 336,600 MT/Yr 1010 MT/D 330 D/Yr

Plant Investment MM$ 11.37

Offsites 0.90

Total 12.27

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	36.40	6,984.4	20.75
CO_2	MT	0.76			
Utilities:					
Power	Kwh	100	0.02	673.2	2.00
Cooling Water	M^3	49.6		87.5	0.26
Steam	MT	0.7	1.10	259.2	0.77
Operating Supplies				33.7	0.10
Total Variable Cost				8,038.0	23.88
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.08
Supervision ½ man/shift				39.0	0.12
Total Labour				65.0	0.20
OTHER COSTS					
Overhead				113.7	0.34
Maintenance				339.0	1.01
Taxes and Insurance				113.7	0.34
Depreciation				910.0	2.70
Interest on Investment				982.0	2.91
Total Fixed Cost				2,523.4	7.50
TOTAL PRODUCTION COST				10,561.4	31.38

ESTIMATED UREA PRODUCTION COST
(83% SOL)
Complex J III

Plant Capacity	392,700 MT/Yr	1190 MT/D	330 D/Yr	
Plant Investment	MM$	12.45		
Working Capital		1.00		
Total		13.45		

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.57	37.71	8,439.1	21.49
CO_2	MT	0.76			
Utilities:					
Power	Kwh	100	0.020	785.4	2.00
Cooling Water	M^3	49.6	0.0052	102.1	0.26
Steam	MT	0.70	1.1000	302.4	0.77
Operating Supplies				39.3	0.10
Total Variable Cost				9,668.3	24.62
FIXED COST					
Labour:					
Operators 5 men/shift				26.0	0.07
Supervision ½ man/shift				39.0	0.10
Total Labour				65.0	0.17
OTHER COSTS					
Overhead				124.5	0.32
Maintenance				371.0	0.94
Taxes and Insurance				124.5	0.32
Depreciation				996.0	2.54
Interest on Investment				1,076.0	2.74
Total Fixed Cost				2,757.0	7.03
TOTAL PRODUCTION COST				12,425.3	31.65

ESTIMATED UREA-AMMONIA SOLUTIONS PRODUCTION COST

Complex S II

Plant Capacity 498,300 MT/Yr 1510 MT/D 330 D/Yr

Plant Investment MM$ 0.232

Working Capital -

Total Investment 0.232

VARIABLE COST	Units	Units/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Ammonia	MT	0.19	33.81	3,199.1	6.42
Urea Solution 83%	MT	0.375	32.42	6,059.3	12.16
Utilities:					
Power	Kwh	4	0.020	40.0	0.08
Water	M^3	.394	0.0670	15.0	0.03
Operating Supplies				19.0	0.04
Total Variable Cost				9,332.4	18.73
DIRECT COST					
Labour:					
Operating 2 men/shift				10.4	0.020
Supervision 1/4 man/shift				19.5	0.040
Total Labour				29.9	0.060
Overhead				2.3	0.005
Maintenance				5.0	0.100
Taxes and Insurance				2.3	0.005
Depreciation				1.9	0.005
Interest on Investment				1.9	0.005
Total Direct Cost				43.3	0.09
TOTAL PRODUCTION COST				9,375.7	18.82

ESTIMATED SULFURIC ACID PRODUCTION COST - B

Complex B III

Plant Capacity	363,000 MT/Yr	1100 MT/D	330 D/Yr
Plant Investment	MM$ 8.51		
Working Capital	0.45		
Total	8.96		

VARIABLE COST	Units	Units/MT	$ Unit	1000 $/Yr	$/MT
Raw Materials:					
Sulfur	MT	0.337	24.50	2,998.4	8.26
Utilities:					
Power	Kwh	3	0.020	21.8	0.06
Boiler Feed Water	M^3	1.3	0.0670	32.7	0.09
Cooling Water	M^3	32.9	0.0052	61.7	0.17
Export Steam	MT	1.14	1.1000	453.8	(1.25)
Total Variable Costs				2,660.8	7.33
FIXED COST					
Labour:					
Operating 3 men/shift				15.6	0.04
Supervision ½ man/shift				39.0	0.11
Total Labour				54.8	0.15
OTHER COSTS					
Overhead				85.1	0.23
Maintenance				260.0	0.72
Taxes and Insurance				85.1	0.23
Depreciation				681.0	1.88
Interest on Investment				717.0	1.98
Total Fixed Cost				1,883.0	5.19
TOTAL PRODUCTION COST				4,543.8	12.52

ESTIMATED SULFURIC ACID PRODUCTION COST - S

Complex JI & SI

Plant Capacity	495,000 MT/Yr	1500 MT/D	330 D/Yr
Plant Investment	MM$ 9.82		
Working Capital	0.60		
Total	10.42		

VARIABLE COST	Units	Units/MT	$ Unit	1000 $/Yr	$/MT
Raw Materials:					
Sulfur	MT	0.337	24.50	4,088.7	8.26
Utilities:					
Power	Kwh	3	0.02	29.7	0.06
Boiler Feed Water	M^3	1.3	0.067	44.6	0.09
Cooling Water	M^3	32.9	0.0052	84.2	0.17
Export Steam	MT	1.14	1.10	618.8	1.25
Total Variable Costs				3,628.4	7.33
FIXED COST					
Labour:					
Operators 3 men/shift				15.6	0.03
Supervision 1 man/shift				39.0	0.08
Total Labour				54.6	0.11
OTHER COSTS					
Overhead				96.4	0.19
Maintenance				290.0	0.59
Taxes and Insurance				96.4	0.19
Depreciation				790.0	1.60
Interest on Investment				830.0	1.68
Total Fixed Cost				2,157.6	4.36
TOTAL PRODUCTION COST				5,786.0	11.69

ESTIMATED SULFURIC ACID PRODUCTION COST

Complex J III

Plant Capacity	620.400 MT/Yr	1880 MT/D	330 D/Yr	
Plant Investment	MM$	12.98		
Working Capital		0.75		
Total		13.73		

VARIABLE COST	Units	Units/MT	$ Unit	1000 $/Yr	$/MT
Raw Materials:					
Sulfur	MT	0.337	24.50	5,124.5	8.26
Utilities:					
Power	Kwh	3	0.020	37.2	0.06
Boiler Feed Water	M^3	1.3	0.0670	55.8	0.09
Cooling Water	M^3	32.9	0.0052	105.4	0.17
Steam (export)	MT	1.14	1.100	775.5	(1.25)
Total Variable Costs				9,547.4	7.33
FIXED COST					
Labour:					
Operating 3 men/shift				15.6	0.03
Supervision ½ man/shift				39.0	0.06
Total Labour				54.6	0.09
OTHER COSTS					
Overhead				129.8	0.21
Maintenance				389.0	0.63
Taxes and Insurance				129.8	0.21
Depreciation				1,038.0	1.67
Interest on Investment				1,098.0	1.79
Total Fixed Cost				2,839.2	4.60
TOTAL PRODUCTION COST				7,386.6	11.93

ESTIMATED SULFURIC ACID PRODUCTION COST

Complex B II

Plant Capacity	990,000 MT/Yr	3000 MT/D	330 D/Yr
Plant Investment	MM$ 16.94		
Working Capital	1.20		
Total	18.14		

VARIABLE COST	Units	Units/MT	$ Unit	1000 $/Yr	$/MT
Raw Materials:					
Sulfur	MT	.337	24.50	8,177.4	8.26
Utilities:					
Power	Kwh	3	0.020	59.4	0.06
Boiler Feed Water	M^3	1.3	0.067	89.2	0.09
Cooling Water	M^3	32.9	0.0052	168.4	0.17
Export Steam	MT	1.14	1.10	1,237.5	(1.25)
Total Variable Cost				7,256.9	7.33
FIXED COST					
Labour:					
Operating 3 men/1 shift				15.6	0.02
Supervision ½ man/shift				39.0	0.04
Total Labour				54.6	0.06
OTHER COSTS					
Overhead				169.4	0.17
Maintenance				520.0	0.53
Taxes and Insurance				169.4	0.17
Depreciation				1,291.0	1.30
Interest on Investment				1,451.0	1.47
Total Fixed Cost				3,655.4	3.70
TOTAL PRODUCTION COST				10,912.3	11.03

ESTIMATED PHOSPHORIC ACID PRODUCTION COST

($45\%\ P_2O_5$)

Complex B III

Plant Capacity	135,300 MT/Yr	410 MT/D	330 D/Yr
Plant Investment	MM$ 11.50		
Working Capital	1.30		
Total	12.80		

VARIABLE COST	Unit	Unit/MT	$ Unit	1000 $/Yr	$/MT
Raw Materials:					
Sulfuric Acid	MT	2.68	12.52	4,539.3	33.55
Phosphate Rock	MT	3.13	19.50	8,258.7	61.04
Utilities:					
Power	Kwh	160	0.020	433.0	3.20
Steam	MT	2.68	1.100	399.1	2.95
Water Cooling	M^3	82.0	0.0052	55.5	0.41
Water Process	M^3	5.0	0.0670	46.0	0.34
Operating Supplies				230.0	1.70
Total Variable Cost				13,961.6	103.19
FIXED COST					
Labour:					
Operators 4 men/shift				21.8	0.16
Supervision ½ man/shift				39.0	0.29
Total Labour				60.8	0.45
OTHER COSTS					
Overhead				115.0	0.85
Maintenance				463.0	3.42
Taxes and Insurance				115.0	0.85
Depreciation				920.0	6.80
Interest on Investment				1,024.0	7.57
Total Fixed Cost				2,697.8	19.94
TOTAL PRODUCTION COST				16,659.4	123.13

ESTIMATED PHOSPHORIC ACID PRODUCTION COST

($45\%\ P_2O_5$)

Complex JI & SI

Plant Capacity	184,800 MT/Yr	560 MT/D	330 D/Yr
Plant Investment	MM$ 14.30		
Working Capital	1.75		
Total	16.05		

VARIABLE COST	Unit	Unit/MT	$ Unit	1000 $/YR	$/MT
Raw Materials:					
Sulfuric Acid	MT	2.68	11.69	5,789.8	31.33
Phosphate Rock	MT	3.13	19.50	11,278.3	61.03
Utilities:					
Power	Kwh	160	0.02	591.3	3.20
Steam	MT	2.68	1.10	545.6	2.95
Water Cooling	M^3	82.0	0.0052	75.8	0.41
Water Process	M^3	5.0	0.067	62.8	0.34
Operating Supplies				314.2	1.70
Total Variable Cost				18,657.8	100.95
FIXED COST					
Labour:					
Operators 4 men/shift				21.8	0.12
Supervision 1 man/shift				39.0	0.21
Total Labour				60.8	0.33
OTHER COSTS					
Overhead				143.0	0.77
Maintenance				580.0	3.14
Taxes and Insurance				143.0	0.77
Depreciation				1,140.0	6.18
Interest on Investment				1,280.0	6.93
Total Fixed Cost				3,346.8	18.12
TOTAL PRODUCTION COST				22,004.6	118.70

ESTIMATED PHOSPHORIC ACID PRODUCTION COST

($45\%\ P_2O_5$)

Complex JIII

Plant Capacity 231,000 MT/Yr 700 MT/D 330 D/Yr

Plant Investment MM$ 15.90

Offsites Working Capital 2.20

Total 18.10

VARIABLE COST	Units	Unit/MT	$ Unit	1000 $/Yr	$/MT
Raw Materials:					
Sulfuric Acid	MT	2.68	11.93	7,385.1	31.97
Phosphate Rock	MT	3.13	19.50	14,100.2	61.04
Utilities:					
Power	Kwh	160	0.020	739.2	3.20
Steam	MT	2.68	1.100	681.5	2.95
Water Cooling	M^3	82.0	0.0052	94.7	0.41
Water Process	M^3	5.0	0.0670	78.5	0.34
Operating Supplies				392.7	1.70
Total Variable Cost				23,471.9	101.61
FIXED COST					
Labour:					
Operators 4 men/shift				21.8	0.09
Supervision ½ man/shift				39.0	0.17
Total Labour				60.8	0.26
OTHER COST					
Overhead				159.0	0.69
Maintenance				631.0	2.73
Taxes and Insurance				159.0	0.69
Depreciation				1,272.0	5.51
Interest on Investment				1,448.0	6.27
Total Fixed Cost				3,729.8	16.15
TOTAL PRODUCTION COST				27,201.7	117.76

ESTIMATED PHOSPHORIC ACID PRODUCTION COST

Complex B II

Plant Capacity	369,600 MT/Yr	1120 MT/D	330 D/Yr
Plant Investment	MM$ 24.18		
Offsites	3.50		
Total	27.68		

VARIABLE COST	Unit	Unit/MT	$ Unit	1000 $/Yr	$/MT
Raw Materials:					
Sulphuric Acid	MT	2.68	11.03	10,925.4	29.56
Phosphate Rock	MT	3.13	19.50	22,560.4	61.04
Utilities:					
Power	Kwh	160	0.02	1,182.7	3.20
Steam	MT	2.68	1.10	1,090.3	2.95
Cooling Water	M^3	82.0	0.0052	151.5	0.41
Process Water	M^3	5.0	0.067	125.7	0.34
Operating Supplies				628.3	1.70
Total Variable Cost				36,664.3	99.20
FIXED COST					
Labour:					
Operators 6 men/shift				31.2	0.08
Supervision ½ man/shift				39.0	0.11
Total Labour				70.2	0.19
OTHER COST					
Overhead				241.8	0.65
Maintenance				1,019.0	2.76
Taxes and Insurance				241.8	0.65
Depreciation				1,934.0	5.23
Interest on Investment				2,214.0	5.99
Total Fixed Cost				5,720.8	15.47
TOTAL PRODUCTION COST				42,385.1	114.67

ESTIMATED MONOAMMONIUM PHOSPHATE (POWDERED) PRODUCTION COST

(11-52-0)

Complex B III

Plant Capacity	260,700 MT/Yr	790 MT/D	330 D/Yr
Plant Investment	MM$ 2.15		
Working Capital	0.60		
Total	2.75		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/YR	$/MT
Raw Materials:					
Phosphoric Acid	MT	0.520	123.13	16,692.6	64.03
Ammonia	MT	0.133	50.49	1,751.9	6.72
Utilities:					
Power	Kwh	2	0.20	10.4	0.04
Operating Supplies				52.1	0.20
Total Variable Cost				18,507.0	70.99
FIXED COST					
Labour:					
Operators 3 men/shift				15.6	0.06
Supervision ½ man/shift				39.0	0.15
Total Labour				54.6	0.21
OTHER COSTS					
Overhead				21.5	0.08
Maintenance				100.0	0.38
Taxes and Insurance				21.5	0.08
Depreciation				172.0	0.66
Interest on Investment				220.0	0.84
Total Fixed Cost				589.6	2.25
TOTAL PRODUCTION COST				19,096.6	73.24

ESTIMATED MONOAMMONIUM PHOSPHATE (POWDERED) PRODUCTION COST - J

(11-52-0)

Complex J I

Plant Capacity	356,400 MT/Yr	1080 MT/D	330 D/Yr
Plant Investment	MM$ 2.46		
Offsites	.80		
Total	3.26		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Phosphoric acid	MT	0.52	119.07	22,064.7	61.91
Ammonia	MT	0.133	37.43	1,774.9	4.98
Utilities:					
Power	Kwh	2	0.02	14.3	0.4
Operating Supplies				71.3	0.20
Total Variable Cost				23,925.2	67.13
FIXED COST					
Labour:					
Operators				15.6	0.04
Supervision				39.0	0.11
Total Labour				54.6	0.15
OTHER COSTS					
Overhead				24.6	0.07
Maintenance				120.0	0.34
Taxes and Insurance				24.6	0.07
Depreciation				200.0	0.56
Interest on Investment				260.0	0.73
Total Fixed Cost				683.8	1.92
TOTAL PRODUCTION COST				24,609.0	69.05

ESTIMATED MONOAMMONIUM PHOSPHATE (POWDERED) PRODUCTION COST - S

(11-52-0)

Complex S I

Plant Capacity	356,400 MT/Yr	1080 MT/D	330 D/Yr
Plant Investment	MM$ 2.46		
Offsites	.80		
Total	3.26		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Phosphuric Acid	MT	0.52	119.07	22,064.7	61.91
Ammonia -. S	MT.	0.133	33.81	1,603.8	4.50
- J			37.43		
Utilities:					
Power	Kwh	2	0.02	14.3	0.04
Operating Supplies				71.3	0.20
Total Variable Cost				23,754.1	66.65
FIXED COST					
Labour:					
Operators 3 men/shift				15.6	0.04
Supervision 1 man/shift				39.0	0.11
Total Labour				54.6	0.15
OTHER COSTS					
Overhead				24.6	0.07
Maintenance				120.0	0.34
Taxes and Insurance				24.6	0.07
Depreciation				200.0	0.56
Interest on Investment				260.0	0.73
Total Fixed Cost				683.8	1.92
TOTAL PRODUCTION COST				24,437.9	68.57

ESTIMATED MONOAMMONIUM PHOSPHATE (POWDERED) PRODUCTION COST

(11-52-0)

Complex J III

Plant Capacity 445,500MT/Yr 1350 MT/D 330 D/Yr

Plant Investment MM$ 2.84

Working Capital 1.00

Total 3.84

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Phosphoric Acid	MT	0.52	117.76	27,282.4	61.24
Ammonia	MT	0.133	37.71	2,236.4	5.02
Utilities:					
Power	Kwh	2	0.020	17.8	0.04
Operating Supplies				89.1	0.20
Total Variable Cost				29,625.7	66.50
FIXED COST					
Labour:					
Operators 3 men/shift				15.6	0.04
Supervisors ½ man/shift				39.0	0.09
Total Labour				54.6	0.13
OTHER COSTS					
Overhead				28.4	0.06
Maintenance				150.0	0.34
Taxes and Insurance				28.4	0.06
Depreciation				227.0	0.51
Interest on Investment				307.0	0.69
Total Fixed Cost				795.4	1.79
TOTAL PRODUCTION COST				30,421.1	68.29

ESTIMATED MONOAMMONIUM PHOSPHATE (POWDERED) PRODUCTION COST

(11-52-0)

Complex B III

Plant Capacity 712,800 MT/Yr 2160 MT/D 330 D/Yr

Plant Investment	MM$ 4.18
Offsites	1.60
Total	5.78

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Phosphoric Acid	MT	0.520	114.67	42,504.2	59.63
Ammonia	MT	0.133	41.81	3,963.1	5.56
Utilities:					
Power	Kwh	2	0.02	28.5	0.04
Operating Supplies				142.6	0.20
Total Variable Cost				46,638.4	65.43
FIXED COST					
Labour:					
Operators 4 men/shift				20.8	0.03
Supervision ½ man/shift				39.0	0.05
Total Labour				59.8	0.08
OTHER COST:					
Overhead				41.8	0.06
Maintenance				240.0	0.34
Taxes and Insurance				41.8	0.06
Depreciation				334.0	0.47
Interest on Investment				462.0	0.65
Total Fixed Cost				1,179.4	1.66
TOTAL PRODUCTION COST				47,817.8	67.09

ESTIMATED GRANULAR FERTILIZER PRODUCTION COST

(23-23-9.5)

Complex B III

Plant Capacity	590,700 MT/Yr	1790 MT/D	330 D/Yr
Plant Investment MM$	9.03		
Working Capital	2.70		
Total	11.73		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Triple Superphosphate					
Mono Ammonium Phosphate	MT	0.442	73.24	19,120.9	32.37
Urea	MT	0.3895	39.96	9,191.3	15.56
Ammonia					
Potash	MT	0.1585	36.00	3,372.9	5.71
Utilities:					
Power	Kwh	43	0.020	508.0	0.86
Steam	MT	0.03	1.100	17.7	0.03
Fuel	Gals	6	0.100	354.4	0.60
Operating Supplies				88.6	0.15
Total Variable Cost				32,653.8	55.28
FIXED COST					
Labour:					
Operators 12 men/shift				62.4	0.11
Supervision. 1 man/shift				78.0	0.13
Total Labour				140.4	0.24
OTHER COSTS					
Overhead				117.3	0.20
Maintenance				356.0	0.60
Taxes and Insurance				117.3	0.20
Depreciation				722.0	1.21
Interest on Investment				938.0	1.59
Total Variable Cost				2,391.0	4.04
TOTAL COST OF PRODUCTION				35,044.8	59.32

ESTIMATED GRANULAR FERILIZER PRODUCTION COST

(23-23-915)

Complex B II

Plant Capacity 732,600 MT/Yr 2220 MT/D 330 D/Yr

Plant Investment MM$ 13.74

Offsites 4.00

Total 17.74

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Triple Superphosphate					
Monoammonium Phosphate	MT	0.442	67.09	21,721.6	29.65
Urea - solid	MT	0.1337	47.97	4,696.0	6.41
Urea Sol.	--	0.2558	40.12	7,516.5	10.26
Potash	MT	0.1585	36.00	4,183.1	5.71
Utilities:					
Power	Kwh	50	0.02	732.6	1.00
Steam	MT	0.53	1.10	424.9	0.58
Fuel	Gals	6	0.10	439.6	0.60
Operating Supplies				109.9	0.15
Total Variable Cost				39,824.2	54.36
FIXED COST					
Labour:					
Operators 12 men/shift				62.4	0.09
Supervision 1 man/shift				78.0	0.11
Total Labour.				140.4	0.20
Other costs:					
Overhead				137.4	0.19
Maintenance				528.0	0.72
Taxes and Insurance				137.4	0.19
Depreciation				1,099.0	1.50
Interest on Investment				1,419.0	1.94
Total Variable Cost				3,461.2	4.74
TOTAL COST OF PRODUCTION				43,285.4	59.10

ESTIMATED GRANULAR FERTILIZER PRODUCTION COST

(23-23-9.5)

Complex J I

Plant Capacity	805,200 MT/Yr	2440 MT/D	330 D/Yr
Plant Investment	MM$ 10.96		
Working Capital	3.70		
Total	14.66		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Triple Superphosphate					
MonoAmmonium Phosphate	MT	0.4420	69.05	24,574.7	30.52
Urea	MT	0.3895	32.19	10,097.2	12.54
Ammonia					
Potash	MT	0.1585	36.0	4,597.7	5.71
Utilities:					
Power	Kwh	43	0.2	692.5	0.86
Steam	MT	0.03	1.100	24.2	0.03
Fuel	Gals	6	0.10	483.1	0.60
Operating Supplies				120.8	0.15
Total Variable Cost				40,590.2	50.41
FIXED COST					
Labour:					
Operators				62.4	0.08
Supervision				78.0	0.10
Total Labour				140.4	0.18
OTHER COSTS					
Overhead				109.6	0.14
Maintenance				410.0	0.51
Taxes and Insurance				109.6	0.14
Depreciation				800.0	0.99
Interest on Investment				1,170.0	1.44
Total Variable Cost				2,739.6	3.40
TOTAL COST OF PRODUCTION				43,329.8	53.82

ESTIMATED GRANULAR FERTILIZER PRODUCTION COST

(23-23-9.5)

Complex S I

Plant Capacity	805,200 MT/Yr	2440 MT/D	330 D/Yr	
Plant Investment	MM$	10.96		
Working Capital		3.70		
Total		14.66		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Triple Superphosphate					
MonoAmmonium Phosphate	MT	0.442	68.57	24,397.6	30.30
Urea	MT	0.3895	30.12	9,445.0	11.73
Ammonia					
Potash	MT	0.1585	36.00	4,597.7	5.71
Utilities:					
Power	Kwh	43	0.02	692.5	0.86
Steam	MT	0.03	1.10	24.2	0.03
Fuel	Gals	6	0.10	483.1	0.60
Operating Supplies				120.8	0.15
Total Variable Costs				39,760.9	49.38
FIXED COST					
Labour:					
Operators 12 men/shift				62.4	0.08
Supervision 1 man/shift				78.0	0.10
Total Labour				140.4	0.18
OTHER COSTS					
Overhead				109.6	0.14
Maintenance				410.0	0.51
Taxes and Insurance				109.6	0.14
Depreciation				800.0	0.99
Interest on Investment				1,170.0	1.45
Total Variable Cost				2,739.6	3.41
TOTAL COST OF PRODUCTION				42,500.5	52.79

ESTIMATED GRANULAR FERTILIZER PRODUCTION COST

(23-23-915)

Complex J II

Plant Capacity 877,800 MT/Yr 2660 MT/D 330 D/Yr

Plant Investment MM$ 11.10

Offsites 4.00

Total 15.10

VARIABLE COST	Units	UNIT/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Triple Superphosphate					
MonoAmmonium Phosphate	MT	0.442	79.03	30,661.6	34.93
Urea	MT	0.3895	36.03	12,315.5	14.03
Ammonia					
Potash	MT	0.1585	36.00	5,012.2	5.71
Utilities:					
Power	Kwh	43	0.02	754.9	0.86
Steam	MT	0.03	1.10	26.3	0.03
Fuel	Gals	6	0.10	526.7	0.60
Operating Supplies				131.9	0.15
Total Variable Cost				49,419.1	56.31
FIXED COST					
Labour:					
Operators 12 men/shift				62.4	0.07
Supervision 1 man/shift				78.0	0.09
Total Labour				140.4	0.16
OTHER COSTS					
Overheads				111.0	0.13
Maintenance				431.0	0.49
Taxes and Insurance				111.0	0.13
Depreciation				888.0	1.01
Interest on Investment				1,208.0	1.38
Total Variable Cost				2,889.4	3.30
TOTAL COST OF PRODUCTION				53,505.3	59.61

ESTIMATED GRANULAR FERTILIZER PRODUCTION COST

(23-23-9.5)

Complex J-III

Plant Capacity	1,018,400 MT/Yr	3080 MT/D	330 D/Yr
Plant Investment	MM$ 12.54		
Working Capital	4.60		
Total	17.14		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $ Yr	$/MT
Raw Materials:					
Triple Superphosphate					
Monoammonium Phosphate	MT	0.442	68.29	30,735.3	30.18
Urea	MT	0.3895	31.65	12,556.9	12.33
Ammonia					
Potash	MT	0.1585	36.00	5,815.1	5.71
Utilities:					
Power	Kwh	43	0.020	875.8	6.86
Steam	MT	0.03	1.100	30.6	0.03
Fuel	Gals	6	0.100	611.0	0.60
Operating Supplies				152.8	0.15
Total Variable Cost				50,777.5	49.86
FIXED COST					
Labour:					
Operators				62.4	0.06
Supervision				78.0	0.08
Total Labour				140.4	0.14
OTHER COSTS					
Overhead				125.4	0.13
Maintenance				479.0	0.47
Taxes and Insurance				125.4	0.13
Depreciation				1,003.0	0.98
Interest on Investment				1,371.0	1.34
Total Variable Cost				3,244.2	3.19
TOTAL COST OF PRODUCTION				54,021.7	53.05

ESTIMATED COST OF TRANSPORTED FERTILIZER MATERIALS

Complex B II & J II

Cost of Prilled Urea - S	=	36.03
Cost of Loading Urea	=	3.00
Freight S to B	=	5.94
Cost of Unloading at B	=	3.00
Cost Bulk Urea in Plant - B		47.97
Cost Urea Ammonia Solution	=	18.82
Cost of loading	=	1.50
Freight S to B	=	1.17
Cost Unloading at B	=	1.50
Cost Urea Solution in Plant B		22.99
Cost /ton NH_3 = (6.42/18.58 x 22.99)/0.19	=	41.81
Cost/ton Urea = (12.16/18.58 x 22.99)/0.37.5	=	40.12
Cost of Map-B	=	67.09
Cost of Loading	=	3.00
Cost of Freight	=	5.94
Cost of Unloading	=	3.00
Cost in Plant - J		79.03

ESTIMATED TRIPLE SUPERPHOSPHATE (RUN OF PILE) PRODUCTION COST

(0-46-0)

Plant Capacity	297,000 MT/Yr	900 MT/D	330 D/Yr
Plant Investment	MM$ 1,752		
Working Capital	3,200		
Total	4,952		

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Phosphate Rock, 34% P_2O_5	MT	0.412	19.50	2,384.9	8.03
Phosphoric Acid, 54% P_2O_5	MT	0.345	123.13	12,616.5	42.48
Utilities:					
Power	Kwh	3	0.02	17.8	0.06
Total Variable Cost				15,019.2	50.57
FIXED COST					
Labour:					
Operators				15.8	0.05
Supervision				19.5	0.07
Total Labour				35.1	0.12
OTHER COSTS					
Overhead				17.5	0.06
Maintenance				43.1	0.15
Taxes and Insurance				17.5	0.06
Depreciation				140.0	0.47
Interest on Investment				396.0	1.33
Total Fixed Cost				649.2	2.19
TOTAL PRODUCTION COST				15,668.4	52.76

ESTIMATED GRANULAR FERTILIZER PRODUCTION COST
(20-20-8.5)

Plant Capacity 679,800 MT/Yr 2060 MT/D 330 D/Yr

Plant Investment	MM$ 9,446
Offsites	3,500
Total	12,946

VARIABLE COST	Units	Unit/MT	$/Unit	1000 $/Yr	$/MT
Raw Materials:					
Triple Superphosphate	MT	0.435	52.76	15,601.4	22.95
MonoAmmonium Phosphate					
Urea	MT	0.3765	30.12	7,708.9	11.34
Ammonia	MT	0.0300	33.81	686.6	1.01
Potash	MT	0.1415	36.00	3,460.2	5.09
Utilities:					
Power	Kwh	43	0.02	584.6	0.86
Steam	MT	0.03		20.4	0.03
Fuel	Gals	6		407.9	0.60
Total Variable Cost				28,470.0	41.88
FIXED COST					
Labour:					
Operators				20.8	0.03
Supervision				58.5	0.09
Total Labour				79.3	0.12
OTHER COSTS					
Overhead				94.5	0.14
Maintenance				383.0	0.56
Taxes and Insurance				94.5	0.14
Depreciation				771.7	1.14
Interest on Investment				1,035.7	1.53
Total Variable Cost				2,458.7	3.63
TOTAL COST OF PRODUCTION				30,928.7	45.51

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