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ASSISTANCE TO ESTABLISH A FERTILIZER BULK BLENDING AND BAGGING PLANT *

SI/SIL/78/801,

SIERRA LEONE,

Terminal report

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

Based on the work of Alain Marais, expert in nitrogen and NPK fertilizer production

United Nations Industrial Development Organization
Vienna

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Introduction

The expert has been sent for a three month mission in Sierra Leone in order to examine the possibilities to establish fertiliser bulk blending and bagging facilities in the country.

He has been assigned to work with the Ministry of Agriculture and Forestry.

The expert has completed the following:

1) Examined the fertiliser consumption and sources of supply in Sierra Leone; studied the projected demand to the year 1985;
2) Established the type and cost of fertilisers presently imported in Sierra Leone;
3) Established the cost of bulk raw materials for nitrogen and NPK fertilisers to Sierra Leone;
4) Established the cost of fertilisers which could be manufactured for crops grown in the country;
5) Studied the infrastructure existing and required to the fertiliser distribution to the farmers;
6) Proposed suitable location where fertiliser plant could be established;
7) Established the suitable capacity for bulk blending and bagging plant and its viability for investment in Sierra Leone;
8) Examined possibilities of regional co-operation and quantities of fertilisers which could be exported.

Acknowledgement

The UNIDO expert gratefully acknowledges the assistance and co-operation of the Ministry of Agriculture and Forestry and the co-operation of his counterpart, Mr. Patrick Vibby, Agricultural Officer, in the preparation of this study.

Summary

Sierra Leone like all West African countries has a basically agricultural economy. Although agriculture is only the second largest productive sector, (the mining sector being the first), about 75% of the population of Sierra Leone is engaged in agriculture. Agriculture in Sierra Leone is generally based on traditional farming systems which comprise only man, a few tools and animals, land, labour and self-produced seeds which are the main inputs. Modern inputs are little known.

The foodcrop oriented agriculture is hardly able to match the increasing requirements of a fast growing population. Rice is the dominant crops and the country's staple fooD, and rice production is far below rice consumption.

Government agricultural policy aims to reach self-sufficiency in rice and other food crop production and develop export-oriented crops generating of foreign exchange. The Ministry of Agriculture and Forestry has stressed the importance of intensive, modern agricultural development using scientific methods of cultivation.

Fertilizer use expansion is the first target of this policy. Fertilizer use is determined by; fertilizer and agricultural product prices,adequate information provided to farmers; and allowance of sufficient credit. According to this agricultural policy, the Government has given to the fertilizer mixing and bagging plant high priority.

The establishment of a 10 tons/hour capacity mixing and bagging plant seems to be adequate and will supply Sierra Leonean agricltural requirements for at least 10 years and reduced fertiliser price on internal market.

Conclusions

Although the level of fertilizer use in Sierra Leone is still low, the potential market is much higher than the present consumption, and as the Government laid more emphasis on intensive agriculture development necessity and started the promotion of agricultural research to improve crops yield and to reach equilibrium between food crops production and consumption as to develop exportation oriented crops; it is expected that for next years fertilizer requirements will increase strongly, especially if farmer can get fertilizer materials of the right type, at the right time and at a price which will not be prohibitive. It seems reasonable to assume that fertilizer requirements will reach at least 19,000 metric tons in 1981 and hence will increase 12% per year.

There is a market large enough to justify the establishment of a mixing and bagging plant. This is the simplest way of making a start in the fertilizer industry; import solid bulk fertilizers and set up facilities which blend nitrogen, phosphate and potash fertilizers and bag them to produce a wide range of mixtures for the national market.

This plant is not too much expensive, of relatively low technical complexity; it requires few skilled people and has a large production flexibility. It will permit to acquire gradually the necessary technical, commercial and management experiences in fertilizer industry.

Bulk blending and bagging plant can produce small quantities of any mixtures required to suit varying farming conditions for which it would be uneconomic to import and the bulk blending and bagging plant can also bag straight fertilizers if demanded. It will help to ensure that an agronomically right and productive balance of nutrients will be maintained.

Lastly, beside all these advantages, it is obvious that the fertilizer industry installation should help to develop and improve the local infrastructure, transport, storage, and marketing infrastructure, as well as applied agricultural research and extensive services. It should also stimulate fertilizer use and increase agricultural productivity.

Recommendations

1. It is recommended to set up fertilizer bulk blending and bagging facilities in Sierra Leone where agriculture is a national priority and there is no doubt that the plant installation will be very profitable for the country.

2. It is recommended to find outside assistance for financing. The factory cost has been estimated at Le.1,530,600 from which about Le.715,500 corresponding to imported equipment should be paid in foreign currencies. Working capital which is a part of the total investment amounts to Le. 826,173 from which about 88% corresponding to bulk imported fertilizer materials, c.i.f. Freetwon would have to be financed in foreign currencies.

Civil works, and building could be financed in national currencies.

Foreign currencies - Le. 715,500 + 727,870 = Le. 1,443,370

National currencies- Le. 913,403

3. As soon as the decision to go ahead with the project would have been taken, it is recommended to have expatriate expert assistance necessary for the following steps to be implemented:

a. State definitively the right location;
b. Prepare a tender specification for implementation;
c. Send the tender specification to a few engineering concerns specialised in fertiliser technologies;
d. Offer analysis for the proposals;
e. Choice of the contractor;
f. Contract preparation.

4. Training abroad is not necessary.

Local training is recommended during plant erection and foreign expert assistance is also recommended for a 2-month period at the plant operation starting in order to complete local training.

5. It is recommended to consider the establishment of fertiliser facilities in the framework of a union project between the two governments of Sierra Leone and Liberia, that would increase the feasibility of the plant and the viability of the investment.

6. An area near the port of Freetown is recommended as the most suitable location to establish fertiliser production facilities. It would avoid expensive storage on the port and difficult transportation of bulk materials on a long distance which otherwise should cause expensive losses.

7. It is recommended that the Government of Sierra Leone requests UNIDO to proceed with implementation of the fertiliser project.

Geography

Sierra Leone, covering an area of 27,925 square miles (73,326 km^2) is situated on the west coast of Africa. It is bordered on the north and north east by Guinea and on the south east by Liberia. It has 210 mile coastline along the Atlantic Ocean which constitutes the country's western boundary.

Sierra Leone consists of four broad regions; the Peninsula Mountains, the Coastal Plain, the Interior Plain and the Interior Plateau and hill region. The four regions running north west to south east are roughly parallel with the coast.

The Peninsula Mountains are located near Freetown, the present youthful topography, with its strongly dissected mountain range rising to almost 3,000 feet (900 m) is the result of relatively recent uplift, possibly in Tertiary Time.

A number of platforms have been carved into the mountain mass. Near the base of the mountains, a number of raised beached are present that are part of the coastal plain.

The Coastal Plain is a strip about 25 miles (40 km) wide adjoining the coast and parallel to it. Most of it is less than 50 feet (15 m) above the sea level. It is built up of marine, deltaic, and fluvial deposits of the Bullom series. The topography is nearly flat with many swamps. The coastal plain may be subdivided into sandy beaches, ridges and lagoons, mangrove swamps, alluvial grassland flood plain, and raised beaches and coastal terraces.

The Interior Plain is a strip about 60 miles (100 km) wide parallel to and east of the coastal plain. It is an old, gently undulating erosion surface that rise from an elevation of 50 feet (15 m) in the west to about 500 feet (150 m) in the east. It is broken by a number of isolated hills which are remaining from an earlier plateau.

The interior plain contains many swamps, especially in the area known as the Boliland Region. This area is underlain by sedimentary rocks of the Rokel River Series and presumably was the site of a delta formed by the merging Mabole, Rokel and Pampana rivers during a period of higher sea level. The rivers have poorly developed flood plains at their present level. However, river terraces far above the present river level are quite extensive.

The Interior Plateau and Hill Region covers the eastern half of Sierra Leone. It consists mainly of elevated plateau country between elevations of 1,000 and 2,000 feet (300 and 600 m) but includes numerous steep sided valleys and domeshaped granite inselbergs. In the central area and near the Guinea border, the Ting and Loma Mountains rise above the main plateau region with peaks higher than 6,000 feet (1,800 m). Most of the area is underlain by granite and acid gneiss, although some smaller areas consist of basic schists. The interior plateau and hills are separated from the interior plain to the west by a rather sharp escarpment especially in the north. Farther south, the escarpment is much less clearly defined and more dissected.

Climate

Sierra Leone has a hot tropical climate with distinct rainy and dry season. Four main types of weather may be recognized. In the rainy season(May-November), thunder storms and squalls; and steady rains.

In the dry season (December - April) dry weather with high humidity and short periods of dry weather with low humidity, sudden drop in relative humidity from almost 100 % to sometimes as low as 20 % can be experienced. This is caused by dry eastern or north eastern winds from the Sahara (Harmattan).

The wet season is more extreme in the coastal area with 120 to 200 inches (3,048 to 5,080 mm)or more of rainfall and least in the north with rainfall of less than 80 to 100 inches (2,032 to 2,540 mm). The dry season is more severe in the north, having less than 5 inches (127 mm) of precipitation, and least in the central eastern part with 10 to 15 inches (254 to 381 mm) or more of rainfall.

The intensity of the rainfall is very high. For Bronthe a maximum daily reinfall of 11.68 inches (297 mm) and for Freetown a maximum hourly rainfall of 5.91 inches (150 mm) have been recorded.

March and April have the hottest days with mean monthly temperatures of 86°F to 93°F (30°C to 34°C) near the coast and 93 to 99°F (34 to 37°C) inland. July and August usually have the coolest days with mean monthly maximum temperatures from 81°F to 83°F (27 to 28°C). Inland nights are coolest in December, January and February with mean monthly maximum temperatures as low as 57 to 68°F (14 to 20°C). Nights are much warmer along the coast and reported mean monthly minimum temperatures range from 73 to 78°F (23 to 26°C) with the coolest nights in July and August.

Human Geography

The population is estimated at about 3 million including a few thousand Europeans, Americans and Asians with an annual growth rate exceeding 2.5%. Last national census was undertaken in December 1974.

The population comprises some 20 tribes, each with its own language and customs. The main tribes are the Mende in the south and the Temne in the north; together they make up about 60% of the population. There is also an important Creole element, descendants of resettled families from England, America and West Indies in the 18th century who reside mainly in the Freetown area.

The Meude and Temne languages are widely spoken, but the majority of Sierra Leonean speaks Krio (a derivative of English) as a lingua franca. English is the official language.

The population density which is about 107 per square mile is the greatest in the Western Area (over 250 per square mile) but decreases to about 25 per square mile in the northern and eastern areas. The population is predominantly rural.

Freetown, the capital and principal city, has an estimated population of about 300,000. The other chief towns are Bo in the south, Makeni in the north and Kenema and Sefadu in the east.

Economic and Social Conditions

Sierra Leone is a predominantly agricultural country with 80% of its population depending on farming and fishing largely of the subsistence variety for livelihood.

Rice is the basic crop as well as the staple food of the country. Oil palm, coffee and cocoa are the most important agricultural exports.

Although agriculture is the dominant sector of the economy, it accounts for only 30 to 35% of the Gross Domestic Product. Mineral exports yield the greatest revenue, and in recent years, diamonds, the country's most valuable product, have accounted for more than two thirds of total foreign earnings. Bauxite and rutile are also mined.

General Nature of Sierra Leone Soils

Uplands

Two types are recognised.

1) River terrace soils along river banks in the interior formed to a large extent from gravel, free alluvium material. Some of these soils can be flooded or become waterlogged during the rainy season.

2) Ferrolitic soils formed an old upland erosion surfaces and steep hills. These soils are acid, low in water holding capacity and available plant nutrients.

Usually the uplands are well drained and aerated. The pH varies from 4.0 to 5.0.

Inland valley swamps

Inland valley swamps occur at depressions of rolling uplands generally with narrow and winding streams at the centre of the swamps. The swamps are found all over the country and are used for lowland rice cultivation in the wet season. The basic material is mainly colluvium. They are poorly drained and have a thick humus rich surface layer clay and often high in iron which have been associated with toxicity problems.

Mangrove swamps

They occur along the cost and in the mouth of creeks and rivers where a saline tidal environment is present; the soils are from recent marine, estuarine mud under salt water.

Two types of mangrove trees are present, Risophora Racemosa and Avicennia Nitida.

Risophora Racemosa occurs on soft fibrous muds that are waterlogged throughout the year. Upon empoldering and drying these muds may develop into very acidic sulphate soils.

Avicennia Nitida occurs on firmer non fibrous soils that are more sandy or somewhat better drained; such soils are not potential acidic sulphate soils.

Bolilands

The Boliland region is a swampy area in the interior plain where the major rivers cross the sedimentary rocks of Rokel River series. It is extremely flat or large sauser, shaped inland depressions usually supporting grassy vegetation. Though this region is flooded in the wet season, the water depth varies largely within boliland soils and pose a serious problem of water control.

Deepflooded grasslands

The riverain grassland areas occur in southern Sierra Leone on the alluvial flood plains of the Wange and Serra Rivers as they cross the coastal plain; they are annually flooded to depth of 6 metres. These are young alluvial soils from the Bullom series. They have a thick dark humus layer and are acidic (pH 3.6 to 4.2) to an extent that aluminium toxicity can be a serious problem in these soils.

Agriculture in Sierra Leone

Sierra Leone is predominantly agricultural country with 70% of its population depending on farming.

Crop production is greatly influenced by climate. The dry season is shortest in the eastern section of Sierra Leone and this area is best suited to plantation crops such as cocoa, coffee, bananas and oil palm. Most citrus crops which go through an annual dormancy period can be grown in areas where the dry season is more intensive. The amount of sunlight is sometimes a limiting factor in production. Sugar cane for example is considered a marginal crop in Sierra Leone because of inadequate sunlight.

The principal crops grown in Sierra Leone are rice, cassava, maize, groundnuts, cocoa, oil palm, coffee and citrus.

Rice

Rice is the most important crop grown in Sierra Leone and the whole farming system is revolving around it. Rice is the staple food of the people in the country as it is a large part of the diet in West Africa.

Traditionally rice is grown on the sloping uplands where shifting cultivation is more easily practised under native management systems. On the more level and productive terraces alluvial flood plains and swamps, the sod of tall native grasses is very difficult to destroy with conventional native handtools. Development of these areas for rice production depends to some degree on mechanization. If minimum mechanization is available, rice production is ideally situated to the coastal plains, river terraces and bolilands. The bolilands, stream terraces and some inland valley swamps occur in large enough tracts to be suited to large scale mechanized rice production. Swamps floating and boliland rice yields are usually higher than upland rice yields.

Practically all upland rice and as much as 60% of the lowland rice is broadcast-seeded directly on the soil.

Approximately 40% of the swamp rice is established by seedling transplants.

Practically all rice is hand harvested. Minimum mechanization of rice production, therefore, need involve only ploughing and preparing the better soils for rice seeding.

Maize

Maize production in Sierra Leone is steadily increasing and as the livestock industry develop, the demand for maize will increase further. Maize can be grown on any of the more productive soils adequately drained. Maize is usually grown either during the early or late part of the rainy season (seeded in May or seeded in September).

Plantation crops

Plantation crops such as oil palm, coffee, cocoa and rubber are being grown on a wide variety of Sierra Leone soils. Generally the limitation to high plantation production is not lack of suitable soils, but rather the climate. The dry season is very intensive. Total rainfall during December, January and February seldom exceeds 4 to 5 inches (100 to 125 mm) and without irrigation crops such as oil palm, coffee, cocoa and rubber make no significant growth for three to five months of the year, especially on upland soils, and cannot be produced competitively for the world market.

More plantations should be established on the well drained better soils where irrigation is possible.

Citrus fruits (oranges, grapefruits and tangerines) produce relatively better than coffee or cocoa. The well drained soils on colluvial footslopes and terraces are more desirable than the upland soils for citrus production, but with moderate fertilization, citrus can produce surprisingly well on the upland soils.

Other crops

A wide variety of crops including vegetables, pineapples, soybeans, sweet potatoes, ginger and cassava are grown in Sierra Leone, mostly on the upland soils in mixed culture with rice. Generally these upland soils are not the best soils for these crops. The deeper well drained soils on colluvial footslopes and terraces are more suited.

Recent crops introductions include fibre crops and pasture grasses for animal feed. Framer interest in growing these new crops is increasing.

(See Table 1 and 2. Principal Crops grown in Sierra Leone)

Table 1

Acreages under Principal Crops and Total Production

Crops	Acreages	Hectares	Total Production mt.	Yield per hectares mt.
Upland rice	600,747	243,122	318,975	1.312
Swampland rice	206,810	83,696	123,903	1.480
Guinea Corn	11,737	4,750	5,868	1.235
Millet	14,090	5,702	6,289	1.103
Maize	25,891	10,478	10,403	0.993
Cocoyam	10,993	4,448	21,670	4.872
Cassava	41,180	16,666	81,179	4.871
Sweet potatoes	17,336	7,016	18,304	2.609
Pepper	2,245	909	2,212	2.433
Beniseed	4,430	1,793	-	-
Coffee	176,077	71,258	19,650	0.276
Cocoa	115,256	46,644	6,431	0.138
Citrus fruit	12,463	5,043	48,441	9.605
Bananas	10,221	4,136	13,689	3.310
Kolanuts	18,497	7,486	3,964	0.530
Coconuts	3,188	1,290	1,878	1.456
Pineapples	1,969	797	15,820	19.850
Mangoes	1,730	700	3,476	4.966
Groundnuts	34,128	13,812	14,917	1.080

Source: Central statistics office 1976

Table 2. Agricultural Production in Sierra Leone

Crops	1961-1965 Area 1000 Ha	1961-1965 Yield Kg/Ha	1961-1965 Production 1000mt.	1974 Area 1000 Ha	1974 Yield Kg/Ha	1974 Production 1000mt.	1975 Area 1000 Ha	1975 Yield Kg/Ha	1975 Production 1000mt	1976 Area 1000Ha	1976 Yield Kg/Ha	1976 Production 1000 mt.
Rice paddy	273	1,230	336	370F	1,416	524*	380F	1,439	547*	390F	1,487	580F
Maize	17	538	9	12F	1,042	13F	13F	1,040	13F	13F	1,038	14F
Millet	7	1,607	12	7F	1,077	7F	8F	1,000	8F	9F	1,000	9F
Sorghum	7	1,585	12	7F	1,385	9F	7F	1,500	11F	7F	1,529	11F
Roots and tubers	25	3,111	78	31F	3,312	103F	32F	3,281	105F	33F	3,287	108F
Sweet potatoes	3	2,633	9	5F	2,111	10F	5F	2,000	10F	5F	2,019	11F
Cassava	20	2,950	59	25F	3,320	83F	26F	3,333	83F	26F	3,346	87F
Broad beans dry	44	505	22	46F	522	24F	47F	527	25F	47F	532	25F
Peas dry	2	563	1	2F	688	1F	2F	688	1F	2F	688	1F
Groundnuts in shell	32	715	23	25F	680	17F	25F	680	17F	27F	667	18F
Sesame seed	2	500	1	2F	410	1F	2F	415	1F	2F	425	1F
Coconuts	-	-	22	-	-	20F	-	-	20F	-	-	20F
Palm kernels	-	-	56	-	-	45*	-	-	52*	-	-	54*
Palm oil	-	-	37	-	-	45*	-	-	55*	-	-	56*
Vegetables	127	321	1	143F	399F	1F	144F	399F	1F	145F	400F	1F
Tomatoes	1	7,273	8	1F	6,923	9F	1F	6,923	9F	1F	6,923	9F
Citrus fruit	-	-	89	-	-	110F	-	-	110F	-	-	110F
Mangoes	-	-	46	-	-	52F	-	-	52F	-	-	52F
Plantains	-	-	154	-	-	200F	-	-	200F	-	-	200F
Coffee green	14	302	4	15F	210	3F	25F	295	7F	15F	333	5F
Cocoa beans	50	73	4	50F	120	6*	50F	120	6*	50F	120	6*

FAO Production Yearbook 1976, Vol.30   F = FAO estimate   * unofficial figures   - data not available

Fertiliser Use in Sierra Leone

In inland valley swamps and irrigated lowlands of Sierra Leone three crops of rice could be taken one after the other during a calendar year. In the uplands, mixed or intercropping of rice with maize, sorghum, pearl millet, pigeon pea, cow pea, cassava, garden egg and tomato is extensively practised in Sierra Leone.

However, the fertilizer level of most soils in Sierra Leone is low and so the average yields are low for almost all crops.

Although rice is the most important crop in Sierra Leone and the average yield estimated at about 1,470 kg per hectare is not too much lower behind of other West African countries, the high per capita consumption and the increasing demand of rice in urban areas have resulted in importations of 40,000 to 50,000 tons per year.

Government efforts to increase rice production have been implemented through mecahnical cultivation of the bolilands and riverain grasslands, and the expansion of rice areas in the inland valley swamps. But extensive cultivation has failed to reach the balance between domestic production and domestic consumption of rice.

It has become evident that higher production will be obtained only through the adoption of modern and scientific methods of cultivation.

The Ministry of Agriculture and Forestry has,therefore, stressed the great importance of intensive agricultural development and fertiliser use is an integral part of such a system.

The best strategy for agriculture production is based on use of high yielding varieties and multiple cropping and for this strategy fertilizers are indespensable.

There are tremendous potentialities of increasing many times more food per unit area per unit time by using multiple cropping but of course the rate of depletion of nutrients is also very high and high yields can be obtained only with heavy use of balanced fertilizers.

Fertilizers applied to one crop benefit to some extension the succeeding crops also and thus exhibit what are known as "direct" "residual" and "cumulative effect".

Results have clearly shown that in mixed or intercropping system the fertiliser use efficiency could be considerably increased and the cash income of the farmer will be augmented with no extra cost on fertilisers.

Naturally in addition to using high yielding varieties and balanced fertilizers, it is also very important to take proper weed and disease control measures, good land preparation and good water control.

Substantial economy could be performed in fertilizer use by developing fertilizer recommendations for mixed or intercropping systems (growing two or more crops together in the same field) in uplands; and single year two crops rotations in irrigated low lands and inland valley swamps.

Table 3 shows performance of rice varieties kg per ha., on farmer's fields under improved and local methods of cultivation.

The Table clearly shows that the varieties under improved practices gave higher yields from 158 to 338% increase over local practices.

There was an important variation among varieties in so far as their response to fertilizer application is concerned.

To get maximum benefit from fertilizer application and improved management, it is also necessary to select the appropriate variety.

Table 3.

Performance of Rice Varieties (kg/ha) on farmers' fields under Improved and Local Methods of Cultivation (Wet season 1975, R.C. School Rokupr)

Variety	Improved Practice	Local Practice	Percentage increase over local practice
1. Rock 1	2,465	682	261.4
2. Rock 2	2,788	1,079	158.4
3. Rock 3	1,945	403	382.6
4. 086	3,256	771	322.3
5. AxBG 7.3	2,955	1,015	191.1
Mean	2,682	790	239.5

The local method consisted of broadcasting the sees without application of fertilisers and plant protection measures while the improved method consisted of sowing seeds in lines and fertiliser application at the rate of 60 kg N, 40 kg P_2O_5, and 40 kg K_2O per hectare.

The use of mineral fertilisers in Sierra Leone initiated 25 years ago about the same time as started mechanical cultivation. Before this time farmers thought of fertiliser use only in terms of organic fertilisers such as farmyard manure, poultry manure and compost which are still in use today but not to a large extent as the mineral fertilisers.

Particularly during the last decade Government authorities laid more emphasis on intensive agricultural development and great efforts have been made to introduce mineral fertiliser use in local traditional methods of cultivation and to inform farmers of the profits returned when regular application is made. Nevertheless there are still many small scale farmers who do not apply any fertiliser at all.

Table 4 and 5 give fertilizer consumption during the decade from 1966 to 1976.

Naturally this consumption seems very low, about 0.3 kg of nutrient per capita during 1971 - 1976 period (Africa average 5.7 kg per capita and world average 20.6 kg per capita). But these tables show a large increasing fertilizer use, about 6.5 times more during the last five years than during the first ones.

The annual fertilizer review 1976 gives figures much more higher(see table 6 nutrient annual average for 1971 - 1976: 2,814 metric tons.

All fertilizers used in Sierra Leone should be imported by the port of Freetown. The port statistics give the amount of imported fertilizers during the last years.

July 1974 to June 1975	- 8,460.29 mt.
July 1975 to June 1976	- 10,558.54 mt.
July 1976 to June 1977	- 2,924.05 mt.
July 1977 to June 1978	- 1,260.58 mt.

Table 4

Ministry of Agriculture and Natural Resources Fertiliser Unit
Fertiliser imported and distributed 1966 - 1970
In mt. of fertiliser material and nutrients N, P_2O_5 and K_2O

Type of Fertiliser	Tonnage	Quantity of Bags	N	P_2O_5	K_2O
Ammonium sulphate	778	15,560	163	-	-
Urea	334	6,680	154	-	-
Nitro chalk	14	280	3	-	-
Single superphosphate	1,094	21,880	-	197	-
Basic slag	39	780	-	7	-
Potassium chloride	115	2,300	-	-	69
Potassium sulphate	33	660	-	-	17
NPK 20-20-0	50	1,000	10	10	10
NPK 15-15-15	20	400	3	3	3
Kieserite ($MgSO_4$)	95	1,900	-	-	-
Total	2,572	51,440	333	217	99

Annual Average

Per nutrient			All nutrients
N	P_2O_5	K_2O	$N + P_2O_5 + K_2O$
67	43	20	130

Average nutrient ratio $N - P_2O_5 - K_2O$ 1 - 0.65 - 0.30

Table 5

Ministry of Agriculture and Natural Resources Fertiliser Unit - Fertilizer Orders 1971 - 1976 Tonnage and Distribution

Type of Fertilizer	Tonnage mt.	Quantity distributed mt.	Stock mt.
Ammonium sulphate	1,000	643	357
Basic slag	150	150	
Urea 46%	350	350	
Potassium sulphate	230	230	
Potassium chloride	671	67	604
NPK 15-15-15	2,100	656	1,444
SSP 18%	950	619	331
Rice fertiliser 20-20-0	9,600	8,266	1,334
Total	15,051	10,981	4,070

Annual average

Per nutrient

N	P_2O_5	K_2O
410	378	51

All nutrient

$N + P_2O_5 + K_2O$
839

Average nutrient ratio - $N - P_2O_5 - K_2O$

1 - 0.65 - 0.30

Table 6

Fertiliser consumption in Sierra Leone

Equivalent nutrients (metric tons)

	N	P_2O_5	K_2O	Total
1966 - 1967				502
1967 - 1968				850
1968 - 1969				1,100
1969 - 1970				2,281
1970 - 1971				2,522
1971 - 1972				1,600
1972 - 1973	530	513	183	1,226
1973 - 1974	1,135	1,128	534	2,797
1974 - 1975	1,044	104	1,300	3,348
1925 - 1976	2,200	2,000	900	5,100

Annual Fertiliser Review 1976

All the informations which have been collected, although they were often contradictory and not very reliable appear to indicate an average fertiliser consumption in Sierra Leone of about 6,000 metric tons per year for the past five years.

Based on 1975 - 1976 importations and with a normal growth rate of 12% per year the actual consumption should be about 13,000 metric tons for the present year.

It is difficult to state why fertilizer use has been suddenly going down on 1977 and 1978. In fact, it might be late ordering and lack of supply.

The actual consumption is low much behind Sierra Leonean agricultural requirements and increase fertilizer use shall be the first target to develop a modern intensive agriculture.

Fertiliser Use and Distribution Recommendations

Important progresses have been made during the last years, particularly for the past five years concerning importation and distribution of fertilizers.

However, there are still many areas where fertilizers are not yet offered.

The Eastern Region, Kono District (a diamond mining district), the western area with the mountain villages and Koinadugu district in the north eastern region have a very low consumption of fertilisers and traditional type of agriculture.

Other areas such as Makeni in Bomboli district, Tombolili district, Port Loko district in the northern province and Pujehum district in the south province have already developed a relatively high fertiliser consumption and many farmers have become fertilizer conscious.

Last there are a few areas fully commercially oriented farmers who generally use fertilizers up to the economic level. These are the project areas, where distributing and marketing systems are relatively well developed. Farm inputs are decided by the project officials and these semiautonomous projects are responsible for the importation and the distribution of their own fertilisers.

In Sierra Leone the Government is responsible for all fertilizer importation and sells them straight to farmers through its agents such as the principal agricultural officers at regional level and the agricultural officers at circle or station level; or sometimes farmers belong to co-operative organizationswhich do the purchasing of fertilizer directly from the Government and distribute them to their members who pay from the harvest proceeds either in cash or in kind.

Generally, fertilizers have created a significant impact on agricltural productivity since the beginning of their application on crops. More yield will be expected if the right fertilizer is applied at the proper time correct dosage on all farms.

Fertilizers are usually the first production input purchased by the Sierra Leonean farmers and the expense incurred represents a major portion of his liquid capital or available credit; therefore technical advisers should provide sound information to him about the types, timing and quantities of fertilizers he should use in order to get a sound return on his investment.

The need to develop right fertilizer recommendations at the farmers level is always very important. Usually, due to the lack of enough extension staff, the mass of small scale farmers are insufficiently reached.

Promotional activities have to be continued and increased, and special care has to be given to the farmers who are not yet applying sufficient fertilizers. They should develop and improve a marketing and distributing system which will be extended to cover areas and farmers not still properly serviced especially in the small farm sector.

The major target of fertilizer marketing and distribution system should be to have fertilizers at the farm, at the right time, of the right type in the right quantity and at the lowest cost. Improving the efficiency with which transport, storage and handling are carried out is the first step to catch up with this objective.

Transportation costs can possibly be reduced by utilising available transport facilities in a better way; transport off-season when freight rates are lower and better use of return load capacity.

Sufficient and adequate storage capacity have to be assured at all levels, import level regional level and farm level.

The best means to improve transport and storage facilities are to promote early planning fertiliser orders. Early ordering is very important in fertiliser importation as it takes several months between orders and arrivals of fertilisers.

Sufficient credit should be allowed to marketing, distributing enterprises and farmers. Co-operative system must be extended to the small scale farmers and credit has to be allowed through co-operative to their members.

Table 7.

Fertiliser Prices in Sierra Leone Internal Market

Fertiliser	Price Le. per 50 kg bag		
	1976	1977	1978
Urea 45 - 46% N	6	9	11.30
Ammonium sulphate 21% N	4	6	7.50
NPK 20-20-0	3	4.50	5.60
NPK 15-15-15	6	9	11.30
Single superphosphate 18% P_2O_5	3	4.50	5.60
Basic slag 17% P_2O_5	3	4.50	5.60
Potassium chloride 60% K_2O	5	7.50	9.40
Potassium sulphate 50% K_2O	5	7.50	9.40

Fertilizer prices on internal market have strongly increased during the last three years in the same time as international market prices were going down, so the Government subsidy must be now very low.

Table 8

Fertilizer Price C and F Freetown Sierra Leone
August 1978

	metric tons	50 kg bags	C and F DM	Price/ton US$	Leones price per bag
NPK 0-20-20	200	4,000	86,100.00	222.14	11.12
NPK 20-20-0	165	3,300	72,715.00	227.40	11.39
Basic slag	500	10,000	154,750.00	159.70	8.00
Urea	200	4,000	82,400.00	212.59	10.64
Muriate of potash	330	6,600	97,350.00	152.22	7.62

Conversion rate used in calculation is 1 DM 1.935 to Le. 1.00
1 US$ to 1.938 DM

Other costs incurred in Sierra Leone

Transporation	Le. 16,707 per ton	0.835 per bag
Handling charges etc.	" 9,111 per ton	0.456 per bag
Landed cost	" 4,364 per ton	0.218 per bag
		1.51

For landed cost add Le. 1.51 to C and F price of 50 kg bag.

Fertiliser Manufacture

Fertilizers are materials containing one or more elements essential to plant growth, nitrogen, phosorus and potassium called macronutrients as well as metals like iron, copper, boron, zinc, etc., called micronutrients.

Nitrogenous fertilizers

Ammonia (NH_3, 82% N) is actually the main source of all nitrogenous fertilizers. As indicated by the chemical formula ammonia consists of nitrogen and hydrogen. Nitrogen a part of the atmospheric air is largely available everywhere. Hydrogen is obtained from hydrocarbons.

Today natural gas (methane) is the usual raw material for the ammonia synthesis and it is also the cheapest one. Liquid ammonia is sometimes used with special equipment for direct application, but the largest part of the ammonia production is converted to ammonium phosphates, ammonium sulphate, ammonium nitrate, urea, or compound fertilizers.

Phosphate fertilizers

Phosphate rock is the basic material for phosphatic fertilizers. It is obtained by a mining industry.

Some raw phosphates (depending on the solubility, formic and citric acid solubility) can be used on certain acid soil in climatic tropical countries finely, ground without any other transformation.

Generally it must be converted into a water soluble form obtained through a reaction with sulphuric acid giving single superphosphate or through an intermediate stage of phosphoric acid which is the basis for triple superphosphate or ammonium phosphate production.

Potash fertilizers

Potassium salts are also obtained by mining industry. Potassium chloride (muriate of potash) is the main source and also the cheapest. Potassium sulphate is sometimes used principally for agronomical reasons, when chloride is noxious for the crops.

Fertilizer Plants

Considering economical reasons, it is heavily recommended that only the developing countries which own natural gas or oil built ammonia plant, like Algeria or Nigeria.

Developing countries in rock phosphate mining areas should develop phosphoric acid plant facilities, like Morocco, Algeria, Tunisia and Togo.

In modern ammonia plant single stream and large capacity based on low cost natural gas, the cost of ammonia per ton is less than half that of small capacity ammonia plants.

The production of 1 ton phosphoric acid (50% P_2O_5) uses 2 tons of raw material (phosphate and sulphur) which result in expensive costs if they are not available near the plant.

Other possibilities for developing countries which do not own fertilizer raw material are NPK satellite plants or mixing plants.

Developing countries with medium sized market, 25,000 tons of nitrogen and 15,000 tons of P_2O_5 per year can import fertilizer intermediates such as ammonia and phosphoric acid to operate granulation plant for the production of NPK fertilizers.

The best solution for developing countries with fertilizer markets smaller than the above consists in blending and bagging plants for the production of NP and NPK formulations using basic imported materials such as urea, mono or diammonium phosphate etc.

However, it was proposed in 1973 before the increase in the price of oil to built an ammonia urea plant in Sierra Leone, mainly to supply the domestic market and to export to neighbouring countries. That plant had to be based on available fuel oil surplus from the Sierra Leone refinery in combination with imported naphtha as feedstock. The proposal was delivered in 1974 after the oil price increase by N-Ren International, a Belgian company. The proposed production would have been 58,000 tons of ammonia and 98,000 tons of urea, with two ammonia plants feeding one urea plant.

The capital cost was estimated at US$42 million.

The proposal was based on the low fuel oil prices prevailing in 1973, the plant would have been then marginally competitive with the European fertilizer complexes exporting to African countries.

However, the plant would have faced severe competition from the new export oriented ammonia/urea plants coming on stream in the Middle East and in Nigeria which are based on low cost natural gas as feedstock.

The proposed Sierra Leone plant can certainly be considered uneconomic and would not have been able to survive without governmental protection. Ammonia could certainly be imported from Nigeria cheaper that it can be produced by small size ammonia plant.

Bulk blending and bagging facilities appear much more suitable for Sierra Leone, agricultural country with fertilizer market still small but that should be increasing strongly in next coming years.

Manufacture of complete or mixed fertilizers

Mixed fertilizers are containing 2 or 3 major nutrient elements (NPK) as well as secondary and trace elements.

Fertilizer mixtures are calculated on the net metric ton basis. The nitrogen (N); phosphoric acid (P_2O_5); and potash (K_2O) and other nutrients are expressed in per cent. An analysis of grade, for example 15-15-15 represents the percentage of nitrogen N, phosphoric acid P_2O_5 and potash K_2O in the fertilizer respectively and the sequence of the numbers in a grade is always NPK.

The ratio between the various nutrients is usually adapted to the special requirements of soil conditions and certain crops.

There are two ways to manufacture complete fertilizers:

1. The process involves complex chemical reactions; compound fertilizers are granulated and each granule is of the same composition.

2. Physical mixing without chemical reaction of dry fertilizer materials to produce complete mixtures powder or granulated.

Costs for mechanically prepared mixtures are lower than for the corresponding compound fertilizers.

Less labour consuming application is a common advantage of both types compound and mechanical mixtures as compared to single fertilizers.

An extensive range of mixed fertilizers is produced and in trade, new types each time more concentrated appear continuously.

In developing countries where the formulations would be manufactured and fertilizers would be bagged, the main reasons for introducing fertilizer blending facilities would be to have an inexpensive way of starting local manufacturing, to promote the efficient use of fertilizers, to make savings in transportation and bagging costs, to assist in building up the infrastructure needed for fertilizer distribution and storage.

With mecahnically mixed fertilizers relatively small quantities of any composition desired can be prepared which may be an advantage where detailed fertilizer recommendations lead to the need for a great variety of fertiliser formulations.

Precautions in blending of fertiliser materials

1. The problem of mechanical segregation of components may exist when fertilizers have to be transported under difficult conditions.

Segregation leads to the destruction of homogeneity of mixed material. Numerous tests have proved that the main cause of segregation is differerences in particle size; the classification which occurs leads to off-grade analysis in blends even if each batch has the correct average composition after leaving the mixer.

Segregation can be kept within acceptable limits if the following precautions are taken.

a) Use materials with similar particle size distribution and containing approximately equal percentages of size fractions, 1 - 2, 2 - 3 and 3 - 4.

b) Avoid coning especially when close size matching is impractical.

c) Minimize handling, segregation occurs only when materials are physically moved.

2. When basic fertilizer materials are to be mechanically mixed, the problem of their compatibility has to be examined.

- Some materials are completely incompatible;
- Some mixtures have to be applied immediately after their preparation;
- Other mixtures can safety be prepared and stored.

Being water soluble all fertilisers are more or less hygroscopic, they have tendency to absorb mixture as water vapour from the air. For safe storage, therefore, the air in storage buildings should have a humidity below the critical relative humidity of the fertilizer materials. Mixtured materials have a lower critical relative humidity than that of either component and hence are more hygroscopic than the single materials.

The main basic materials to be mixed in a bulk blending plant are:

urea	: 45% N
diammonium phosphate	: 18 - 46
monoammonium phosphate	: 11 - 51
potassium chloride	: 60% K_2O

If superphosphate single or triple have to be used, precautions should be taken to avoid mixturing with diammonium or monoammonium phosphates.

Bulk Blending and Bagging Plant
Description of the Plant

The mixing and bagging plant will include:

- Raw material unloading facilities, reception and handling;
- Bulk raw material storage;
- Reclaiming bulk raw material from storage;
- Blending installation;
- Bagging facilities;
- Bagged product storage;
- Maintenance workshop;
- Spare part warehouse;
- Laboratory;
- Infirmary;
- Administrative buildings.

Bulk material reception and handling

The raw material will be delivered by trucks (about 10 tons). Trucks will go through a weighing machine on an underground hopper equipped with a screen (100 mm x 100 mm).

Reclaiming under the hopper will be carried up by means of a belt conveyor feeding bucket elevator.

The elevator feeds another belt conveyor located under the peak at the roof. This conveyor will be equipped with a tripper carriage running along the length of the bulk material storage and feeding the bins on each side.

The unloading and handling rate will be 100 tons/hour.

Raw material storage

Storage capacity will be about 5,000 metric tons of bulk material. The building will have an area of 1,500 square metres and the following sizes:

Length: 50 metres
Width: 30 metres
Height: 10 metres

The width includes a five metre lateral gallery for payloader operation.

As at least 4 or 5 different materials will have to be operated, individual storage bins will be provided with partition walls of the type commonly called "American partitions" which are very well done to carry the load of the stack and not too much expensive.

The bin capacities which seem appropriate are:

1 bin of 2,000 tons

2 bins of 1,000 tons

2 bins of 500 tons

Anyway this type of partitions can be easily moved to enlarge or to lessen if it would be necessary.

The storage building should have a concrete floor high enough to prevent entrance of rain water and to isolate fertilizers from the soil moisture.

Reclaiming, mixing and bagging

Mixing and bagging plant will have an area of 300 square metres and the following sizes:

Length: 30 metres

Width: 10 metres

Height: 19.5 metres

Reclaiming should be performed by using payloader equipped with an hydraulic tilting shovel with a capacity of about 1 m^3.

The payloader feeds a receiving hopper (about 5 m^3 of capacity) equipped with a grid (100 mm x 100 mm).

The hopper itself through a regulating damper and a belt extractor equipped with a magnetic drum feeds a bucket elevator which carries material up to a screen and into a cluster of 4 bins (4 x 5 m^3). A lump crusher shall be provided in order to crush the overflow from the screen.

The 4 bins will be equipped at their bottom with a vibrator and and closed with a discharge gate.

Basic material fertilizer will be stored in these bins and through a belt distributor and a weighing hopper feeded into the mixer. The handling rate of the material through the bucket elevator, the screen and to the bins will be about 50 tons/hour. The mixer capacity will be 10 tons/hour.

At the exit of the mixer a bucket elevator will carry up blended material into two bagging hoppers, one for granulated material and the second for powdered material.

These hoppers will also be equipped with vibrator and discharge gate. They will feed two bagging machines for granulated and powdered material.

The handling rate of material through the elevator to the bins will be about 15 tons/hour.

Bagging machine capacity will be 100 tons/hour or 200 x 50 kg bags.

At the bagging machine exit two belt conveyors will be provided to carry out bagged material towards bagged fertiliser storage. If it is necessary to bag single basic material such as urea or diammonium phosphate for instance, it will be possible to takeit directly under the screen to the bagging hopper by passing all the mixing operation.

Bagged fertiliser storage

The bagged fertilizer storage building will have a capacity of 3,000 metric tons and the following sizes:

Length:	50 metres
Width:	25 metres
Height:	7 metres
Total area:	1250 square metres

The building storage floor must be moisture proof and bagged fertilisers should be advantageously stored on wood floor as it is in palletisation system.

Empty bag storage

An area of about 50 square metres will be needed for the storage of empty bags.

Maintenance, warehouse, laboratory

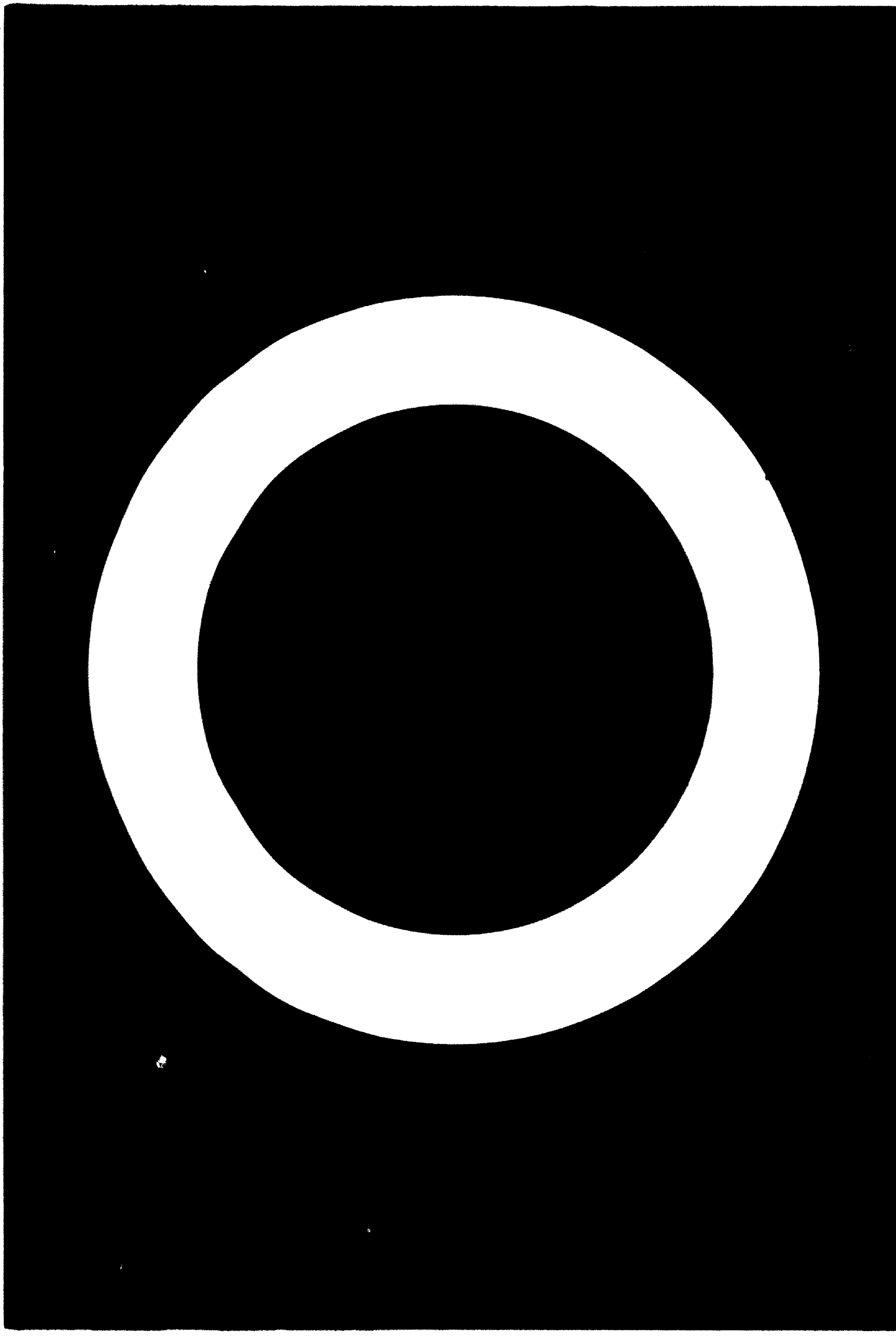
An area of about 150 square metres will be needed for maintenance workshop, spare parts warehouse and laboratory.

The total area of the bulk blending and bagging plant will be 3,250 square metres. Its sizes will be:

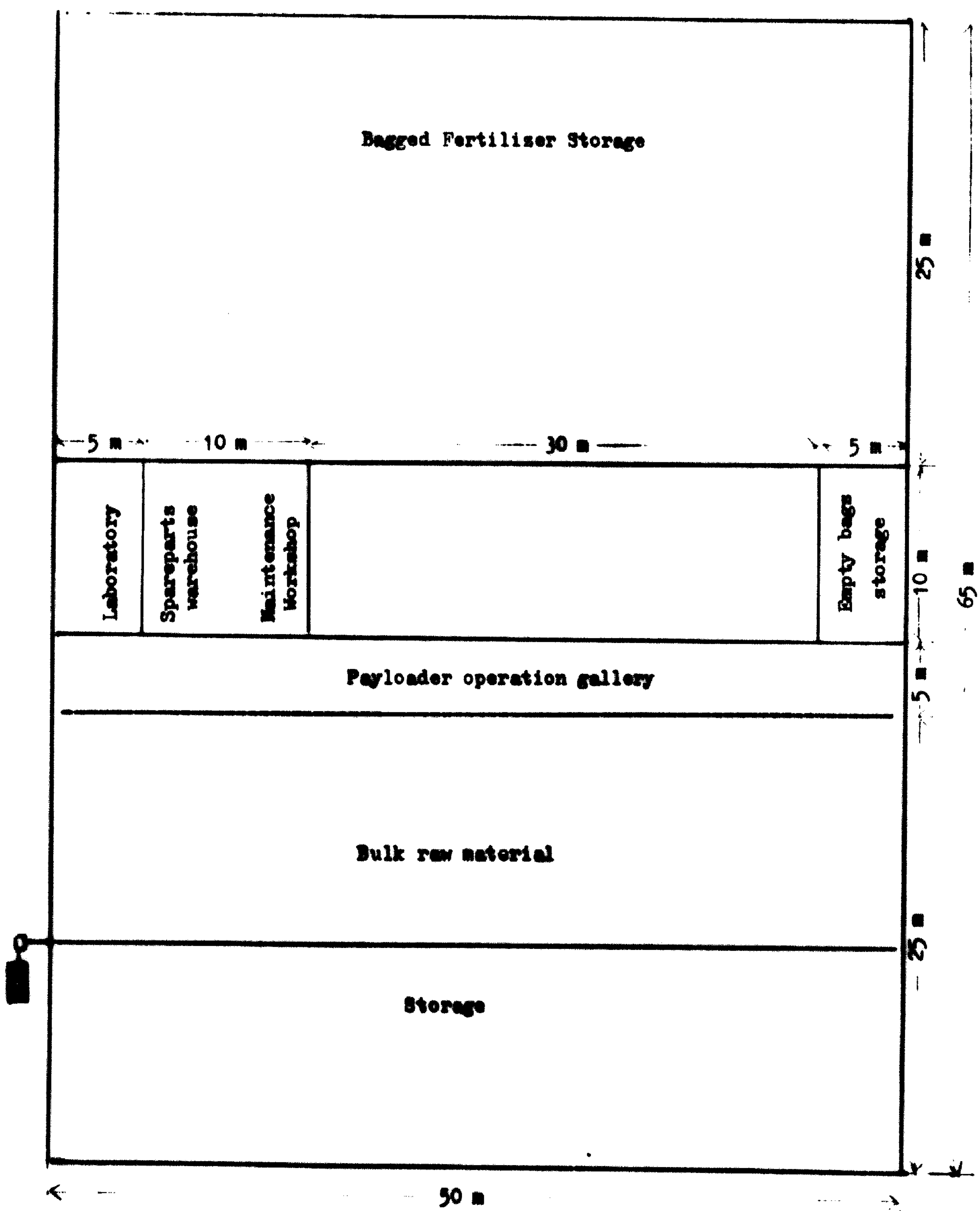
Length:	65 metres
Width:	50 metres

excluding administration buildings and social services.

A fertiliser bulk blending and bagging plant almost similar to this one is completely described in the United Nations Fertilizer Industry Series Monograph No.8.



Mixing and Bagging Plant Areas



Mixing and Bagging Plant Equipment List

Basic material unloading and storage

PBR	Weighing machine
TR1	Receiving hopper
T1	Belt extractor
E1	Bucket elevator
T2	Belt conveyor
CV1	Tripper carriage

Reclaiming and mixing

TR2	Reclaiming hopper
T3	Belt extractor
E2	Bucket elevator
C1	Screen
Em1	Lump crusher
TN1	Shuttle belt conveyor
S1,S2,S3,S4.	Feeding hoppers
V1,V2,V3,V4.	Vibrators
ME1	Mixer
E3	Bucket elevator

Bagging and shipping

S5	Granulated bagging hopper
V5	Vibrator
S6	Powdered bagging hopper
V6	Vibrator
ES1	Granulated bagging machine
ES2	Powdered bagging machine
T4	Bag belt conveyor
T5	Bag belt conveyor

Fertiliser blending and bagging plant

Designed capacity:	10 metric tons per year
Raw material storage:	5,000 metric tons
Bagged fertilizer storage:	3,000 metric tons

Investment cost	US$
Mechanical and electrical equipment export packed FOB European port	605,000
Shipping freight to Freetown, delivery (10 per cent of FOB price)	60,500
Erection, installation and painting (20% of FOB cost)	121,000
Total equipment cost delivered and installed	786,500
Civil engineering, civil works site preparation foundations	80,000
Bulk storage building, mixing tower, bagging building product storage building 3,250 m^2 (Le.15 per sq.foot)	525,000
Unforeseen 10%	139,100
Total Plant Cost	1,530,600

NB 1: Construction cost appears high in Sierra Leone. Le.15 per square foot is the lowest estimate that has been gotten for this kind of industrial building.

NB 2: Conversion rate used in calculation is: US$ 1 = Le.1

Fertilizer Bulk Blending and Bagging Plant Staff

Administrative staff	Number	Annual cost per person Le.	Total annual cost Le.
Director	1	5,000	5,000
Secretary to Director	1	1,563	1,563
Administrative clerk	1	1,000	1,000
Record clerk	1	1,000	1,000
Clerk Typist	1	1,000	1,000
Security guards	2	800	1,600
Telephone operator	1	780	780
Driver	1	750	750
Total administrative	9		12,693
Finance Section			
Accountant	1	3,125	3,125
Cashier	1	1,775	1,775
Accountants	1	1,000	1,000
Clerk typist	1	950	950
Total Finance	4		6,850
Operation section			
Plant engineer	1	4,000	4,000
Clerk	1	1,000	1,000
Operators (machine)	5	745	3,725
Drivers	2	750	1,500
Storekeeper	1	1,200	1,200
Unskilled labourers	6	504	3,024
Total operation	16		14,449

(cont'd)

	Number	Annual cost per person Le.	Total annual cost Le.
Maintenance Section			
Senior mechanic	1	1,295	1,295
Assistant mechanic	1	880	880
Senior electrician	1	1,295	1,295
Assistant electrician	1	880	880
Total maintenance	4		4,350
Laboratory staff			
Senior laboratory staff	1	1,113	1,113
Laboratory assistant	1	880	880
Total laboratory	2		1,993
Total Plant Staff	35		40,335

1. Total salaries amount to Le. 40,335 to operate the factory 8 hours/day, 6 days per week.
   Production about 20,000 metric tons/year.

2. Total salaries amount to Le. 51,544 to operate the plant on 2 shifts, 16 hours per day. It is necessary to add one operation section and an assistant mechanic and an assistant electrician.

   Production about 40,000 metric tons/year.

3. Total salaries amount to Le. 62, 753 to operate the plant on 3 shifts, 24 hours per day 300 days per year. It is necessary to add 2 operation sections, 2 assistant mechanics and 2 assistant electricians.

   Production about 60,000 metric tons/year.

   Salaries include all social charges.

Rice Fertilisation - Requirements for the Coming Years

Total area under cultivation in Sierra Leone is about 528,000 hectares, 12.9% of arable land. 368,000 hectares, 70% of the total cultivated area are under rice cultivation. Rice is the most important crop in Sierra Leone and has to be the most important fertiliser consumer.

Rice cultivation is practised under five different ecological conditions. Uplands, Inland Valley Swamps, Mangrove Swamps, Bolilands, and Riverian Grasslands, Irrigated lowland rice culture is practised too but on a very small scale.

These five distinctly different areas have been studied for last past years by the Rice Research Station of Rokupr and fertiliser use recommendations have been developed after a campaign of numerous trials by Rokupr.

Fertilizer use in rice cultivation is very low yet, but it is expected to increase strongly as the Ministry of Agriculture and Forestry has stressed the necessity of modern intensive agricultural development with the purpose of Sierra Leone getting its self-sufficiency.

Fertiliser consumption which is reasonably expected to be matched in five years will be approximately

$$N.10 - P_2O_5.5 - K_2O.5. \quad kg/ha.$$

Uplands

Upland rice culture is producing the bulk of rice in Sierra Leone. The area under upland rice cultivation is about 260,000 hectares with a potential extension of 40,000 hectares.

- Fertilizer recommendations: N.60 - P.30 - K.30 kg/ha.
  P_2O_5 as basal at sowing time
  N + K in 3 splits at 15 - 40 and 70 days after seeding;
- Potential requirements for 260,000 hectares
  N. 15,600 - P. 7,800 - K. 7,800 metric tons
- Fertilizer consumption expected to be reached in 5 years
  N.10 - P. 5 - K. 5. kg/ha.
- Requirements in five years for 260,000 hectares uplands culture
  N. 2,600 - P. 1,300 - K. 1,300 metric tons.

Inland Valley Swamps

Actual area 60,000 hectares, potential 200,000 hectares

- Fertiliser recommendations
  N.40 - P. 80 - K. 80 kg/ha.
  four applications NPK 10 - 20 - 20
- Potential requirements for 60,000 hectares
  N. 2,400 - P. 4,800 - K. 4,800 metric tons
- Fertiliser consumption expected to be reached in 5 years
  N. 5 - P. 10 - K. 10 kg/ha.
- Requirements in five years for 60,000 hectares of inland culture
  N. 600 - P. 1,200 - K. 1,200 metric tons

Mangrove Swamps

Actual area 25,000 hectares potential area 60,000 hectares

- Fertilizer recommendations

  N.80 - P.30 - K. 30 kg/ha.

  N. in four splits

  P and K as basal nutrients together.

- Potential requirements for 25,000 hectares

  N. 2,000 - P.750 - K.750 mt.

- Fertilizer use expected to be reached in 5 years

  N. 13 - P. 5 - K. 5 kg/ha.

- Requirements in 5 years for 25,000 ha of Mangrove culture

  N. 330 - P. 125 - K. 125. mt.

Bolilands

Actual area 20,000 hectares

- Fertilizer recommendations

  N. 60 - P. 30 - K. 30 kg/ha.

  N in 2 splits

- Requirements for 20,000 ha.

  N. 1,200 - P. 600 - K. 600 mt.

- Fertilizer consumption expected to be reached in 5 years

  N. 10 - P. 5 K. 5 kg/ha.

- Requirements in 5 years for 20,000 ha. of Boliland culture

  N. 200 - P. 100 - K. 100 mt.

Riverain grasslands

Little is known about the fertilisation of riverrain grasslands. Nitrogen and phosphorus are required but more experimental evidences are necessary.

Irrigated lowlands

Balanced application of NPK at N. 80 - P. 40 - K. 40 kg/ha., is required for maximum yield.

Irrigated lowlands comprise a very small proportion of the total rice area.

Total fertiliser requirements for rice cultivation according to Rice Research Station of Rokupr recommendation

Uplands -	N. 15,600 -	P. 7,800 -	K. 7,800	mt.
Inland Valley Swamps -	N. 2,400 -	P. 4,800 -	K. 4,800	mt.
Mangrove Swamps -	N. 2,000 -	P. 750 -	K. 750	mt.
Bolilands -	N. 1,200 -	P. 600 -	K. 600	mt.
Total -	N. 21,200 -	P.13,950 -	K.13,350	mt.

Total fertiliser consumption expected to be reached in five years for rice cultivation.

Uplands -	N. 2,600 -	P. 1,300 -	K. 1,300	mt.
Inland Valley Swamps -	N. 600 -	P. 1,200 -	K. 1,200	mt.
Mangrove Swamps -	N. 330 -	P. 125 -	K. 125	mt.
Bolilands -	N. 200 -	P. 100 -	K. 100	mt.
Total -	N. 3,730 -	P. 2,725 -	K. 2,725	mt.

Total Nutrients N + P + K - 9,180 mt.

The potential extension area requirements are not included in these figures which should be considered as a minimum.

1/ On upland soils P. must be supplied as a basis in sewing time. It will be supplied by triple or single superphosphate. Triple is usually cheaper when there is no domestic manufacture.

N. and K. should be supplied in 3 splits and will be supplied by by urea and potassium chloride.

- Upland soils fertiliser requirements in 5 years

Urea 45%	5,778 mt.
TSP 46%	2,826 mt.
Kcl. 60%	2,167 mt.

2/ On Mangrove Swamp soils, N has to be supplied in four splits and will be supplied by urea.

P and K must be supplied as basal together and will be supplied by triple or single superphosphate and potassium chloride.

- Mangrove soils fertilizer requirements in 5 years

urea	45%	734 mt.
TSP	46%	272 mt.
Kcl	60%	209 mt.

3/ On Inland valley swamp soils NPK might be supplied together in four applications of NPK 10-20-20.

- Inland valley swamps soils requirements in 5 years

NPK 10-20-20, 6,000 mt.

4/ On Boliland soils N has to be supplied in 2 splits and will be supplied by urea.

P and K might be supplied togehter by triple superphosphate and potassium chloride respectively.

- Boliland soils requirements in five years

Urea	45%	445 mt.
TSP	46%	218 mt.
KCl.	60%	167 mt.

Total fertiliser requirements on rice cultivation in 5 years

Urea	6,957 mt.
TSP	3,316 mt.
NPK (10-20-20)	6,000 mt.
KCl	2,543 mt.
Total	**18,816 mt.**

Fertiliser use on rice cultivation might be reasonably expected to reach 18,816 metric tons in five years, in 1983, according to Rokupr rice research station specialists.

If fertilizer facilities should be established in Sierra Leone, the mixing and bagging plant will not be operating before two years (at the beginning of 1981). It will be assumed that fertiliser requirements in 1981 will be about 13,400 mt. for rice growing and will get an increasing of 12% per year.

Rice fertilizer expected to be required in 1981 at the operation plant starting.

Urea 45%	4,955 mt.
TSP 46%	2,362 mt.
NPK (10-20-20)	4,273 mt.
KCl.	1,811 mt.
<u>Total</u>	<u>13,401 mt.</u>

Fertilizer Recommendations for Crops in Sierra Leone

Fertilizer recommendations for the main crops grown in Sierra Leone (excluded rice whose fertilizers has already been studied) are resumed in the following table . (Table No.9)

It is clear that this table is only a rough guide and that recommendations might change according to the response of crops to fertilizer in field experiement.

Intermixed crops with rice cultation which profit rice fertilization have not been taken into account.

It has been assumed that at the starting of the blending and bagging plant in 1981 fertilizer consumption would be about 10% of the normal requirements.

- <u>Maize</u>

about 11,000 hectares N 120 - P_2O_5.60 - K_2O. 40 kg/ha.
Requirements in 1981 (10%) N. 132 - P_2O_5. 66 - K_2O. 44 mt.

<u>NPK 24-12-18: 550 mt</u>.

- <u>Grain legumes</u>

Cowpeas, soybean, groundnut, about 20,000 hectares
N. 30 - P. 60 kg/ha.
Requirements in 1981 (10%) N. 60 - P_2O_5. 120 mt.

<u>NPK 20-40-0: 300 mt</u>.

- <u>Cassava</u>

about 17,000 hectares N.40 - P_2O_5. 60 - K_2O. 60 kg/ha.

Table 9

Fertilizer Recommendations for Crops in Sierra Leone

Crop	Nutrients kg/hectare N	P_2O_5	K_2O	
Maize	120	60	40	
Grain legumes (cowpeas, soybeans groundnuts)	30	60	-	
Cassava	40	60	60	(1)
Pineapple	120	60	60	(1)
Garden vegetables in general onion, lettuce, etc.	30	60	60	(1)
Bananas and plantains	40	60	80	
Tobacco (cigarettes)	20	70	100	(1)
Sugar cane	50	30	60	
Citrus	90	70	90	
Coffee 1-5 years	15	36	20	
" over 5 years	40	30	40	
Cocoa up to 3 years	20	36	30	
over 3 years	30	30	40	

(1) Sulfate of potash to supply K.

Source: Njala University College - University of Sierra Leone

Requirements in 1981 (10%): N. 68 - P_2O_5. 102 - K_2O. 102 mt.

N-P-K 10-20-20 510 mt.
Ammonium sulphate 81 mt.

Garden vegetables

Onion, lettuce etc. - about 7,000 hectares

N. 30 - P_2O_5. 60 - K_2O. 60 kg/ha.

Requirement in 1981 (10%): N.21 - P_2O_5. 42 - K_2O. 42 mt.

N-P-K 10-20-20 210 mt.

Coffee

About 70,000 hectares N. 40 - P_2O_5. 30 - K_2O. 40 kg/ha.

Requirement in 1981 (10%): N. 280 - P_2O_5. 210 - K_2O. 280 mt.

N-P-K 15-15-20 1,400 mt.
Urea 156 mt.

Cocoa

About 40,000 hectares, N. 30 - P_2O_5. 30 - K_2O. 40 kg/ha

Requirements in 1981 (10%): N. 120 - P_2O_5. 120 - K_2O. 160 mt.

N-P-K 15-15-20 800 mt.

Total Fertiliser Requirements for these Crops in 1981

N-P-K	24-12- 8	550 mt.
N-P-K	20-40- 0	300 mt.
N-P-K	10-20-20	720 mt.
N-P-K	15-15-20	2,200 mt.
urea		156 mt.
Ammonium sulphate		81 mt.

Potassium sulphate should be the carrier of K_2O in the formulation N-P-K 10-20-20 used for cassava and vegetables.

Oil palm

Fertiliser recommendation for oil palm according to: "Integrated Agricultural Development Project" are:

N. 12, 16, 18 ounces per tree in the first years

P_2O_5. 18 ounces per tree

K_2O. 18, 24 ounces per tree.

There is 60 trees per acre.

P_2O_5. 30 kg/acre

K_2O. 40 kg/acre

N. 20, 30 kg/acre in the first years.

There is about 15,000/20,000 acres in cultivation or in project.

It has been assumed for oil palm fertilisation:

Urea 400 mt.

Triplesuperphosphate 500 mt.

Potassium chloride 600 mt.

Total fertilizer assumed to be required at the plant starting (1981)

Urea	5,511 mt.
Triple superphosphate	2,862 mt.
Ammonium sulphate	81 mt.
Potassium chloride	2,411 mt.
NPK 10-20-20 (Kcl.)	4,273 mt.
NPK 24-12-18	550 mt.
NPK 20-40	300 mt.
NPK 10-20-20 (K_2SO_4)	720 mt.
NPK 15-15-20	2,200 mt.
Total	**18,908 mt.**

N-P-K 10-20-20 Manufacture

1) KCl cheaper than K_2SO_4 will be the bearer of potassium

	%	N%	P_2O_5%	K_2O%
Ammonium sulphate A.S.	27.08	5.686	-	-
Monoammonium phosphate MAP	39.22	4.314	20,000	-
Potassium chloride KCl.	33.33	-	-	20.000
Filler (dolomite, sand ..)	0.37	-	-	-
Total	100.00	10.0	20.0	20.0

2)

	%	N%	P_2O_5%	K_2O%
Ammonium sulphate A.S.	10.35	2.174	-	-
Diammonium phosphate DAP	43.48	7.826	20.0	-
Potassium chloride KCl	33.33	-	-	20.000
Filler	12.84	-	-	-
Total	100.00	10.0	20.0	20.0

Cost of basic imported fertilizers necessary to manufacture 1 mt. NPK 10-20-20

1)

	mt.	cost/mt. Le.	cost/mt. 10-20-20 Le.
A.S.	0.2708	91.95	24.900
MAP	0.3922	163.45	64.105
KCl.	0.3333	79.95	26.647
Total cost			115.652

2)

	mt.	cost/mt. Le.	cost/mt. 10-20-20 Le.
A.S.	0.1035	91.95	9.517
DAP	0.4348	158.45	68.834
KCl.	0.3333	79.95	26.647
Total			105.058

The formulation (2) Le. 105.058 is less expensive than formulation (1) Le. 115.652/mt.; but it requires 12.84% of filler which might be a problem to manufacture granulated product if filler of similar particle-size is not easily available.

Anyway, the raw material cost depends mainly of the market conditions at the time of supplying and the choice of basic fertilizer components should be done according to the best market opportunities and easy supply.

Raw materials necessary to manufacture 4,273 mt. of NPK 10-20-20

Formulation (1)

MAP	1,676 mt.	4,273 mt.
AS	1,157 mt.	
KCl	1,425 mt.	
Filler	15 mt.	

Manufacture of NPK 24-12-8

Raw materials	%	N%	P_2O_5%	K_2O%
Urea	27.425	12.34125	-	-
Ammonium sulphate	33.155	6.96255	-	-
Diammonium phosphate	26.09	4.6962	12	-
Potassium chloride	13.33	-	-	8
Total	100.00	24.0	12.0	8.0

Raw material cost to manufacture 1 mt. NPK 24-12-8

Raw material	mt.	cost/mt. Le.	cost/mt. 24-12-8 Le.
Urea	0.27425	154.95	42.495
A.S.	0.33155	91.95	34.486
DAP	0.2609	158.45	41.340
KCl	0.1333	79.95	10.657
Total			128.978

Raw materials necessary to manufacture 550 mt. NPK 24-12-8

Urea:	150.838 mt.	550 mt.
AS:	182.353 mt.	
DAP:	143.495 mt.	
KCl:	73.315 mt.	

Manufacture of N-P 20-40

Raw material	%	N%	P_2O_5%	K_2O%
Urea	9.70	4.365	-	-
Diammonium phosphate	86.96	15.6528	40	-
Filler	3.34	-	-	-
Total	100.00	20	40	-

Raw material cost for 1 mt. of NPK 20-40-0

Raw material	M.t.	cost/mt. (Le.)	cost/mt. (20-40) Le.
Urea	0.0970	154.95	15.030
DAP	0.8696	158.45	138.223
Total			153.253

Raw material necessary to manufacture 300 mt. N.P 20-40

urea	29,100 mt.
DAP	260.880 mt.

Manufacture of NPK 10-20-20

Potassium sulphate must be used to supply K_2O

Raw materials	%	N%	P_2O_5%	K_2O%
Ammonium sulphate	10.35	2.1735	-	-
Diammonium phosphate	43.48	7.8264	20	-
Potassium sulphate	40.00	-	-	20
Filler	6.17	-	-	-
Total	100.00	10	20	20

Raw material cost to manufacture 1 mt. of NPK 10-20-20

Raw materials	mt.	cost/mt. Le.	cost/mt. 10-20-20 Le.
Ammonium sulphate	0.1035	91.95	9.517
DAP	0.4348	158.45	68.894
K_2SO_4	0.4000	99.95	39.980
Total			118.391

Raw materials necessary to manufacture 720 mt. of NPK 10-20-20

AS	74,520
DAP	313.056)
K_2SO_4	288.000

Manufacture of NPK 15-15-20

Raw material	%	N%	P_2O_5%	K_2O%
Urea	8.24	3.708	-	-
Ammonium sulphate	25.82	5.4222	-	-
Diammonium phosphate	32.61	5.8698	15	-
Potassium chloride	33.33	-	-	20
Total		15	15	20

Raw material cost to manufacture 1 mt. of NPK 15-15-20

Raw materials	mt.	Cost/mt. Le.	Cost/mt. 15-15-20. Le.
Urea	0.0824	154.95	12.768
Ammonium sulphate	0.2582	91.95	23.742
Diammonium phosphate	0.3261	158.45	51.671
Potassium chloride	0.3333	79.95	26.647
Total			114.828

Raw materials necessary to manufacture 2,200 mt. of NPK 15-15-20

Urea	181.28 mt.	
A.S.	568.04 mt.	2,200 mt.
DAP	717.42 mt.	
KCl.	733.26 mt.	

Mixing and Bagging Plant Location

There are usually two adequate locations to establish fertilizer mixing and bagging facilities.

The first one is close to the raw material supplying centre, In this case it would be the port of Freetown by which basic fertilizer material will be imported.

The second one is the main consuming centre which would be somewhere around Bo and Njala area.

However, there are no railway facilites in Sierra Leone and considering the limited transport capacity, it will be easier to carry bagged material than bulk material by lorries and losses shall be certainly minimized. Therefore, it is proposed to locate the fertilizer blending and bagging plant in the Freetown area as it appears to be most suitable location.

It has been noticed not too far from the port an old cement factory which is no more operating for several years and which seems a very appropriate site.

Another available location would be the one called "Government wharf". This second place is larger than the first one and might be better in case of future extension of the plant.

Anyway for further calculation, it has been assumed that the factory will be situated on a site at about 10 kilometres from the port of Freetown.

Table 10. **Fertilizer International Market Prices, 1978**

Fertilizer bulk	N	P_2O_5	K_2O	FOB price US$ USA-Europe-Port	Freight	CIF Price US$ Freetown	Average price US$
Urea	45/46	-	-	128/135	12/15	140/150	145
Diammonium phosphate DAP	18	46	-	130/140	12/15	142/155	148.5
Ammonium sulphate AS	21	-	-	67/70	12/15	79/85	82
Monoammonium phosphate MAP	11	51	-	140	12/15	152/155	153.5
Single superphosphate SSP	-	18	-	50/60	12/15	62/75	68.5
Triple superphosphate TSP	-	46	-	92/105	12/15	104/120	112
Potassium chloride KCl	-	-	60	50/55	15/20	65/75	70
Potassium sulphate K_2SO_4	-	-	50	72/80	12/15	84/96	90
NPK 15-15-15 (bagged)	15	15	15	145/180	20/25	165/205	185
NP 20-20 (bagged)	20	20	-	140	20/25	160/185	172.5

Raw Material Price

Prices have been calculated for one metric ton of basic fertilizer delivered factory on lorry.

There is no custom duties on fertilizer material importation in Sierra Leone.

Port expenses, handling charge, portrage, shipping agency fee, transit amount to Le.9.1 per metric ton.

Transport charge has been estimated at an average of Le. 0.085 per metric ton per kilometre, that is to say transporation cost from the quay to the plant 0.085 x 10 = Le. 0.85/metric ton.

Price of bulk fertilizer delivered at the plant

Conversion rate used in calculation is US$ 1 = Le. 1.

Table 11

Fertilizer	Price CIF Freetown Le./mt.	Port expenses Le./mt.	Transport Le./mt.	Price delivered factory. Le/mt.
Urea 45%	145	9.1	0.85	154.95
Ammonium sulphate 21%	82	9.1	0.85	91.95
Diammonium phosphate 18-46	148.5	9.1	0.85	158.45
Monoammonium phosphate 11-51	153.5	9.1	0.85	163.45
Triplesuperphosphate 46%	112	9.1	0.85	121.95
Single superphosphate 18%	68.5	9.1	0.85	78.45
Potassium chloride 60%	70	9.1	0.85	79.95
Potassium sulphate 50%	90	9.1	0.85	99.95

Basic single fertiliser material to be imported on the first year of operation

Urea	5,872.218 mt.
Ammonium sulphate	2,062.913 mt.
Monoammonium phosphate	1,676.000 mt.
Diammonium phosphate	1,434.851 mt.
Triple superphosphate	2,862.000 mt.
Potassium chloride	4,642.575 mt.
Potassium sulphate	288.000 mt.
Filler for NPK formulation	69.443 mt.
Total	18,908 mt.

Raw material costs (production 18,908 mt.)

It has been assumed handling losses 1%

Urea	5,931 mt.	Cost.	Le.	919,008.45
AS	2,084 mt.	"	"	191,623.80
MAP	1,693 mt.	"	"	276,720.80
DAP	1,450 mt.	"	"	229,752.50
TSP	2,891 mt.	"	"	352,557.40
KCl.	4,689 mt.	"	"	374,885.50
K_2SO_4	291	"	"	29,085.40
	Total cost Le.			2,373,633.85

It has been assumed that production will be increased by the fourth year up to 26,500 mt. and the seventh year up to 37,200 mt.

Raw material costs (production 26,500 mt.): Le. 3,326,703

Raw material costs (production 37,200 mt.): Le. 4,669,938

Utilities

Operating supplies

The main consumption will be diesel oil for payloaders. It has been estimated 10 litres/hour, i.e. 33.04 cents per metric ton. Oil and grease consumption amounts to about 7.5 cents per metric ton.

Electricity

Total power installed:		250 KW
Unloading and storage consumption:		1 KWH/mt.
Blending, bagging and shipping:		6.5 KWH/mt.
Straight bagging single fertiliser		5.0 KWH/mt.
Lighting:	about	4,000 KWH/year
Demand per month		175 KW

Cost Le. 5.00 per KW of demand per month plus consumption rate per unit 8.5 cents.

Bags

A polyethylene valve bag costs 42 cents i.e. Le. 8.4/mt.. It has been assumed a 3% loss.

Bag cost per metric ton: Le. 8.652

Labour

Production up to 20,000	mt./year, 1 shift:	Le. 40,335/year
Production up to 40,000	mt./year, 2 shifts:	Le. 51,544/year
Production up to 60,000	mt./year, 3 shifts:	Le. 62,753/year

Working capital

3 months	raw materials	Le. 593,408.45
1 month	bagged product	Le. 232,764.33
	Total	826,173.00

Land site

It has been assumed that the land where the plant will be established, will be rented at Le. 100 per month.

Estimated Production Cost
Production 18,908 mt./year

Total investment cost Le.2,356,773	Mechanical and electrical equipments	Le. 865,100
	Building and civil work	Le. 665,500
	Working capital	Le. 826,173

Variable costs

Raw materials	Le.2,373,633.85
Bags	163,592.10
Operating supplies (fuel, oil etc..)	7,665.30
Electricity	11,883.57
Total variable costs	Le.2,556,774.80 (1)

Fixed costs

Labour	Le.	40,335.00	
Maintenance - 2% building costs		13,310.00	
6% equipment		51,906.00	
Insurance - 1% investment		15,306.00	
Administrative costs 3% labour		1,210.00	
Land rent		1,200.00	
Total fixed costs:	Le.	123,267.00	(2)

Depreciations

Buildings 4%	Le.	26,620.00	
Equipment 10%		86,510.00	
Total Depreciations	Le.	113,130.00	(3)

Total Production Costs (1)+(2)+(3):	Le. 2,793,172.00
Production Costs excluded Raw Materials:	Le. 419,538.00
	Le. 22.188/mt.

Estimated Production Cost
Production 26,500 mt./year

Total investment Le. 2,681,073	Mechanical and electrical equipment:	Le.	865,100
	Building and civil sorks:	Le.	665,500
	Working capital:	Le.	1,150,473

Variable costs

Raw materials:	Le.	3,326,703.00
Bags:		229,278.00
Operating supplies (fuel, oil etc..):		10,743.00
Electricity:		16,665.00
Total variable costs:	**Le.**	**3,583,389.00** (1)

Fixed costs

Labour:		Le.	45,940.00
Maintenance	2% building costs:		13,310.00
	6% equipment:		51,906.00
Insurance	1% investment		15,306.00
Administrative costs: 3% labour:			1,378.00
Land rent:			1,200.00
Total fixed costs:		**Le.**	**129,040.00** (2)

Depreciations

Buildings 4%:	Le.	26,620.00
Equipment 10%:		86,510.00
Total depreciations:	**Le.**	**113,130.00** (3)

Total production costs (1)+(2)+(3):	**Le. 3,825,559.00**
Production costs excluded raw materials:	**Le. 498,856.00**
	Le. 18,825/mt.

Estimated Production Cost
Production 37,200 mt./year

Total investment Le. 3,137,935	Mechanical and electrical equipment:	Le. 865,100
	Building and civil works:	Le. 665,500
	Working capital:	Le. 1,607,335
Variable costs		
Raw materials:		Le. 4,669,938
Bags:		321,855
Operating supplies:		15,081
Electricity:		23,380
Total variable costs:		Le. 5,030,254 (1)
Fixed costs		
Labour:		Le. 51,544
Maintenance 2% building costs:		13,310
6% equipment:		51,906
Insurance 1% investment:		15,306
Administration costs 3% labour:		1,546
Land rent:		1,200
Total fixed costs:		Le. 134,812 (2)
Depreciations		
Buildings 4% per year:		Le. 26,620
Equipment 10%		86,510
Total depreciatons:		Le. 113,130 (3)
Total production costs (1)+(2)+(3)		Le. 5,278,196
Production costs excluded raw materials:		Le. 608,258
		Le. 16,351/mt.

Financing, Financial Charges

Assumption

Investment cost will be financed by a loan.

Capital:	Le. 1,530,600	
Interest rate:	10%	
Loan duration:	10 years	
Loan refund:	3 years free	
:	7 years refunding, 7 equal parts Le. 218,657.14	

Working capital will be financed by a special loan.

Capital:	Le. 826,173	
Interest rate:	10%	annuity Le.217,942
Loan duration:	5 years	loan 165,235
Loan refund:	5 equal parts	interest 52,707

Capital applications

1st year	30%	Le. 459,180
2nd year	50%	Le. 765,300
3rd year	20%	Le. 306,120
+ 100% working capital		Le. 826,173

Interest before starting operations

Le. 459,180 x $(1.10)^2$ - 1 = Le. 96,427.80

Le. 765,300 x 1.10 - 1 = Le. 76,530.00

Total: Le.172,957.80

Capital application is assumed at the beginning of the year.

Loan refunding is assumed at the end of the year.

Factory operation starting is assumed at the beginning of the 3rd year.

Interest before starting will be financed by a short term loan.

Capital:	Le.172,957.80	
Interest rate:	10%	annuity Le.45,625.80
Loan duration:	5 years	
Loan refunding:	5 equal parts	

<u>The fourth year Production will be increased up to 26,500 mt.</u>

Increasing working capital will be financed by a short term loan.

Capital	Le. 324,300		Le.
Interest rate	10%	Annuity:	85,549.5
Loan duration	5 years	Loan:	64,860
Loan refunding	5 equal parts	Interest:	20,689.5

<u>The seventh year Production will be increased up to 37,200 mt.</u>

Increasing working capital will be financed by a loan.

Capital	Le. 456,862		
Interest rate	10%	Annuity:	Le.120,519
Loan duration	5 years	Loan:	91,372.4
Loan refunding	5 equal parts	Interest:	29,146.6

It has been assumed that the fertilizer mixing and bagging facilities would be a government factory and that "Gate sale price" would not be charged by any tax or return on investment.

Gate sale prices have been established to allow the plant self-sufficiency for paying all production costs and financial charges including loan refunding.

<u>Table 12</u> gives the total amount of financial charges including loans refunding.

13% of gate sale price increasing up to 15.8% at the beginning of loan refunding and decreasing down to 9.8 and 6.5% when production increase.

Raw materials amount 85/88% of the production cost and 74/79% of the gate sale prices.

<u>Table 13</u> gives fertilizer gate sale prices necessary to allow fertilizer plant self-sufficiency to assume all its charges.

Table 12: Financial Charges - Loan Refunding
(Lei)

Years	1	2	3	4	5	6	7	8	9	10
Production mt.	18,908	18,908	18,908	26,500	26,500	26,500	37,200	37,200	37,200	37,200
Amortization interest before starting	45,626	45,626	45,626	45,626	45,626	-	-	-	-	-
Loan interest after starting	153,060	153,060	153,060	153,060	131,194	109,329	87,463	65,597	43,731	21,866
Amortization loan for working capital	217,942	217,942	217,942	217,942	217,942	-	-	-	-	-
Amortization loan for increasing working capital (1)	-	-	-	85,550	85,550	85,549	85,549	85,549	-	-
Amortization loan for increasing working capital (2)	-	-	-	-	-	-	120,519	120,519	120,519	120,519
Principal loan refunding	-	-	-	218,658	218,657	218,657	218,657	218,657	218,657	218,657
Total loan costs (Interest on different loan)	251,393	251,393	251,393	272,082	250,216	130,018	137,299	115,433	93,5[illegible]7	71,702
Total financial charges Including refunding	416,628	416,628	416,628	720,836	698,969	413,535	572,188	490,322	386,907	361,012
Total operating costs including raw materials	2,793,172	2,793,172	2,793,172	3,825,559	3,825,559	3,825,559	5,278,196	5,278,196	5,278,196	5,278,196
% Financial charges/ Production costs	14.9	14.9	14.9	18.81	18.27	10.81	10.81	9.29	7.33	6.84

Table 13 **Fertilizer Costs Le./mt.**

Year		1	2	3	4	5	6	7	8	9	10
Production		18.908	18.908	18.908	26.500	26.500	26.500	37.200	37.200	37.200	37.200
Urea	**Production cost**	178.69	178.69	178.69	175.33	175.33	175.33	172.85	172.85	172.85	172.85
	Gate sale price	205.34	205.34	205.34	208.37	207.36	194.28	191.59	188.91	185.52	84.67
AS	**Production cost**	115.06	115.06	115.06	111.70	111.70	111.70	109.22	109.22	109.22	109.22
	Gate sale price	132.22	132.22	132.22	132.75	132.11	123.77	121.06	119.37	117.23	116.69
TSP	Production cost	145.36	145.36	145.36	142.00	142.00	142.00	139.52	139.52	139.52	139.52
	Gate sale price	167.04	167.04	167.04	168.76	167.95	157.35	154.64	152.48	149.75	149.06
KCl	Production cost	102.94	102.94	102.94	99.58	99.58	99.58	97.10	97.10	97.10	97.10
	Gate sale price	118.30	118.30	118.30	118.34	117.77	110.34	107.63	106.12	104.22	103.74
NPK(1) 10-20-20	Production cost	139.00	139.00	139.00	135.64	135.64	135.64	133.16	133.16	133.16	133.16
	Gate sale price	159.73	159.73	159.73	161.20	160.42	150.30	147.60	145.53	142.92	142.27
NPK 24-12-8	Production cost	152.46	152.46	152.46	149.10	149.10	149.10	146.62	146.62	146.62	146.62
	Gate sale price	175.20	175.20	175.20	177.19	176.34	165.22	162.51	160.24	157.37	156.65
NP 20-40-0	Production cost	176.98	176.98	176.98	173.62	173.62	173.62	171.14	171.14	171.14	171.14
	Gate sale price	203.38	203.38	203.38	206.34	205.34	192.39	189.69	187.04	183.69	182.85
NPK (2) K_2SO_4 10-20-20	Production cost	141.77	141.77	141.77	138.41	138.41	138.41	135.93	135.93	135.93	135.93
	Gate sale price	162.92	162.92	162.92	164.49	163.70	153.37	150.67	148.56	145.89	145.23
NPK 15-15-20	Production cost	138.17	138.17	138.17	134.81	134.81	134.81	132.33	132.33	132.33	132.33
	Gate sale price	158.78	158.78	158.78	160.21	159.44	149.38	146.68	144.62	142.03	141.38

10-20-20. (1) **KCl. Potassium chloride is the bearer of potassium**

10-20-20. (2) **K_2SO_4. Potassium sulphate is the bearer of potassium**

Possibilities of Regional Co-operation

Sierra Leone and Liberia have signed an agreement called Mano River Union Convention whose target is to develop Union Projects drawing profit for both two countries.

Governments of Sierra Leone and of Liberia have made agriculture a national priority and aim to develop modern intensive agriculture in order to reach food crops self-sufficiency and increase export oriented crops earning foreign exchange for the countries.

Establishment of fertilizer mixing and bagging facilities could be financed and implemented within the framework of a Union project between the Government of Sierra Leone and of Liberia.

The plant whose mixing capacity is about 60,000 mt/year would be sufficient to supply the requirements of both two countries for the coming years; and when consumption would outrun production, it would be possible to add extra mixing and bagging capacities.

The plant at its beginning would operate at higher capacity and the feasibility would be improved.

Agriculture and fertilizer use in Liberia

Liberia,covering an area of 37,743 square miles (97,750 km^2) with a population of 1,503,200 (1974 census) and a population growth rate of 3.3% per year, has like Sierra Leone and like all West African states a basically agricultural economy.

About 70% of its population is engaged in agriculture, and agriculture in Liberia like in Sierra Leone is the second largest production sector (the mining sector being the first.)

Staple crops such as rice, cassava and vegetables are produced along with export oriented crops such as rubber, cocoa, coffee, oil palm and sugar cane.

Rice is the most important crop, and rice self-sufficiency is the first purpose for the Ministry of Agriculture which is responsible for implementing all government agricultural policies.

In 1975, rice production reached 229,000 metric tons and 45,000 tons importation have been necessary to supply domestic consumption.

Fertilizer use in Liberia is already important, about 20,000 metric tons per year. In 1977 Liberia spent more than 3 million dollars for importing fertilizers (price CIF Monrovia),(see table.14.)

The Ministry of Agriculture has undertaken a study to evaluate the minimum demand for fertilizers in each of the years 1978-1980, 1985 and 1990.

This study covers only confirmed agricultural projects which will be the major fertilizer consumers. (see table 15)

It has been assumed for the following study that the Liberian agriculture requirements in 1981 would be

NPK (15-15-15)	9,000 mt.
NPK (9-18-27)	9,000 mt.
Urea 45%	2,500 mt.
Triple superphosphate	900 mt.
Potassium chloride	3,500 mt.
Total fertilizers	**24,900 mt.**

Possibilities of Regional Co-operation

Sierra Leone and Liberia have signed an agreement called Mano River Unio[illegible]ntion whose target is to develop Union Projects drawing profit for bo[illegible]wo co[illegible]es.

[illegible]rnments of Sierra Leone and of Liberia have made agriculture [illegible] nationa[illegible]ority and aim to develop modern intensive agriculture i[illegible]der to reach f[illegible]crops self-sufficiency and increase export oriented[illegible]ps earning foreign exch[illegible]for the countries.

Establishm[illegible]of fertilizer mixing and bagging faciliti[illegible]ould be financed and impl[illegible]ed within the framework of a Union p[illegible]ct between the Governm[illegible]f Sierra Leone and of Liberia.

The plant whose m[illegible] capacity is about 60,000 [illegible]ear would be sufficient to supply the requiremen[illegible] both two countries fo[illegible]he coming years; and when consumption would [illegible]n production, it[illegible]ld be possible to add extra mixing and bagging capa[illegible]s.

The plant at its beginning [illegible]d opera[illegible] higher capacity and the feasibility would be improved.

Agriculture and fertilizer use in Li[illegible]

Liberia,covering an area of [illegible] miles (97,750 km^2) with a population of 1,503,200 (1974 [illegible]us) and [illegible]ulation growth rate of 3.3% per year, has like Si[illegible] Leone and li[illegible]l West African states a basically agricultural ec[illegible]y.

About 70% of its pop[illegible]ion is engaged in agri[illegible]re, and agriculture in Liberia like in Sier[illegible]eone is the second largest [illegible]uction sector (the mining sector being the fir[illegible]

Staple crops [illegible] as rice, cassava and vegetables are [illegible]uced along with export oriented[illegible]ps such as rubber, cocoa, coffee, oil palm[illegible] sugar cane.

Rice is [illegible]most important crop, and rice self-sufficiency [illegible]he first purpose fo[illegible] Ministry of Agriculture which is responsible for implemen[illegible] all government agricultural policies.

I[illegible]75, rice production reached 229,000 metric tons and 45,000 to[illegible] impo[illegible]ion have been necessary to supply domestic consumption.

Table 14. **Fertiliser Consumption in Liberia**

Fertilizers	1974		1975		1976		1977	
	metric tons	CIF price US$	metric tons	CIF price US$	metric tons	CIF price US$	metric tons	CIF price US$
Calcium ammonium nitrate	32,238	1,584,413	13,714.6	2,372,399	16,745.8	1,841,402	10,137.8	998,743
Ammonium sulphate	163.6	25,504	70.3	1,514	710.8	88,023	309.5	38,912
Other nitrogenous	1,988.1	451,095	390.8	106,625	3,058.7	674,940	2,307.8	557,396
Phosphatic fertilisers	3,621.1	422,870	597.6	107,915	532.2	68,282	798.1	73,979
Potassic fertilizers	2,904.7	1,590	468.1	212,442	1,848.4	292,511	1,069.5	300,508
Manufactured fertilisers not else specified	3,180.9	2,233	565.3	431,441	60.6	13,395	4,767	1,213,872
Total:	44,096.4	2,487,705	15,806.6	3,245,942	22,956.5	2,978,553	19,389.7	3,183,406

Statistic Ministry of Plan - Monrovia, Liberia

Table 15. Liberia: Projected Demand for Fertilizers by Type
(in metric tons)

	1978	1979	1980	1985	1990
NPK 15-15-15	5,262	6,704	8,740	32,291	52,124
NPK 9-18-27	8,767	8,735	8,646	8,464	17,322
Urea	1,216	1,673	2,411	9,285	12,630
Superphosphate (triple)	310	539	813	5,015	7,633
Rock phosphate	1,613	2,151	2,791	5,701	6,201
Potassium chloride	2,013	2,504	3,431	12,410	18,099
Total	19,181	22,306	26,832	73,166	114,009

Monrovia - Ministry of Agriculture (The Potential Demand for Fertiliser Products in Liberia)
August 1978

NPK 15-15-15 Manufacture

1)

	%	N%	P_2O_5%	K_2O%
Ammonium sulphate AS	43.0	9.03	-	-
Diammonium phosphate DAP	32.0	5.76	14.72	-
Potassium chloride KCl	25.0	-	-	15
Total	100.0	14.79	14.72	15

2)

	%	N%	P_2O_5%	K_2O%
Urea	9.12	4.104	-	-
Ammonium sulphate AS	36.47	7.659	-	-
Monoammonium phosphate MAP	29.41	3.235	15	-
Potassium chloride KCl	25.0	-	-	15
Total	100.00	15	15	15

Cost of material necessary to manufacture 1 mt. of NPK 15-15-15

1)

	mt.	Cost/mt. Le.	Cost/mt. 15-15-15 Le.
Ammonium sulphate AS	0.430	91.95	39.5385
Diammonium phosphate DAP	0.320	158.45	50.7040
Potassium chloride KCl	0.250	79.95	19.9875
Total cost			110.23

2)

	mt	Cost/mt. Le.	Cost/mt. 15-15-15 Le.
Urea	0.0912	154.95	14.1314
Ammonium sulphate	0.3647	91.95	33.5342
Monoammonium phosphate	0.2941	163.45	48.0706
Potassium chloride	0.2500	79.95	19.9875
Total cost			115.726

The formulation (1) is the cheapest, even if it is necessary to use about 2% more to get the accurate quantity of nutrients.

Diammonium phosphate is usually the cheapest supplier for nitrogen and phosphorus.

Raw materials necessary to manufacture 9,000 mt. NPK 15-15-15

Formulation (1)

Ammonium sulphate:	3,870 mt.	9,000 mt.
Diammonium phosphate:	2,880 mt.	
Potassium chloride:	2,250 mt.	

Manufacture of NPK 9-18-27

1)

Raw materials	%	N%	P_2O_5%	K_2O%
Ammonium sulphate AS	9.32	1.957	-	-
Diammonium phosphate DAP	39.13	7.043	18.00	-
Potassium chloride KCl	45.00	-	-	27.00
Filler	6.55	-	-	-
Total	100.00	9	18	27

2)

Urea	4.08	1.836	-	-
Ammonium sulphate AS	15.62	3.280	-	-
Monoammonium phosphate MAP	35.30	3.884	18.00	-
Potassium chloride KCl	45.00	-	-	27.00
Total	100.0	9	18	27

Cost of imported basic fertiliser necessary to manufacture 1 mt. of NPK 9-18-27

1)

Raw materials	mt.	Cost/mt. Le.	Cost/mt. 9-18-27 Le.
Ammonium sulphate	0.0932	91.95	8.570
Diammonium phosphate	0.3913	158.45	62.002
Potassium chloride	0.4500	79.95	35.978
Total cost			106.55

2)

Raw materials	mt.	Cost/mt. Le.	Cost/mt. 9-18-27 Le.
Urea	0.0408	154.95	6.322
Ammonium sulphate	0.1562	91.95	14.363
Monoammonium phosphate	0.3530	163.45	57.698
Potassium chloride	0.4500	79.95	35.978
Total cost	1.000		114.366

Raw materials necessary to manufacture 9,000 mt. NPK 9-18-27

Formulation (1)

Ammonium sulphate	838.80 mt.
Diammonium phosphate	3,521.70 mt.
Potassium chloride	4,050.00 mt.

Bulk fertilisers to be imported to supply Liberian agriculture requirements

Urea	2,500 mt.
Ammonium sulphate	4,709 mt.
Diammonium phosphate	6,402 mt.
Triple superphosphate	900 mt.
Potassium chloride	9,800 mt.
Filler	589 mt.
Total	24,900 mt.

Imported raw material cost

Urea	Le. 387,375
Ammonium sulphate	432,993
Diammonium phosphate	1,014,397
Triple superphosphate	109,755
Potassium chloride	783,510
Total	Le. 2,728,029

Taking into account 1% losses; Raw material cost = Le. 2,755,310

Total raw material cost to supply Sierra Leonean and Liberian agricultures

18,908 mt.	Le. 2,373,634
24,900 mt.	Le. 2,755,310
43,808 mt.	Le. 5,128,944

It has been assumed that after 5 years total plant production will increase up to 60,000 metric tons per year.

Production 60.000 mt.

Raw material cost Le. 7.024.667

Investment cost and working capital would be financed in the same conditions as for the first study.

Production Cost

Production 43.808 mt.

Working capital:	Le. 1,765,910	Annuity Le. 465,842
Interest rate:	10%	Loan: Le. 353,182
Duration:	5 years	Interest: Le. 112,660
Loan refunding:	5 equal parts	

Production: 60.000 mt.

Working capital: Le. 2,411,609

Increase to be financed:	Le. 645,699	
Interest rate:	10%	Annuity Le. 170,334
Duration:	5 years	Loan: Le. 129,139.8
Loan refunding:	5 equal parts	Interest: Le. 41,194.2

Table 16 gives the total amount of financial charges including loans refunding.

They amount 10.3% of the gate sale price, increase up to a maximum 13.2% at the beginning of loan, refunding and decrease down to 5% after production increasing to 60,000 mt.

Raw materials amount 88/89% of the production cost and 79/84% of the gate sale price.

Table 17 gives fertiliser gate sale prices to allow fertiliser plant self-sufficiency to finance all its charges.

Estimated Production Cost
Production 43,808 mt./year

Total investment cost Le. 3,296,510	Equipment	Le.	865,100
	Building, civil work	Le.	665,500
	Working capital	Le.	1,765,910

Variable costs

Raw materials	Le.	5,128,944
Bags		379,027
Operating supplies		17,760
Electricity		27,533
Total variable costs	Le.	5,553,264

Fixed costs

Labour	Le.	54,346
Maintenance: 2% building cost		13,310
6% equipment		51,906
Insurance: 1% investment		15,306
Administrative costs, 3% labour		1,630
Land rent		1,200
Total fixed costs	Le.	137,698

Depreciations

Buildings 4%	Le.	26,620
Equipment 10%		86,510
Total depreciations	Le.	113,130

Total Production Costs **Le. 5,804,092**

Production costs excluded raw materials: Le. 675,148

Le. 15.4/mt.

Estimated Production Cost
Production 60,000 mt./year

Total investment Le.3,942,209	Equipment	Le.	865,100
	Buildings, civil work	Le.	665,500
	Working capital	Le.	2,411,609

Variable costs

Raw materials	Le.	7,024,667
Bags		519,120
Operating supplies		24,324
Electricity		37,710
Total Variable costs	Le.	7,605,821

Fixed costs

Labour		Le.	62,753
Maintenance	2% building costs		13,310
	6% equipment		51,906
Insurance	1% investment		15,306
Administrative costs	3% labour		1,883
Land rent			1,200
Total fixed costs		Le.	146,358

Depreciations

Buildings	4%	Le.	26,620
Equipment	10%		86,510
Total depreciations		Le.	113,130

Total production costs:	Le. 7,865,309
Total production costs excluded raw materials:	Le. 840,642
	Le. 14.01/mt.

Table 16 **Financial Charges Loan Refunding II**

Years	1	2	3	4	5	6	7	8	9	10
Production mt.	43,808	43,808	43,808	43,808	43,808	60,000	60,000	60,000	60,000	60,000
Amortisation interest before plant starting, Le.	45,626	45,626	45,626	45,626	45,626	-	-	-	-	-
Loan interests after plant starting, Le.	153,060	153,060	153,060	153,060	131,194	109,329	87,463	65,597	43,731	21,866
Amortization loan for working capital, Le.	465,842	465,842	465,842	465,852	465,842	-	-	-	-	-
Principal loan refunding Le.	-	-	-	218,568	218,658	218,658	218,658	218,658	218,658	218,658
Amortisation loan for increasing working capital	-	-	-	-	-	170,334	170,334	170,334	170,333	170,333
Total financial charges including loan refunding	664,528	664,528	664,528	883,186	861,320	498,321	476,455	454,589	432,722	410,857
Total loan costs (interest on different loans)	311,346	311,346	311,346	311,346	289,480	150,523	128,657	106,791	84,925	63,060
Total production costs including raw materials	5,804,092	5,804,092	5,804,092	5,804,092	5,804,092	7,865,309	7,865,309	7,865,309	7,865,309	7,865,309
% Financial charges/production costs	11.45	11.45	11.45	15.22	14.84	6.34	6.06	5.78	5.50	5.22

Table 17 Fertiliser Costs Le./mt.

Years		1	2	3	4	5	6	7	8	9	10
Production mt.		43,808	43,800	43,800	43,800	43,800	60,000	60,000	60,000	60,000	60,000
Urea	Production cost	171.90	171.90	171.90	171.90	171.90	170.51	170.51	170.51	170.51	170.51
	Gate sale price	191.58	191.58	191.58	198.06	197.41	181.31	180.84	180.37	179.47	179.42
AS	Production cost	108.27	108.27	108.27	108,27	108,27	106.89	106.89	106.89	106.89	106.89
	Gate sale price	120.67	120.67	120.67	124.75	124.34	113.66	113.37	113.07	112.78	112.47
TSP	Production cost	138.57	138.57	138.57	138.57	138.57	137.18	137.18	137.18	137.18	137.18
	Gate sale price	154.44	154.44	154.44	159.66	159.13	145.87	145.49	145.11	144.74	144.36
KCl	Production cost	96.15	96.15	96.15	96.15	96.15	94.76	94.76	94.76	94.76	94.76
	Gate sale price	107.16	107.16	107.16	110.78	110.42	100.76	100.50	100.24	99.98	99.71
10-20-20 (1)	Production cost	132.21	132.21	132.21	132.21	132.21	130.82	130.82	130.82	130.82	130.82
	Gate sale price	147.35	147.35	147.35	152.33	151.83	139.11	138.75	138.38	138.05	137.65
24-12-8	Production cost	145.67	145.67	145.67	145.67	145.67	142.28	142.28	142.28	142.28	142.28
	Gate sale price	162.35	162.35	162.35	167.84	167.29	151.29	150.90	150.50	150.12	149.71
20-40	Production cost	170.19	170.19	170.19	170.19	170.19	168.80	168.80	168.80	168.80	168.80
	Gate sale price	189.68	189.68	189.68	196.09	195.45	179.50	179.03	178.56	178.10	177.62
10-20-20 (2)	Production cost	134.98	134.98	134.98	134.98	134.98	133.58	133.58	133.58	133.58	133.58
	Gate Sale price	150.43	150.43	150.43	155.52	155.01	142.04	141.67	141.30	140.94	140.56
15-15-20	Production cost	131.38	131.38	131.38	131.38	131.38	129.99	129.99	129.99	129.99	129.99
	Gate sale price	146.42	146.41	146.42	151.37	150.88	138.23	137.86	137.50	137.15	136.78
15-15-15	Production cost	126.73	126.73	126.73	126.73	126.73	125.34	125.34	125.34	125.34	125.34
	Gate sale price	141.24	141.24	141.24	146.67	145.54	133.28	132.93	132.58	132.24	131.89
9-18-27	Production cost	123.02	123.02	123.02	123.02	123.02	121.63	121.63	121.63	121.63	121.63
	Gate sale price	137.10	137.10	137.10	141.74	141.28	129.34	128.90	128.66	128.33	127.98

10-20-20 (1) Bearer of K is KCl - potassium chloride

10-20-20 (2) Bearer of K is K_2SO_4 - potassium sulphate

Persons met in Sierra Leone

Mr. Jackson, Minister of Agriculture and Forestry

Mr. Kuyembeh, Permanent Secretary, Ministry of Plan

Mr. Sessai, Permanent Secretary, Ministry of Agriculture and Forestry

Mr. A.R. Siafa, Chief Agriculturist

Mr. L.M. Feika, Assistant Chief Agriculturist

Mr. Radcliffe E. Williams, Assistant Chief Agriculturist

Mr. Bangora, Deputy Secretary, Ministry of Agriculture and Forestry

Dr. E. Rhodes, Acting Head of Soils Department, Njala University College

Dr. R. Jones, Director of Rokupr Rice Research Station

Dr. I.C. Mahapatra, Project Manager, Rokupr Rice Research Station

Mr. Edrich Kandee, Port Statistics

Mr. Baldwin E. Banks, Director Economic Affairs Division, Mano River Union

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