# OPTIMUM NUMBER, SIZE AND LOCATION OF OILSEEDS PROCESSING PLANTS IN THE SUDAN

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## Introduction

Oilseeds production and exports in the Sudan, especially groundnuts, are undergoing continual changes in terms of production and marketing. Production of groundnuts, sesame and cottonseed has increased steadily over the last few years and more increases are expected as a result of new investments and policy changes in the agricultural sector. On the marketing side, policy measures to strengthen the country's comparative advantage in the world market and improve infrastructure are being undertaken. Efforts to increase processed oilseeds exports as a substitute for raw seed exports has also been an important policy objective.

The increase in supply and the emphasis on exporting oil and cake rather than unprocessed seeds will affect the location, number, and size of processing plants needed to implement the planned strategy. Assuming that the present trend of increased production and exports of processed oilseeds continues, economic information is needed to serve as guidelines and to give more precise direction to the expected changes in marketing services.1/

The present marketing services of oilseeds in the Sudan are rather inefficient. Sudan is geographically a large country with several important production regions for oilseeds that are distant from demand centers (Figure 1). Costs of transportation are high, the processing activity is concentrated in the capital city of Khartoum, and the processing capacity is underutilized. Sudan had 87 active oilseeds processing plants in 1979 that ranged in size from less than 2,000 tons to over 14,000 tons of oilseeds processed (Table 1). These plants had a total rated capacity of 1,036,000 tons of oilseeds annually but processed only 456,000 tons in the 1979/80 season.2/ If the country is to improve its comparative advantage in the world vegetable oil market, Sudan must remedy these processing and transportation inefficiencies.

The present research uses an economic framework to analyze the costs of transportation, storage, and processing of oilseeds in the Sudan. It outlines the potential gains from reorganizing the oilseeds processing industry. The specific objectives are:

1. To determine the optimum location, number and size of processing plants for 1979/80 and 1989/90.
2. To analyze the impact of changes in selected variables in the model on plant location, marketing costs and product flow.
3. To demonstrate the applicability of spatial analysis techniques to solving industry location problems in developing countries.

**Methods of Analysis**

To achieve the stated objectives, a survey of 20 processing plants, 15 oilseeds merchants, and 66 truckers was conducted during 1981. With this information and secondary data, transportation and processing cost functions were estimated using regression analysis [Saaty]. Railroad rates and the distances between different points were obtained from the Sudan Railway Authority. The cost coefficients given by the functions were then used in a linear programming transshipment model. This model allows for transshipment points between origins and destinations and permits storage and processing activities to be incorporated. The problem can thus be represented, using this model, as a cost-minimization problem

[Dantzig]. Parametric programming techniques are used to simulate changes in supply, demand and plant operating capacity of the Sudan oileeds industry. For modeling purposes, Sudan is divided into 12 producing regions, 7 oil and cake consumption centers and one export port, Port Sudan (Figure 1).

The calendar year is divided into three time periods to facilitate representation of the assembly, processing and demand activities. Period one which is the beginning of the processing season, runs from November 1 to the end of February. During this period, the groundnut and sesame crops are harvested and a large proportion is delivered from farms to the auction markets. It is also the period when cotton ginning starts. Although not all the quantities purchased are moved from auction markets during this period, enough is transported to keep the processing plants working at low operating capacity.

The second period extends from March 1 to June 30. During this period all the quantities purchased are assembled at the processing plants and export port. Quantities transported are stored at the processing plants while the processing operation continues. The third period extends from July 1 to the end of October. Demands on the transportation system are low and the stored quantities are being depleted as they are turned into oil and cake.

The distribution of finished products continues throughout the year. Pipeline storage for short periods before distribution to the ultimate consumers is performed by plant owners, wholesalers and to some extent by retailers. Storage of finished products at the plant level is considered and incorporated in the model; however, storage by wholesalers and retailers is not considered.

**The Model**

The economic value of processing any commodity is usually reflected in changing the product form which adds value and contributes to GNP through the payments for the resources used in the activity. Improvements in the organization of the oilseed processing industry as well as the infrastructure and services for the agricultural sector will have the effect of reducing marketing costs for inputs and output, and stimulate agricultural development.

Four important factors affect the optimum number, size, and location of processing plants. These are 1) the quantity of the raw product, 2) the costs encountered in assembling the raw material, 3) the processing costs encountered in changing the form of the product, and 4) the costs of distributing the final products to consuming centers and the export port. The assembly, processing and distribution costs are the forces which vary with plant numbers and location.

To find the equilibrium between the assembly and processing costs given a certain level of production, assume that a positively sloping linear assembly cost function represents the type of function encountered in oilseeds assembly. Given this assumption, the total assembly cost function (TAC) would be expected to decline as the number of plants increases because the size of the supply area for particular plants and the total distance required for assembly are reduced [Bressler and King].

TPC represents total seasonal processing costs associated with processing a fixed volume of product. Due to the economies of scale effect, the TPC for a given volume of production would be expected to increase as the number of plants increases. This relationship results from the fact that the minimum costs of establishing and maintaining processing plants vary directly with the number of plants considered providing that all plants at all locations use the same production technology.

The equilibrium between the distribution costs and processing costs given a certain quantity of production is similar to the assembly and processing cost example. Assuming a positively sloping linear distribution cost function, the total distribution cost would be expected to decline as the number of plants increases because the size of the market area for particular plants and total distance required for distribution are reduced.

The summation of these three relationships results in a combined assembly, processing and distribution cost function that can be used in evaluating the efficiency of the marketing system. The optimum number and location of plants are determined when the effects of reduced assembly and distribution costs are just offset by the opposite effects of increased processing costs as the number of plants increases.

A number of assumptions are used throughout the analysis. These assumptions are:

1. The volume of production of oilseeds is fixed for the season under consideration.
2. Each plant location will have a transportation network to support it.
3. Factor prices are assumed to be constant at all plant sites and to have no effect on location and size of plant.

4. Production is assumed to be concentrated at one point in the center of the production region and demand is concentrated at one point in the center of the consuming regions. This is to enable calculation of assembly and distribution costs for the area as a whole.
5. The surplus production over domestic consumption of oil and cakes is exported at the world market price where Sudan is considered a small exporter and price taker.

**Schematic Diagram**

Figure 2 schematically describes the transportation, processing and distribution of oilseeds as represented in the mathematical model. The net farm production, (i.e., production net of seeds kept on the farm and losses during harvesting) is moved to the auction market by trucks or animals depending on the distance to the market and volume of product. After the auction market transactions are completed, the product is transported to the processing plants mostly by trucks but in some regions by rail. Each processing plant receives all the quantities needed for processing at a steady rate throughout the season. Parts of these quantities are processed during the first period and the rest is stored at the plant for processing in subsequent periods.

The output of processing, oil and cake, is shipped by truck or rail to the different demand centers, to Port Sudan for export, or stored for use in a later period. The supply of finished products in a subsequent time period is thus composed of the output of processing in that particular period plus the stocks carried from the previous period.

## Description of the Mathematical Programming Algorithm

The general formulation of linear programming as used in the analysis is mathematically represented as follows:

$$\text{Minimize } Q = \sum_{i}\sum_{j}\sum_{m}\sum_{k} t_{ijm}X_{ijk} + \sum_{i}\sum_{j}\sum_{k} C_{j}X_{ijk} + \sum_{i}\sum_{j}\sum_{k} r_{j}X_{ijk} +$$

$$\sum_{p}\sum_{m}\sum_{j}\sum_{g}\sum_{k} t_{pmjg}H_{pjgk} + \sum_{p}\sum_{j} f_{pjk}L_{pjk}$$

where,

Q = Total cost of transporting the raw material from areas of production to processing plants, cost of processing and storage of raw material, and cost of distribution and storage of final product, expressed in Sudanese pounds (L.S.).

i = 1,...,12 (number of production locations)

k = 1,...,3 (number of time periods)

j = 1,...,87 (number of processing plants)

g = 1,...,11 (number of consuming regions for final product)

m = 1,2 (mode of transportation, rail or truck)

p = 1,2 (final product of processing, oil and cake)

$D_g$ = total quantity of product p demanded

$D_d$ = domestic demand for product p

$D_e$ = export demand for product p

$P_s$ = total supply of product

Z = level at which domestic demand for product p is fixed

$t_{ijm}$ = unit cost of shipping seeds from location i to processing plant j by mode m, in L.S. per ton.

$X_{ijk}$ = quantity of raw material (groundnuts, sesame or-cottonseeds) shipped from region i to plant j for processing and storage in time k.

$C_j$ = cost of storage of raw material at processing plant j in L.S. per ton.

$r_j$ = unit processing cost in L.S. per ton of seeds.

$t_{pmjg}$ = unit cost of shipping final product p by mode m from plant j to demand area g in L.S. per ton.

$H_{pjgk}$ = quantity of final product p shipped from plant j to demand area g in time k.

$f_{pjk}$ = cost of storage of final product p at plant j in time k in L.S. per ton per period.

$L_{pjk}$ = quantity of final product p stored at plant j in time k.

$S_i$ = quantity of raw material available at origin i to be shipped for storage and processing.

$M_{jk}$ = capacity of processing plant j in period k in tons.

$B_{jk}$ = raw material storage capacity at processing plant j in time k.

Subject to:

1. Total quantity processed during the season in region i must be less or equal to the total quantity supplied,

   $$\sum_{j}\sum_{k} X_{ijk} \leq S_i$$

2. The quantity of raw material shipped to a processing plant must be equal to or less than the plant's processsing and storage capacity,

   $$\sum_{i} X_{ijk} \leq M_{jk} + B_{jk}$$

3. The quantity of final product shipped must be equal to the quantity demanded,

   $\sum_j H_{jg} = D_g$, all g

4. Total demand equals domestic demand plus export demand,

   $D_g = D_d + D_e$

5. Domestic demand is fixed at value Z. Export demand is equal to total supply of product less domestic demand,

   $D_e = P_s - Z$

6. Final product shipment equals final product equivalent of raw material processed,

   $P = \alpha \sum_i X_{ijk} + (1-\alpha) \sum_i X_{ijk}$ for all j, k

**Results of the Transhipment Model Analysis**

Although the model was used to obtain optimal solutions for the three time periods, (November 1 to February 28, March 1 to June 30, and July 1 to October 31), this paper presents the results of the analysis for the whole year. Table 2 provides a summary of the analysis of the optimal solution for the six alternative simulations that were studied. These simulations are as follows:

1. Optimal solution for 1979/80 with plants operating at 50 percent of rated capacity and limited exports of oil and cake.
2. Plants operate at 70 percent of rated capacity with increased oil and cake exports and reduced seed exports in 1979/80.
3. Optimal location, number and size of plants for the base period of 1979/80.

4. Domestic demand for oil and cake increases by 20 percent relative to 1979/80.

5. Optimal location, number and size of plants based upon projections of raw material supply and final demand for 1989/90.

6. Closing of plants currently located in port area because of saline water problem at those plants with 1989/90 assumptions.

**Optimal Solution for 1979/80 With Plants at 50 percent of Capacity**

In this simulation, the processing plants operate at less than 50 percent of rated capacity which is similar to the actual situation in 1979/80. This model solution shipped and processed 468,936 tons of seeds, distributed 137,529 tons of oil for domestic consumption, and 31,761 tons for export. For cake, 108,000 tons are distributed for domestic consumption and 192,600 are exported. The balance of the total seeds supply, 407,064 tons, is exported as seeds. These are mainly groundnuts and sesame since cottonseeds are not exported. The transportation and handling of unprocessed oilseeds for export, however, are not included in the model. They are determined as the residual over the quantities processed.

The total cost as determined by the model is L.S. 65.6 million or L.S. 140 per ton.[3/] This total cost includes the cost of handling and transporting the raw material from auction markets and ginning factories to the processing plants, the cost of processing, and the cost of handling and transporting the final products to the demand centers and the port. The processing costs include the fixed costs, charged to the first time period, and the operating costs for the whole year.

**The Basic Solution: Increasing the Utilization of Processing Plant Capacity for 1979/80**

Assuming that the utilization of processing plant capacity can be increased to 70 percent and that unprocessed seeds can be diverted from export to processing, the model is run to evaluate the impact of increasing the utilization of processing capacity on the total cost of transportation, processing and distribution activities and on the average cost of processing. Other simulations in the following subsections are compared with this second simulation.

Column 3 of Table 2 displays the aggregate statistics for this solution. Changes in quantities processed and resulting output are evident. The total cost for the activities of transportation, processing and distribution is L.S. 90.5 million or L.S. 144 per ton compared to L.S. 140 per ton in the previous solution. This represents mainly an increase in the total cost of transporting the raw material and distributing the final products to a smaller number of plants with increased operating capacity. To evaluate the impact of increasing the processing capacity on the average cost of processing, a total cost of processing equation, viz.,

$$TCP = 4583 + 110X$$

is used. This equation was estimated using the survey data on costs of processing. Substituting the quantity of seeds processed for $X_1$, the average cost of processing is found to be about L.S. 110 per ton for both the 50 percent and 70 percent processing capacities.

## Optimal Plant Location, Number and Size for 1979/80

For the basic solution the processing plants operating in 1979/80 were categorized according to similarity in rated processing capacity. Twenty categories were obtained and each category was entered in the model as one processing unit. In contrast to the basic solution, the constraint on plant capacity for this solution was removed to find the optimum plant locations that would process the product with minimum cost.

The total quantity of seeds moved and processed, as shown in Table 2, is the same as in the basic solution since there is no change in supply, demand or in the processing capacity. The quantity of seeds exported and the quantities of oil and cake distributed for local consumption or exported also remain the same as in the basic solution. There is, however, a reduction in the total cost of transporting the raw material, processing, and distribution of final products as a result of reorganizing the processing plants. The total cost of these activities is L.S. 84.7 million compared to L.S. 90.5 million for the same activities in the basic solution, a reduction of L.S. 5.8 million for the year. The per unit cost, for all the activities, is L.S. 134 compared to L.S. 144 for the basic solution, a seven percent improvement in efficiency. This represents a significant reduction in the cost of transporting the raw material and distributing the final product as there is no change in the per unit cost of processing.

This optimal solution reduces the number of processing units from 20 to 13 yet all the domestic demand and export requirements of oil and cake as specified in the basic solution are met. To determine the optimum number and size of processing plants, the total quantity of raw material optimally assigned to any location is divided by the number of processing plants in the processing unit in that particular location. Based on this procedure, the total number of processing plants has decreased from 87 to 40, a reduction of more than 50 percent as a result of the least-cost optimization procedure (Table 3). The optimum plant size ranges from 2,000 to 65,000 tons annual processing capacity compared to a range of 1,000 to 24,000 tons in the previous solution for 1979/80.

The solution for the model thus indicates a smaller number of processing plants with a larger average plant processing size than what existed in 1979/80. Theoretically, as the number of processing plants decreases and average processing capacity increases, transportation costs would increase and processing costs would decrease. The optimal plant location model, however, has resulted in a reduced number of processing plants and a reduced per unit cost of transportation. This is because the relocation of processing plants has shifted the concentration of processing activity from the Khartoum region, where no raw material is produced, to the regions where oilseeds production is concentrated (Figure 1).

**An Increase In Domestic Consumption of Oil and Cake by 20 Percent**

For this variation, the model is used to determine the impact of an increase in the domestic demand for oil and cake by 20 percent on plant location and the total cost of transportation and processing for 1979/80. The quantities of oil and cake designated for export have been reduced by the amount of increase in domestic demand since the same processing capacity is used.

The total quantity of seeds moved and processed is 630,228 tons and the total quantity of oil and cake distributed in the domestic market is 165,030 tons and 129,600 tons, respectively. The oil and cake quantities exported are 62,490 tons and 272,400 tons, respectively. The quantity of seeds exported is 245,772 tons (Table 2).

The main impact of the increase in domestic demand for oil and cake is on the total cost of transportation, processing and distribution of final products. The total cost of these activities is L.S. 83.8 million compared to L.S. 84.7 million in the previous solution, a reduction of L.S. 0.9 million for the year, or a one percent decrease in costs. Total cost declines because the final product is shipped shorter distances when sold in the domestic market rather than in the export market. Shipments to the export port originate in interior areas of Sudan and must be transported long distances. There is no significant change in plant location, number or size of plants and the percentage distribution of the processing activity among the regions.

The economic implication of the increase in domestic demand, assuming that it reduces the quantities exported, is that it will reduce the amount of foreign exchange earnings. Returns to farmers should not be affected if domestic prices are equivalent to international prices and the local currency is not overvalued. With an increase in oil seeds production and the development of processing capacity, however, production of oil and cake should be enough to satisfy domestic demand plus a surplus for export.

Optimal Plant Location, Number and Size for 1989/90

The projections of supply and demand of vegetable oil and cake were from published data that were based on certain expected relative changes in the supply of raw material and the demand for final products (Table 4). Increased investment to rehabilitate agricultural projects, currency devaluation, and measures to increase producers' incentives are the main reasons for expecting relative changes in supply. On the demand side, internal migration and different rates of population growth are reasons for the expected relative changes in domestic demand [Ministry of National Planning and World Bank]. Exports are treated as the residual (supply minus domestic demand) with Sudan as a price taker in the world market. The projections of supply of raw material and demand for final products are used to determine number, size and location of plants for 1989/90.

The model required the movement and processing of 1,736,280 tons of seeds with 228,510 tons of oil distributed for domestic consumption and 398,250 tons exported (Table 2). For cake 168,000 tons are distributed domestically and 945,000 tons exported. The total quantity of seeds processed represents the total expected supply for 1989/90 with no export of seeds. The total cost of transportation, processing and distribution activities is L./S. 241.5 million or L.S. 139 per ton calculated at constant 1979/80 Sudanese pounds. The per unit cost of processing remains the same at L.S. 110 per unit since the same regression equation for the cost of processing is used.

The model solution has 10 processing units comprising 29 processing plants to process the 1989/90 production compared to 40 processing plants for 1979/80. The average processing capacity ranges from 24,000 tons to 165,000 tons annually. The same procedure as before has been used to determine the optimum number and size of processing plants. Overall, the model solution for the 1989/90 product supports the previous results of 1979/80 in terms of having fewer and larger processing plants. Relative future changes in the costs of processing resulting from changes in technology, for instance, may result in a different set of numbers and sizes of processing plants. Due to a lack of appropriate data, however, this technology factor has not been incorporated in the model.[4]

The economic implications indicated by the results of the solution are more or less the same as those discussed for the plant location model for 1979/80. More returns are expected as a result of increased processing since there is more value added. These returns will be reflected in increased payments for the factors of production involved, mainly processors and laborers. The reduction in transportation costs will benefit processors and farmers and could reduce prices for domestic consumers. Since there is still no processing in the third period there is a need to develop and strengthen the storage facilities for the final products and for the raw material as processing plants acquire all their raw materials at the beginning of the season. The shift in distribution of processing activity to areas of production entails the development and strengthening of supporting facilities for the processing industry. Improvements in the infrastructure, establishing a packing materials industry, availability of spare parts, and improvement of the marketing services, are just a few of the areas where more emphasis on development is needed. The shift in processing activity also indicates that more jobs will be created in the areas of production. Again, this is expected to reduce migration from rural areas to the capital city, especially of the young and productive members of those communities. Needless to say, this could help in solving the social and economic problems existing at the present time as a result of a very high urbanization rate.

**Closing of Plants at the Port Area for 1989/90**

The existing processing plants in Port Sudan have some technical problems, mainly the problem of saline water. These plants have so far been treated in the model as part of the Eastern region. This simulation eliminates the port area as a possible location to determine the impact on processing plants' location, number and size.

The solution for this model in terms of the quantity of seeds processed and the quantity of oil and cake produced and distributed or exported is the same as in the previous model. The overall processing activity and distribution of final products is also the same.

There is also no export of seeds. There is, however, a change in the total cost of transportation, processing and distribution. The total cost for these activities is L.S. 243.0 million when the port's processing plants are excluded compared to L.S. 241.5 million for the model with the port's plants included. The model, including processing plants in the export port, represents the optimum plant location that minimizes the total cost of transporting the raw material, processing and distributing the final products. Logically, any diversion from that optimum solution would increase the total cost of these activities. For this reason, there is an increase in total cost from L.S. 241.5 million to L.S. 243.0 million when the processing plants at the port are excluded. The increase in total cost of L.S. 1.5 million could be compared to the cost of solving the saline water problem.

As expected, the solution results in a major change in the regional distribution of the processing activity. The share of the Eastern region in the total processing activity declines from 25 to 20 percent while the share of the Central region increases by the same amount.

**Conclusions**

Overall, the solution of the model has resulted in fewer and larger processing plants, no increase in the per unit cost of processing, lower per unit cost of transportation, and a geographical redistribution of the processing activity. A number of economic implications are indicated as a result.

For policymakers, the redistribution of the processing activity complies with the present government policy of trying to bring together the small processing plants into larger economic units. Since the geographical re-distribution reduces the costs of transportation, this will strengthen the country's comparative advantage, and increase exports and foreign exchange earnings. Moreover, since the redistribution gives more emphasis to processing in the areas of production, it is expected to create more employment in these areas and reduces migration of the labor force to the capital city. On the other hand, processing in the areas of production will mean establishing and maintaining the necessary supporting services for the processing industry to succeed in these areas. Marketing and transportation services, a packing industry, more availability of spare parts, banking services, etc., all need to be established and strengthened.

For processors and farmers, a reduction in transportation costs and the expected increase in exports will probably increase their returns and provide them incentives to increase production. Consumers, on the other hand, could benefit from the increased efficiency by having reduced prices for oil.

The adjustments needed to reorganize the oilseeds industry to achieve the savings in costs and other benefits revealed by the analysis can be done in two ways. First, by allowing the older and smaller plants to close down and gradually replace them by the optimum number and size of plants in the locations indicated in the analysis. This would delay realizing the benefits of a full reduction in costs until all adjustments are completed. A second approach is to conduct a detailed cost study of the existing processing plants and compare the costs of replacing the existing firms with the future annual savings estimated by the model.

The results of the analysis, however, need inter-firm coordination to be fully realized. Whether coordination is desirable depends on how the groups concerned and the society as a whole value cost savings and the development of industry to make it more competitive.

**Footnotes**

1/ Marketing services include the transportation, storage, handling and processing of products in the oilseed industry.

2/ Rated capacity is defined as the number of tons of seeds that a properly engineered plant can process when a continuous and even flow of seeds enters the plant 24 hours a day.

3/ One Sudanese pound (L.S.) equals U.S. $2.00 at the official exchange rate in September of 1979.

4/ Should such changes occur, new input coefficients may be entered into the model to acquire a new optimal solution.


Figure 1: The Sudan: Major Oilseed Production and Consumption Centers

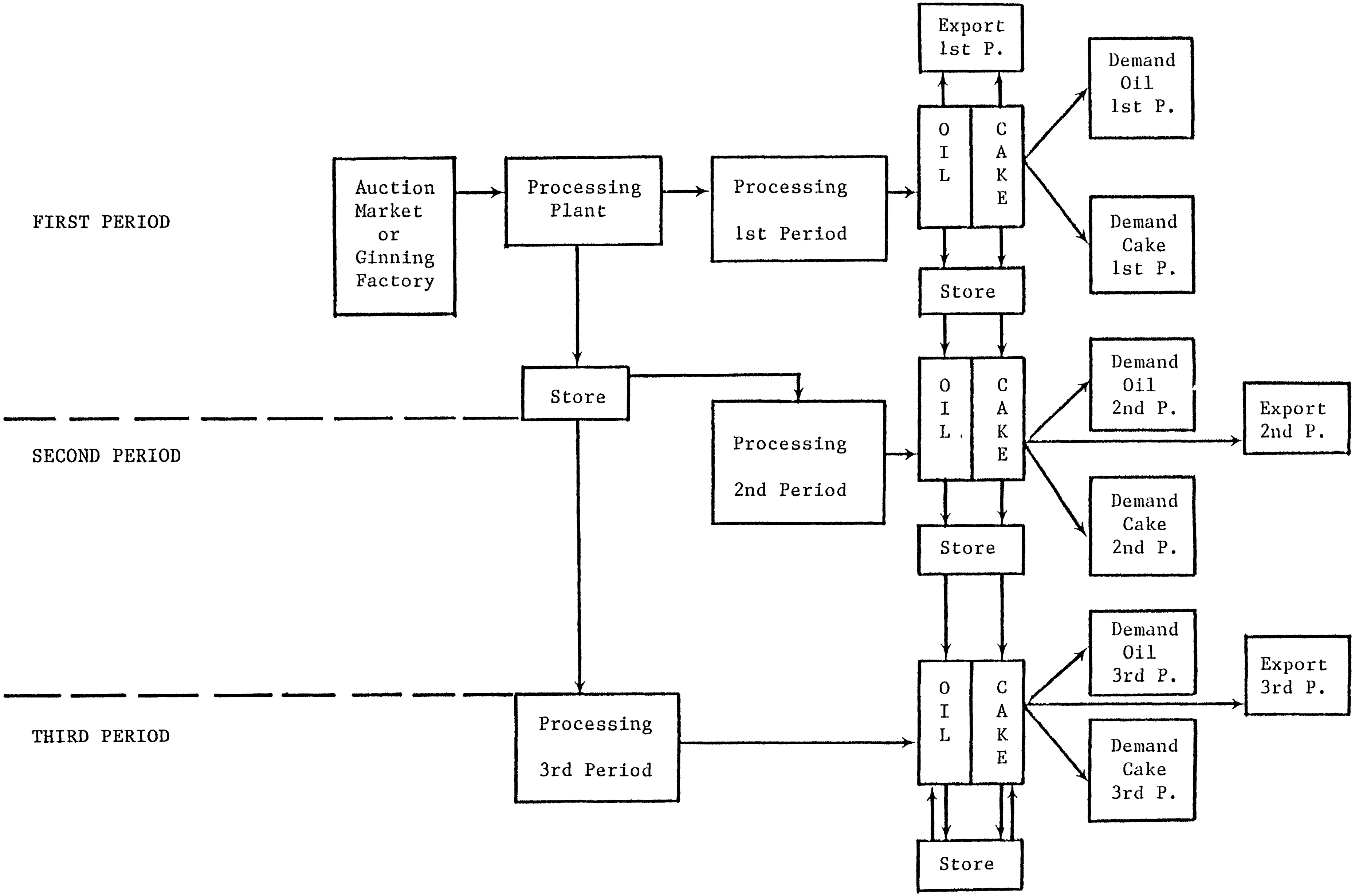


Figure 2: Schematic Diagram of Oilseeds Marketing, Transportation and Processing Sector of the Mathematical Model for 3 Periods, Sudan.

Table 1: Number and Size of Oilseeds Processing Plants, 1979/80 Season, Sudan

| Quantity of Oilseeds Processed (tons) | Number of Plants |
| --- | --- |
| Under 2,000 | 32 |
| 2,000-3,999 | 20 |
| 4,000-5,999 | 9 |
| 6,000-7,999 | 9 |
| 8,000-9,999 | 4 |
| 10,000-11,999 | 3 |
| 12,000-13,999 | 3 |
| Over 14,000 | 7 |
| TOTAL | 87 |

Source: Ministry of Industry, Sudan, Mimeograph, 1980.

Table  Optimal Solution for Location, Number and Size of Processing Plants 1979/80, Sudan

| Item | Processing Units Selected By The Model | | | | | | | | | | | | | Total Units Selected | Processsing Units Excluded | | | | | | | GRAND TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plant Code Number | | | | | | | | | | | | | | | | | | | | | |
| | 1 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 16 | 17 | 18 | 19 | 13 | 2 | 3 | 4 | 12 | 14 | 15 | 20 | |
| Processing Unit Total Capacity, 000' tons/year | 168 | 13 | 6 | 9 | 29 | 24 | 19 | 4 | 61 | 15 | 39 | 3 | 21 | | | | | | | | | |
| Number of Processing Plants in Each Unit of Basic Solution | 7 | 2 | 3 | 5 | 2 | 8 | 1 | 2 | 3 | 3 | 4 | 2 | 6 | 48 | 8 | 6 | 4 | 4 | 2 | 12 | 3 | 87 |
| Plant Average Rated Processing Capacity, 000' tons/year | 24 | 6 | 2 | 2 | 14 | 3 | 19 | 2 | 20 | 5 | 10 | 1 | 4 | | | | | | | | | |
| Quantity of Seeds Processed, 000'tons/year | 23 | 2 | 48 | 11 | 131 | 22 | 35 | 31 | 83 | 81 | 57 | 71 | 35 | 630 | | | | | | | | 630 |
| Number of Processing Plants in Each Unit of Optimum Solution | 1 | - | 3 | 5 | 2 | 8 | 1 | 2 | 3 | 3 | 4 | 2 | 6 | 40 | | | | | | | | 40 |
| Optimum Plant Capacity, 000'tons/years | 24 | - | 17 | 2 | 65 | 3 | 35 | 16 | 28 | 27 | 14 | 36 | 6 | | | | | | | | | |

Source: Babiker

Figure 1: The Sudan: Major Oilseed Production and Consumption Centers

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