Improvement of Postharvest Grain Systems

Grain Storage, Processing and Marketing
Report No. 96
August 1984

PROJECT DESIGN

STORAGE AND INVENTORY LOAN COMPONENT

KORDOFAN RAINFED AGRICULTURE PROJECT (650–0054), SUDAN

KSU
KANSAS STATE UNIVERSITY

FOOD & FEED GRAIN INSTITUTE
MANHATTAN, KANSAS 66506

REPORT SUMMARY

Title of Report/Publication: Project Design, Storage and Inventory Loan Component, Kordofan Rainfed Agriculture Project (650-0054), Sudan

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Period of Report/Publication: August 1984

Project Title: Improvement of Postharvest Grain Systems

Contract Number: AID/DSAN-CA-0256

Contractor: Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas

SUMMARY STATEMENT

The design of the storage and inventory loan component of the Kordofan Rainfed Agriculture Project in Sudan involves increasing storage capacity, improving storage management techniques, and offering marketing credit for sorghum, sesame, and groundnuts. The project component design is directed towards both the governmental and private sector. The technical and economic analyses address both sectors, and a section on implementation procedures sets forth some of the needed parameters for project implementation in these two areas.

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KORDOFAN RAINFED AGRICULTURE PROJECT (650-0054), SUDAN

Prepared by

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AGENCY FOR INTERNATIONAL DEVELOPMENT
UNITED STATES DEPARTMENT OF STATE

AID/DSAN-CA-0256
Improvement of Postharvest Grain Systems

at the

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PREFACE

This report addresses the statement of work as attached in Appendix A. The statement of work encompasses the project design for the development of a storage and inventory loan component in the Kordofan Rainfed Agriculture Project (650-0054). Also, included in the statement of work is the need to address the incorporation of the private sector within the project design. The team accepts the sole responsibility for the contents of this report. However, the parameters of the team's work were dictated by the statement of work as drafted by USAID/Khartoum.

SECTION I

PROJECT DESCRIPTION

The design for the storage and inventory loan component of this project involves only three cereal grain and oilseed crops in the Kordofan Region, those of sorghum, sesame, and groundnuts. Current production loan operations of the Agriculture Bank of Sudan (ABS) involve only these three crops. The other cereal crop grown in this region is millet, but since only 10 percent or less of the millet production in the Kordofan Region enters the marketing system, this is not significant enough to warrant inclusion in the project.

Agricultural production in the Kordofan Region is composed of the traditional and mechanized sectors. The traditional sector consists of small farmers who produce sorghum, millet, sesame, groundnuts, and other minor crops. All production processes are carried out by manual labor. The mechanized sector is composed of large farm units which use mechanized tillage, planting, and threshing operations to produce a single crop, sorghum. Sorghum, sesame, and groundnuts are actively traded in the private sector, with the latter two crops generally being grown as cash crops. No estimate can be made of the total amount of sorghum marketed. It is generally stated that nearly 75 percent of the sorghum marketed in the Kordofan Region is from the mechanized production sector, with the balance from the traditional farming sector.

Storage and handling losses have not been adequately researched. However, the best available information suggests that weight losses in sorghum are in the range of 6 to 7 percent and damaged kernels in sorghum runs from 12 to 13 percent during a one-year storage period. There is no available information on storage and handling losses in oilseeds.

Market prices for all crops within the region are seasonal. Low prices occur at harvest and rapidly increase in the six-month period following the harvest.

Three areas of activities are in the Kordofan Region are proposed under this project. These areas are: (1) providing storage capacity, (2) improving the storage techniques for cereal grains and oilseeds, and (3) using marketing credit as an extension of production credit. While storage capacity does exist in the Kordofan Region, the storage structures are used for multiple purposes. The storage structures are small brick stores ranging in size from 5 x 6 meters to 20 x 6 meters. Neither the construction nor the general condition of such warehouses lends itself to the specific requirements for proper grain storage or sound storage management processes. Although some grain stocks are fumigated, it appears to be done on an irregular basis. There is no evidence that other standard practices of correct storage techniques are applied.

Marketing credit used as an extension of production credit will allow producers to store their production after harvest so as to avail themselves of seasonal price increases. However, the Project Identification Document (PID) envisions marketing credit solely in the form of inventory loans separate from production credit. In the traditional production sector there are three major obstacles that will make such marketing credit largely impracticable. First, the producer who is capable of internally generating the cash needed to cover production costs has no need for inventory loans, since he is financially able to

control the product (with only minor losses) until such time as increases in price indicate a highly-profitable sale of the commodity. Second, the producer who is capable of internally generating his production costs often sells commodities on an intermittent basis after harvest in order to generate cash to reinvest in animals. With the commodity under his personal control, the producer can stage his sales as investment opportunities present themselves. Therefore, he has no need for marketing credit as such. Third, the producer who requires production credit and who must procure it on an informal system from the merchant is usually bound by contract to deliver his commodities to the lender as repayment of the loan. This eliminates the potential of extending marketing credit on this product. For social and traditional reasons, it is not in the general interest of the producer to repay informal credit with money. In actuality, the production credit granted through the informal system is a type of forward contracting procedure.

In the mechanized sorghum production sector, there may be cases where marketing credit alone could be put to good use. However, it appears that marketing credit must also be used jointly with production credit in other instances in this sector.

In summary, inventory credit alone may not be a sufficient factor with which to stimulate production. However, by providing production credit along with marketing credit, this should result in a sufficient inflow of cash into the yearly agricultural cycle so as to stimulate production.

The project area is defined in Figure 1. The prerequisite for this project area is the construction of road networks under the Kordofan Rainfed Agriculture Project and another USAID project. These road networks are critical to the establishment of storage facilities. Without all-weather road systems over which to operate, storage facilities can be utilized for only a portion of the year. This would seriously degrade the economic viability of the project component to such a degree that it would not be economically feasible.

The overall goals of the storage and inventory loan project component are (1) loss reduction, (2) improvement in storage conditions and practices, and (3) improvement in prices received by farmers. To achieve these goals, two intervention mechanisms will be utilized.

The first intervention mechanism will be instituted with the ABS. The purpose of this activity is to reinforce the current credit and storage operations of the ABS, both in existing locations (El Obeid and Dilling) and at the proposed locations (Abu Gubeiha and Talodi). A 3,000-MT warehouse will be constructed at each of the following locations: El Obeid, Dilling, Abu Gubeiha, and Talodi. Each warehouse will have the capacity to store 33,000 bags of cereal grains or oilseeds. To ensure the adequacy of proper storage techniques with which to preserve the quantity and quality of the commodities stored for producers, the project proposes to train the warehouse managers and other personnel, and provide the needed equipment and chemicals. Provisions for adequate capital for marketing credit, either as an extension of production credit or solely as inventory loans, will be included.

The ownership and management of the warehouses will lie with the ABS. As detailed in other sections of this report, it would not be wise for the private sector to own or manage ABS facilities since the financial and other interests of the private sector currently preclude effective coordination with the ABS.

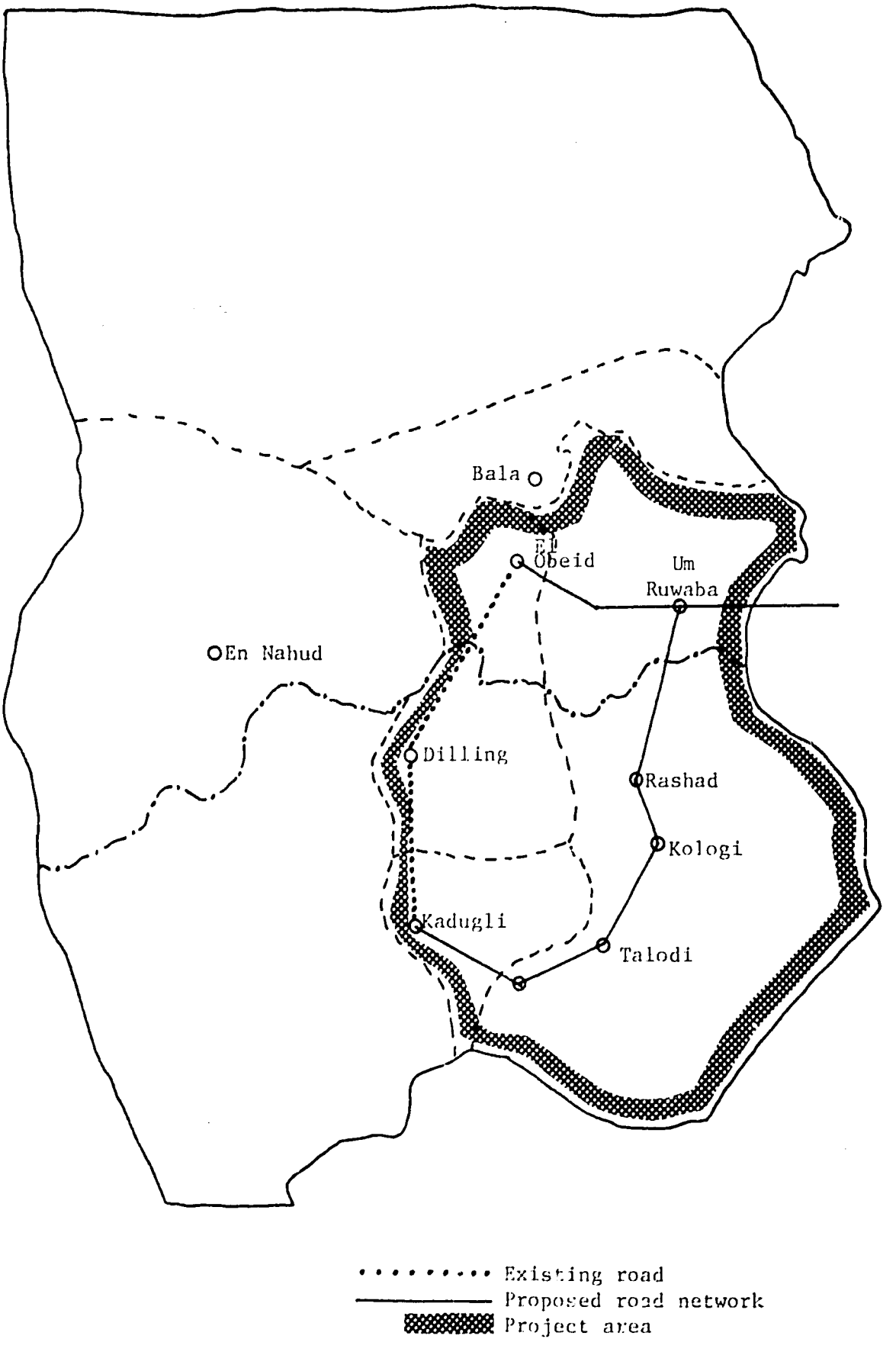

FIGURE 1. Project Area Within Kordofan Region

The primary target group for ABS storage and loan operations will be the mechanized sorghum production sector. The secondary target group will be the cooperative sector, made up of traditional farmers. This priority does not in any way diminish the intention of supporting cooperative growth in the traditional sector, but rather focuses on the necessity of having large volumes of stored commodities in order to economically support the ABS warehouses. Because the entire output of the mechanized sector is marketable surplus, and because of the present level of ABS financial involvement in the mechanized sector, it will be possible to generate large volumes of commodities to be stored. In the case of the traditional sector, little marketable surplus exists. The rate of growth of the cooperative sector will be slow because the output of the traditional farmer is small and extremely variable. As this growth occurs, the needed storage facilities will be available for cooperatives. For this reason, the primary emphasis has been placed on the mechanized sector, but the project will also support future traditional sector growth.

The four locations selected for warehouses will serve specific groups of clients. For example, the Dilling warehouse will serve the mechanized sector, while the El Obeid warehouse will serve the traditional sector as under current operations. The facilities at Abu Gubeiha and Talodi will warehouse commodities of both the mechanized and traditional sectors. Therefore, the ABS must be willing to extend the production loan and storage operations, such as those at Um Ruwaba and El Obeid, to Abu Gubeiha and Talodi.

Specific purposes that should be achieved by this intervention mechanism are (1) establishment of incentives for further development of the cooperative sector amoung traditional farmers, (2) reduction in farmer losses of stored commodities, (3) improvement in prices and net income received by farmers, (4) establishment of a role model for storage design and storage practices, and (5) improvement in the institutional performance of the ABS.

To address the need to place other improvements within the existing marketing system, a second intervention mechanism will be utilized. This part of the project component will be totally directed towards the private-sector cereal grain and oilseed trade.

A pilot project will introduce correctly-designed facilities and improved handling, conditioning, and storage practices into the private sector. The purpose of this activity will be to reduce looses and improve storage conditions and practices so as to produce a better-quality product for the marketplace.

A pilot project is essential for introducing new technology into this sector. There is a basic lack of knowledge about the costs of operations and investment as related to the functions of handling, conditioning, and storing of agricultural commodities. Since there is strong emphasis by the merchant sector on the cleaning of grain, such needs will be included in the storage facilities. Again, it is not known what the costs and returns for the conditioning of grain will be. Neither is there existing knowledge about costs as related to prices and revenues. This pilot project will test the technical and economic feasibility of storage designs and operations. Thereafter, modifications can be introduced which may be more appropriate than the plan introduced under this pilot project.

Under this pilot project, three storage units will be constructed in El Obeid. This location was chosen because it is the major market center for agricultural commodities and it is also the center of operations for the major merchants in the Kordofan Region. In addition, power requirements for the cleaning equipment restrict the siting of facilities to El Obeid. The ABS will be responsible for the construction of the warehouses. Upon completion, these facilities will be offered to the private sector for sale or lease. The options to be used in this process are (1) outright sale of the facility, (2) sale of the facility through financing, (3) long-term lease of the facility, and (4) long-term lease of the facility with the option to purchase by applying previous lease payments to a predetermined sale price. In the case of leases, the ABS will retain the ownership of the warehouse. Certain conditions surrounding this ownership are further discussed in Section IV.

Recommended facilities are two 3,000-MT and one 6,000-MT bag warehouses. A 2,000-MT bulk storage facility was originally proposed, based on the reasons given in the Technical Analysis appendix. However, the economic and financial feasibility of such a bulk storage complex proved not to be viable, as described in the Economic Analysis appendix.

Coordination of this pilot project will be carried out through the El Obeid Chamber of Commerce. Technical assistance will be provided to ensure a correct implementation process. Training in proper handling, conditioning, and storage techniques will be provided. The necessary equipment for all such techniques will be provided as part of the facility package, regardless of the ownership or lease option selected. All training and technical assistance will be provided directly to the private sector by an expatriate firm as described in Section IV and Appendix B.

As a result of the successful implementation and completion of the pilot project, the following specific purposes are expected to be achieved: (1) to determine the technical and economic feasibility of storage unit designs and operational practices, (2) to act as a role model for loss reduction techniques, (3) to act as a stimulus to the private sector in upgrading storage and handling operations, and (4) to act as a role model to the private sector for improved storage facilities and storage practices.

SECTION II

TECHNICAL ANALYSIS

The technical analysis of the project is divided into two parts: (1) ABS warehouses and (2) the private-sector pilot project.

ABS Warehouses

The determination of future storage locations and the size of these facilities is dictated by five important elements: (1) the lack of road infrastructure over which to transport commodities during all seasons of the year, (2) the warehouses to be constructed by the International Development Agency (IDA) project, (3) the current and proposed locations of ABS branch offices and secondary offices, (4) the projected growth patterns of ABS storage operations in the Kordofan Region, and (5) the distribution of sorghum, sesame, and groundnut production.

Based on all considerations, the proposed sites are Dilling, El Obeid, Abu Gubeiha, and Talodi. The warehouse positioning in the Kordofan Region conforms with the calculated dispersion of the production of sorghum, which is the major crop. Because of the estimated levels of sorghum, sesame, and groundnut production in the above areas and the growth patterns of ABS operations at Um Ruwaba, El Obeid, and Dilling, a warehouse size of 3,000 MT (33,000 bags) was selected. Construction costs indicate that a smaller warehouse unit would greatly increase the investment cost per MT of storage capacity. A larger unit would be totally uneconomical at this time. A standard size for all locations will facilitate the construction process and should reduce or at least stabilize the expected cost of construction.

The ABS has an established planning, engineering, and construction program for building grain storage warehouses. During the period 1981-83 the ABS built warehouses at five locations and intends to construct three warehouses in the near future. The ABS has a consulting engineering firm under contract which is capable of doing design, engineering, and supervision work of grain storage warehouses. However, certain design criteria should be carefully considered. The design criteria, as detailed in Appendix B, deal with warehouse capacity, dimensions, siting, and construction specifications.

This project component will be implemented through the ABS. Warehouse projects are generally divided into two contracts. The first contract is for foreign procurement items and the second contract is for actual construction of the warehouse. The first and the second contracts will be bid at the same time. The tenders will be open to international as well as local bidders. Although the ABS does not at present have any pre-qualification criteria for the contractors, these criteria should be established and used according to the guidelines in Appendix B.

The time schedule for constructing the warehouses is: (1) pre-qualify the contractors and acquire site, 3 months; (2) design the warehouse, prepare specifications for imported and local items, and prepare tender documents, 3 months; (3) invite and let bids, 3 months; (4) import building materials, 6 months; (5) undertake civil, mechanical, and electrical construction, 9 months. The time

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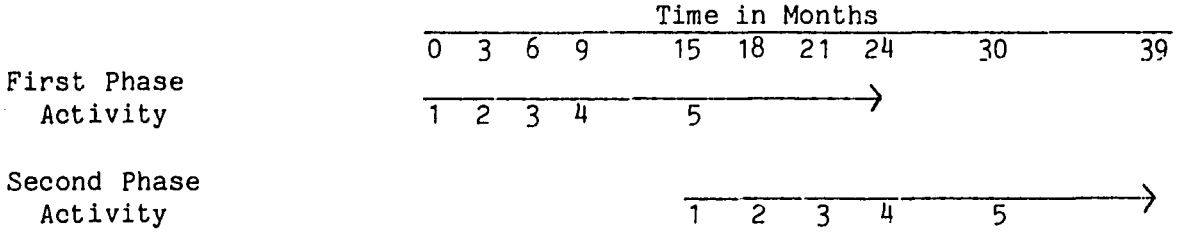
sequence for construction is shown in the following diagram. This sequence, which illustrates the construction of two groups of warehouses, is recommended to facilitate proper management of the project and to gather experience as to the problems encountered.



The ABS and the consulting engineering firm will select and acquire the sites for each of the warehouses, and pre-qualify the contractors. The consulting engineering firm will design the facilities, make detailed construction drawings and specifications, estimate the cost of materials and construction, and prepare all tender and contract documents. USAID will seek technical assistance from a qualified storage management specialist from the U.S. to review the design and specifications of the warehouse. After the review, tenders will be invited by the ABS. These tenders will be evaluated and let by the ABS in conjunction with the consulting engineering firm. The selected contractors will procure and construct the warehouses. If required, USAID may seek technical assistance during the construction of the first three warehouses.

Each warehouse is designed for 1600 m^2 of floor area. The estimated foreign exchange component is based on the total of 100 tons of imported material per warehouse. The estimated C&F Port Sudan price of these imported materials is $200,000. The estimated local currency component will depend on the final design and engineering. This estimate is prepared on the basis of construction experience of the ABS. The estimated total for local currency costs is Ls 633,500. Foreign exchange and local currency costs are detailed in Appendix B.

The success of the project will depend on the ability of the warehouse managers to preserve the quality and quantity of the stored products. The existing methods of grain storage are unsatisfactory. There is a definite need for training grain storage warehouse personnel.

The ABS does not have any specific methods and practices concerning grain storage. Although the ABS is currently in the process of organizing a pest control unit, at present there is no qualified stored-product entomologist on the ABS payroll. Rather than centralizing its pest control activities, the ABS should train individual warehouse managers in pest control methods and should execute the control program without having to depend on the central office. However, the ABS central office should ensure that proper chemicals, equipment, and supplies are available in each ABS warehouse.

The main objective of the training program is to train ABS warehouse managers and other ABS supervisors. The subject matter of the training should include: (1) insect and rodent biology, (2) insect and rodent identification, and (3) integrated pest control measures dealing with inspection, housekeeping, physical and mechanical controls, and chemical controls, including chemical control methods and practices, grain protectants and fumigants, pesticide application, pesticide safety, and rodenticides.

The first step in implementing the training program is for USAID/Khartoum to appoint an appropriate trainer from the U.S. A pre-training trip by the selected trainer will be made to Khartoum/El Obeid to assess the specific training needs, select the training and demonstration sites, and create outlines for the development of training materials such as slides, transparencies, handouts and training manuals. This must be done jointly with an ABS counterpart. Local arrangements and logistics will be discussed at this time, and a definite training schedule will be set up. The trainer will advise USAID as to the type, quantity, and procurement source of pesticides to be regularly used in the projects and in the training program. Appropriate training materials will be prepared by the trainer in the U.S.

After the training is completed, periodical technical assistance from the trainer is recommended to monitor the impact of training, assist the warehouse managers in installing a viable pest control and storage program, and collect data for USAID and the GOS on the technical and economic benefits of the program. The cost estimate for training is $125,500 plus Ls10,000.

Private-Sector Pilot Project

The study team's discussions with the private-sector grain traders indicated the need for improved storage facilities. However, the merchants were not interested in building the warehouses themselves, because they do not possess the necessary expertise, experience, and supervision capability for such an undertaking. If another organization would build the improved warehouses, the merchants would use the facilities under purchase or lease options, if the price were right. Besides storage facilities, the merchants also stressed the need to clean grain before marketing. Even though no grain grading factors exist in the Sudanese buying and selling norms, some subjective criteria as to grain cleanliness do exist in pricing the grain during a normal production year.

The pilot project will consist of three storage facilities: a 3,000-MT bag warehouse, a 6,000-MT bag warehouse, and a 2,000-MT bulk storage facility (or a 3,000-MT bag warehouse, depending on the economic feasibility of each alternative). The size of the storage facilities is dictated by the fact that the ABS warehouses will have a capacity of 3,000 MT and so will facilitate the construction process. The 3,000-MT size fits the needs of an individual merchant, and the 6,000-MT size will allow a group of merchants to jointly use this facility to market their grain. The 2,000-MT bulk storage facility is included as a prototype to test the technical and economic feasibility of such a facility. In order for bagged grain to be cleaned, the bags must be emptied before the grain passes through the cleaner. After cleaning, the grain can either be rebagged for storage in the warehouses, or it can be stored in bulk for rebagging immediately prior shipment. In the latter case, any benefits accruing from the bulk storage can be achieved. Therefore, the use of bulk storage is a logical alternative when cleaning is to be done.

The proposed bag warehouses are described and defined in the technical analysis section on ABS warehouses. The design criteria and implementation procedures are identical to those set forth for the ABS warehouses.

The design and specifications for the bulk storage facility are described in Appendix B. The estimated cost of this facility is $896,336 plus Ls259,000.

The high cost of this facility is due to the large amount of imported materials and to the fact that it must be constructed by an external contractor, since this capability does not exist in Sudan.

Implementation of a bulk storage facililty will require a turnkey approach. A contractor from the U.S. must be hired based on competitive bids. The time schedule for construction of the bulk storage facility is: (1) select grain storage specialist in the U.S. and construction site in El Obeid, 2 months; (2) invite bids and assign contract to turnkey contractor, 3 months; (3) design facility, procure and ship materials to Sudan, 4 months; (4) mobilize resources at construction site, 4 months; (5) transport materials to construction site, 1 month; (6) undertake construction, 4 months. The time sequence for construction activities is shown in the following diagram.

	Time in Months						
	0	2	5	9	13	14	18
Activity	1	2	3	4	5	6	

Each of the three storage facilities will have a grain cleaner included in its equipment. These grain cleaners are to be imported from the U.S. The specifications are given in Appendix B. Each cleaner unit costs $12,000. The total cost for the three cleaners is $36,000.

Training is a key element in order to be able to achieve the goals set forth for this project. The selected operator should be involved with the construction phase of the facility. He should work informally with the contractor, since seeing how the facility is built will benefit him during later operations.

Technical assistance under the private-sector pilot project will be provided to accomplish the tasks set forth in Section IV on implementation considerations. Technical assistance will be provided by a grain storage management specialist and a grain marketing specialist. The training package will be the same as that set forth for the ABS warehouse segment of the project. However, it will also include the use, maintenance, and repair of the cleaners in the private-sector pilot project, as well as training in the operation of the bulk storage facility. The training is directed towards the merchants and their employees. The cost estimate of required technical assistance and training is $386,800.

SECTION III

ECONOMIC ANALYSIS

The economic analysis of the storage and inventory loan component is divided into two parts. The first part deals with the storage facilities for the ABS, and the second addresses the pilot project directed toward the private sector.

ABS Warehouses

A reduction in both weight loss and percentage of damaged kernels of stored cereal grains and oilseeds will result from the construction of suitable storage facilities and the application of correct storage management practices. Costs for construction of facilities and the necessary training and technical assistance will require that storage fees be raised to reflect the cost levels associated with such facilities and operations. The trade-off between reduced storage losses and increased levels of storage fees is detailed in Appendix C. Storage fees should be established at a minimum of 23 piastres per bag per month for the new warehouses, rather than the current rate of 10 piastres per bag per month. However, as a result of loss reduction due to new warehouses and good management practices, the farmer-clients of the ABS will be able to realize a differential of 57 piastres per bag per month, as further detailed in Appendix C. This is in addition to seasonal price increases which should create an added incentive for the farmer to participate in ABS credit programs. The storage fee of 23 piastres per bag per month will cover the operating costs of the ABS warehouses plus generate a net margin of 17 percent return on revenues.

Because of the nature of this project component and its focus on increasing farmer income in the traditional sector and to a lesser degree in the mechanized sector, projected storage capacities will not be fully utilized. ABS loan storage operations will be in effect for no more than four to five months out of the year, depending on the commodity in storage. To overcome what could be a serious constraint to the economic viability of the project, the storage capacity must be utilized for the remaining 7 to 8 months of the marketing year. Two possibilities exist for the alternative use of the storage facilities when they are not being utilized by the ABS. The first is the use of storage capacity for food grain reserves. The second is the lack of adequate cereal grain and oilseed storage capacity in the Kordofan Region, which presents the opportunity for renting the storage facilities to the private sector during the period of non-use by the ABS.

Based on staged construction schedules, facility investments will be Ls1,012,000 for project year 1, Ls2,654,230 for project year 2, and Ls1,642,230 for project year 3. Investment costs for training will be Ls127,100 for project year 2, Ls133,900 for project year 3, and Ls25,300 for project year 4. Investment costs in technical assistance for construction oversight will be Ls24,200 in project year 1, Ls48,400 in project year 2, and Ls48,400 in project year 3.

Direct benefits of the ABS warehouse and inventory loan project component are (1) positive net operating margins (storage fees and rentals greater than operating costs) generated by ABS storage activities and rentals, (2) increased incomes for farmers, and (3) loss reduction in security grain reserve stocks.

Revenues generated by ABS warehouse operations are (1) storage fees charged to client-farmers, (2) storage fees charged for food security stocks, and (3) revenues from renting warehouses during periods of non-use by the ABS. Farmer benefits are (1) an increase in income due to the ability to store crops for later sale when prices are higher, and (2) an increase in income due to loss reduction of the crop while in storage.

Calculation of the direct rate of return is conservatively biased. This bias is fully explained and described in Appendix C. The direct rate of return is 12.02 percent annually. While by some standards this may be considered low, there are several basic factors which need to be taken into account. First, investment and benefit flows are conservatively biased. Second, because of the need to stage construction of facilities benefits are not generated until the third and fourth year of the project. Third, the slow growth in volume stored during the fifteen-year time period analyzed reflects the reality of the situation when such an undertaking is a new concept in a marketing system.

The results of a sensitivity analysis, shown below, illustrate that the conservatively-biased base case annual rate of return is extremely stable, given the levels of possible divergence in investment costs and benefits.

Sensitivity Analysis

	Alternative	Percent Annual Rate of Return
1.	Base case	12.02
2.	Investment costs for facilities increased 25 percent	9.59
3.	Benefits increased 15 percent	13.80
4.	Benefits decreased 15 percent	10.11
5.	Warehouse rental revenue increased 100 percent	12.64
6.	Worst case example: investment cost for facilities increased 25 percent and benefits decreased 15 percent	7.88

Associated benefits of project activities are (1) the value of construction labor, other employment, and engineering fees, (2) the value of training incorporated in the project, (3) the value of the facilities as role models which can be replicated by the private sector, and (4) the value of improving the institutional performance of the ABS. The annual rate of return to investment in ABS warehouses from associated benefits is 9.97 percent. Given the direct rate of return of 12.02 percent annually and the associated rate of return of 9.97 percent annually, the annual social rate of return for this project component is 21.99 percent.

Private-Sector Pilot Project

Since one of the specific purposes of the pilot project is to test the economic and financial viability of the storage facilities in a specific setting, a preliminary analysis was conducted to derive an indication of the economic and financial feasibility of the storage units.

Gross revenues generated by the new facilities are not storage revenues as such, because the storage operations are internal to merchandising activities. The revenues generated by a storage facility in this type of situation are (1) rent expenses defrayed by ownership or lease of the facility, (2) value of loss reduction in terms of the original purchase price of stocks, and (3) value of loss reduction in terms of sales margins. Other benefits with this type of storage installation are reduced handling costs and the ability to spread margins due to the availability of storage. These latter benefits were not considered in the analysis of rates of return. The preliminary analysis is detailed below.

Purchase Options

	3,000-MT Warehouse		6,000 MT-Warehouse		2,000 MT-Bulk Facility	
	Cash Purchase	Financed Purchase	Cash Purchase	Financed Purchase	Cash Purchase	Financed Purchase
IRR	17.7	17.7	18.0	18.0	2.8	2.8
FRR	14.1	0.9	14.4	1.2	-1.3	N/C

Lease Options

	3,000-MT Warehouse	6,000 MT-Warehouse	2,000 MT-Bulk Facility
Return on additional gross revenue	34.0	35.0	-121.0
Return on additional gross revenue plus working capital release	43.0	44.0	-44.0

For the bag warehouses, the results of the purchase options indicate that for cash sale, the internal rate of return (IRR) and the financial rate of financial (FRR) may not be attractive to the private sector. In the case of financed sale, the FRR is almost zero. The major obstacle to financed purchases is the interest rate of 21.5 percent, which is substantially above the IRR. The FRR is nearly zero because there is no return to equity capital since all net income is being expended for interest costs. In the case of the lease option, attractive returns on gross revenue are generally indicated.

The bulk storage facility does not warrant further consideration for any of the possible options at this time. The IRR and FRR in the purchase options, and the returns to gross revenues in the lease option, reveal that this facility is not financially viable. Therefore, it is deleted from the project description and is replaced by a 3,000-MT bag warehouse unit.

In any event, as stated in Section IV, further information collection and economic and financial analysis must be done before presenting the options to the private sector.

SECTION IV

IMPLEMENTATION CONSIDERATIONS

Alternatives for Ownership and Management of ABS Warehouses

The available alternatives concerning ownership and management of the ABS warehouses are: (1) ABS ownership and management, (2) ABS ownership with hired private-sector management, (3) ABS ownership with warehouse leased by and managed by the private sector, and (4) private-sector ownership and management.

Technical feasibility is not a problem with any of the above options. The major constraint is the reluctance on the part of the private sector to become involved in any type of operation that may require close governmental supervision or limit their ability to conduct their own merchandising operations. While it appears that the private sector has the financial resources to exercise either ownership or lease of the proposed ABS warehouses, available investment opportunities in the merchandising and trading of goods are far more lucrative. In other words, it is paramount to the private sector that money be turned often in order to achieve significant returns on financial resources. Again, this creates a constraint in private-sector involvement, since the process of storage for hire is not particularly remunerative to a sector which is constantly trying to achieve returns through the turnover of capital resources. This is not to indicate that the private sector is not interested in specially-constructed storage facilities for the safekeeping of agricultural commodities. Their interest, however, lies in storage facilities which they can either buy or lease for their own use, and thereby exercise independent control over the day-to-day marketing operations. As shown in Appendix C, there are substantial differences in financial returns to a storage unit operated for private sector trading activities and one operated by the ABS where farmers own the crop.

These constraints effectively eliminate options 2, 3, and 4. Option 1 is not undesirable, since it should be the responsibility of the ABS to maintain close physical and financial control over stored commodities which in effect constitute collateral for inventory or production loans. It should also be the responsibility of the ABS to take such actions as to eliminate the potential for conflict between the bank and outside storage facility management in the case of shortages, losses due to failure to institute sound storage practices, or differences in accounting of inventories.

The traditional sector production and loan operations at Um Ruwaba and El Obeid require an element of mutual trust between the two parties working to help the traditional farmer achieve higher commodity prices. This mutual trust must exist if any amount of continued growth in cooperatives is to be expected. Any third-party conflicts which may be introduced will only hinder further growth.

If a third-party operation takes over the responsibility for the warehouse, it may be thought that such an operator has the first right to purchase commodities when they are offered for sale by the cooperatives or the bank. Other merchants may be reluctant to bid against the operator of the warehouse and therefore the farmer-member of the cooperative may not receive the highest possible price for his production. Regardless of who operates the warehouses, a massive amount of training will be required. It is far better to be able to focus this training on one specific institution rather than spread it over

several different organizations. If the training is not limited to one institution, this could create a situation where the responsibility for different actions is unclear.

Finally, there is no experience base in Sudan on which to gauge the viability of private ownership, the exact nature of conflicts which may arise, or the necessary regulations to ensure adequate management and price flexibility. Only in industrial countries do such arrangements exist where the private sector operates "public warehousing". The nature of the marketing system and long years of experience allow this practice to take place in industrial countries. Conditions are perhaps not right for this to work in Sudan.

Introduction of Quality Control Mechanisms

The design of the project, encompassing two separate components, allows specific opportunities for the introduction of quality control mechanisms. First, the ABS storage component will require a training activity which is directed towards establishing correct quality preservation techniques in cereal grain and oilseed storage. This will not only reduce quantity losses, but will also dramatically reduce damaged kernels, an important quality factor.

Secondly, this same training approach will be applied to the private-sector component of the project, again directed towards implementing correct quality preservation techniques. In addition, each pilot facility will be equipped with grain cleaners, allowing the removal of foreign material from the grain before sending it into the retail market. Training in the correct use and maintenance of cleaners will be included in the proposed training activity directed towards the private sector.

Thirdly, both project components allow excellent opportunities to begin investigations directed toward resolving the problem of aflatoxin in groundnuts. While this should not be a specific part of the project, the opportunity for serious investigation of the problem will be available because of the storage structures being constructed under the project.

Neither at this time nor in the immediate future will the domestic marketing system of the Kordofan Region is prepared for or be able to use a grades and standards system. Any thought of this should be discouraged until such time as good faciliies and good practices exist on a widespread basis.

Inventory Loan Procedures

As detailed in the project description, marketing credit (inventory loans) will most likely be implemented in connection with production credit in the first stages of the project. The basic procedure for implementing marketing credit seems to be in place. This procedure entails granting additional credit above and beyond the production loan if the market value of the commodities delivered to the ABS exceeds the amount of the production loans.

Estimates of production credit financing by the ABS in the Kordofan Region are detailed in Table 1. Both the Um Ruwaba and El Obeid branch offices show substantial growth performance, even given the less than satisfactory weather conditions. While the Dilling branch office shows a decline, this is most likely an abnormality produced by the expansion of other mechanized schemes which for the most part are beyond the reach of this branch office.

TABLE 1

Production Credit Financing

Agriculture Bank of Sudan
Kordofan Region Branch Offices

Year	Sorghum	Sesame	Groundnuts
	Percent of Divisional Total Cultivated Area Financed		
	Um Ruwaba Branch Office[1]		
1979-80	-	5.0	14.9
1980-81	-	9.0	38.0
1981-82	-	12.0	49.1
1982-83	-	10.8	19.2
1983-84	-	16.0	1.9
	El Obeid Branch Office[2]		
1980-81	-	1.8	1.5
1981-82	-	7.5	6.3
1982-83	-	20.6	
1983-84	-	28.6	
	Dilling Branch Office[3]		
1979-80	79.4	-	-
1980-81	71.7	-	-
1981-82	70.4	-	-
1982-83	38.2	-	-
1983-84	32.2	-	-

[1]As a percent of total cultivated area in the administrative division of Um Ruwaba.

[2]As a percent of total cultivated area in the administrative division of El Obeid.

[3]As a percent of total mechanized cultivated area in South Kordofan.

Source: Tables 3, 7, 8, 9, and 10, Appendix D.

As a consequence of the need to couple marketing credit with production credit in the near term, repayment percentages and loan extension procedures should be analyzed in depth for each branch office. The limited available data, shown in Table 2, does not suffice to make any accurate judgments. It is recommended that the ABS receive some form of assistance in (1) analyzing the performance of each branch office as to operational cost per loan, repayment rates by type of loan, rates of default, and loan extension procedures for bad debt reserves, and (2) developing management processes which will reduce the likelihood of loan losses, based on the performance analysis.

Loan procedures for both production and marketing credit are constrained by the environment in which the ABS operates. The costs of the loan transactions are of great importance since the ABS must cover the expense of servicing these loans. For loans to the mechanized sector, the monetary value of the loans will be quite high, and therefore the ABS can grant loans to individual farmers. For loans to the traditional sector, the small monetary value of such loans prohibits granting credit to individual farmers. If each traditional farmer were granted credit on an individual basis, the cost of servicing the loan would exceed the interest generated. Therefore, these transactions must be handled on the basis of a group of traditional farmers organized into a cooperative.

All loan and collection procedures, whether for production or marketing credit, should be handled either at the branch office building location or in the field, depending on the sector being financed. At no time should loan or collection procedures be performed at the warehouse facilities. This means that no office should be established within a warehouse from which to conduct this type of business transaction. This approach will allow the warehouse to be only for the storage of commodities. By separating the physical functions of storage and loan operations, the warehouse can be rented out for other purposes during periods of non-use. Prospective private-sector renters will more likely be interested in renting warehouse space if ABS loan and collection operations are not at the same location. This is exactly the same procedure currently used by the ABS, except that the facilities are rented rather than owned by the bank.

Private Sector Pilot Project

The study team is unaware of any previous AID project which has been directly extended to the private sector as in this project component. Several major risks exist in the implementation of this private-sector pilot project. The risks inherent in such a project are (1) hesitance on the part of the private sector to become involved with governmental development projects, (2) actual commitment by the private sector to accept training in cleaning and storage practices, (3) willingness of the private sector to provide needed preliminary information, (4) willingness of the private sector to cooperate in providing information about operation of the new facilities, and (5) non-fulfillment by the private sector or the ABS as to facility ownership or lease agreements.

These risks can, for the most part, be overcome by the correct approach to implementation of such a pilot project. First, the ABS is the logical institution through which to construct the bagged-product warehouses because the ABS is responsible for constructing the other warehouses under this project. However, limits on the authority of the ABS must be defined within the project paper. Given the possible ownership or lease discussed in the project description, the following criteria should be established: (1) If the warehouses

TABLE 2

Repayment Percentages

Agriculture Bank of Sudan
Kordofan Branch Offices

Year	Loan Volume (Ls)	Repayment (%)
	Um Ruwaba Branch Office	
1977-78	15,828	100
1978-79	126,559	100
1979-80	117,180	92
1980-81	362,606	78
1981-82	722,582	89
1982-83	612,401	79
1983-84	1,684,000	70
	El Obeid Branch Office	
1980-81	N/A	N/A
1981-82	N/A	N/A
1982-83	N/A	70.8
1983-84	N/A	66.1
	Dilling Branch Office	
1979-80	N/A	76.2
1980-81	N/A	N/A
1981-82	N/A	N/A
1982-83	N/A	87.7[1]
1983-84	N/A	47.1[1]

[1]Stated as cumulative.

Source: Agriculture Bank of Sudan.

are to be sold to the private sector, the price will be determined by USAID and the technical assistance organization (described later in this subsection) in consultation with the ABS. The price of the facilities should at least cover basic construction costs but not include any undue overhead costs. (2) The sale of the warehouses will be on a cash basis or will be financed at a rate of interest to be determined by USAID, the ABS, and the technical assistance organization. (3) In the case of leases, or leases with option to purchase, the integrity of the lease agreement must be maintained by the ABS. The ABS will have no right or power to confiscate either leased or financed property except in the case of default in payment by the borrower or leasee. (4) In the case of financed sale or lease, the financial agreements between the private sector and the ABS will contain clauses stating the level of warehouse maintenance expected to be performed by the borrower or leasee. (5) The ABS and the construction contractor selected must agree to work with the private sector on an informal basis during the construction phase of the facilities.

Secondly. project implementation will require the services of an external technical assistance organization which has no binding relationship with USAID or the Government of Sudan (GOS). In this way, a level of independent integrity can be created so as to be able to effectively communicate with the private sector. The coordination of the project will be carried out through the Chamber of Commerce of El Obeid. The Chamber of Commerce has been selected as the coordinating agency because it represents a wide range of merchants and business people from the private sector. By action of its membership, the Chamber will select merchants who wish to participate in the pilot project.

The technical assistance organization must retain the same individuals in each specific job for the duration of the project. This continuity of effort will enable the technical assistance organization to achieve a high level of rapport with the private sector over time. A careful selection process must be undertaken to identify a technical assistance organization which fits the above criteria.

Thirdly, all technical assistance is recommended as short-term TDY. This assistance should begin in the first stage of project implementation. Its first actions will be to develop a relationship with the private sector and explain the details and implications of the proposed pilot project. During these early stages, information will be gathered which with to construct a complete analysis of the pilot project facilities.[1] This information base will be used to establish facility sale and lease prices and the viability of the four options presented in the project description. The results concerning the viability of the options will be discussed in close coordination with the El Obeid Chamber of Commerce. It will then become the responsibility of the Chamber to select those members who will have first priority for availing themselves of new facilities.

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[1]While a preliminary analysis is provided in this report, the lack of accurate data prevents the needed thorough analysis of costs and returns.

The technical assistance organization will work closely with the second technical assistance team responsible for warehouse construction oversight (refer to ABS component in the technical analysis section). The technical assistance organization will also provide training in storage management, handling, and conditioning of cereal grains and oilseeds.

The technical assistance organization will remain in place for two years after final construction of the last facility. During this time, additional training will be provided and information collected on the operation of the facilities. This will enable the technical assistance organization to analyze operational results and to recommend improvements in design and operational methods for future facilities. A cost estimate of needed technical assistance is detailed in the technical analysis, Appendix B.

APPENDIX A

KORDOFAN RAINFED AGRICULTURE
PP DESIGN - STORAGE COMPONENT

Statement of Work

Background

This project will address three interrelated agricultural problems--farm-to-market transport, access to crop storage, and seasonal cash flow constraints--in order to improve production incentives and increase farmer income. Additional returns from agriculture will provide private commercial farmers with the means to increase production. To the extent possible, USAID intends to implement the project through private businesses and farmers' associations. One of the principal tasks of the PP design team is to identify mechanisms to involve the private sector in project implementation.

Kordofan Region, located in Western Sudan, is one of the country's highest producing rainfed agriculture areas. Without investments in transport and marketing, however, increased production potential is limited. Slow travel and rough roads have meant high transit costs to compensate for time, vehicle repairs and fuel. These costs cut directly into the farmer's return on his crops and raise prices for agricultural inputs, commodities and imported food. Poor access to regional and national markets has limited marketing options and at times discouraged production because of inability to evacuate crops. For most farmers, agricultural profits are low. Seasonal cash flow constraints force them to sell crops immediately after harvest when high supplies drive prices down. Storage as a commercial operation is limited to high-volume mechanized farmers and merchants who can hold crops until prices rise. While the marketing system has led to a dynamic merchant class, limited profits from incremental production have mitigated incentives to expand cultivation and invest in agriculture. Sustained growth requires greater shared interests, and thus cooperation, between merchants and farmers.

KORAG has three components to improve the marketing and transport network in Kordofan's central production belt:

(1) improved farm-to-market roads will increase seasonal accessibility in rural areas;

(2) crop storage facilities will increase farmers' profit margins through gains in marketing profits;

(3) inventory loans will alleviate cash flow constraints that reduce marketing options.

The components are interrelated. Farm-to-market roads link production areas to regional markets and major transportation arteries. Storage sites provide a holding point between producer and consumer, allowing higher marketing profits from seasonal price increases. The third component, credit, gives farmers the financial flexibility to store their crops. This background section provides additional details on the project's storage component only.

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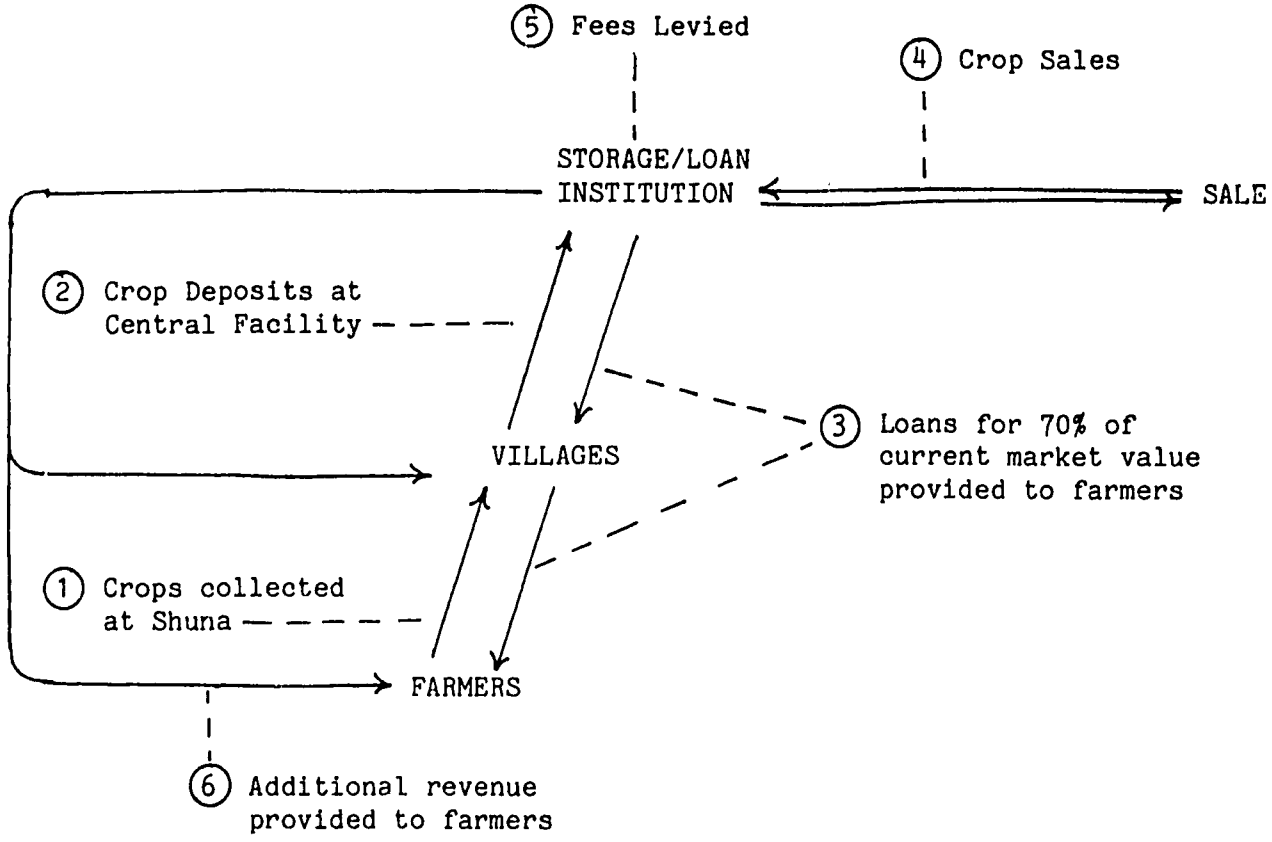
A national storage study for the Ministry of Finance and Economic Planning, current analyses for an Egypt/Sudan integration project, and USAID-sponsored marketing studies have indicated that flat warehouses and gravity-fed storage bins best suit most storage needs in rural Sudan. Flat warehouses, characterized by high loss rates, dominate commercial storage facilities in Kordofan. Most of these warehouses are old and overcrowded with poor pest control and little ventilation. Average storage loss rates in Kordofan Region are estimated at 25 percent for sorghum, 15 percent for groundnuts and 10 percent for sesame. Despite the high loss rates, flat warehouses have proved attractive because of their versatility. Moreover, loss rates could be reduced substantially with improved construction and management. Widespread diversification into gravity-fed bulk storage could further reduce loss rates and curtail imports for jute bags now absorbing $15 million annually in foreign exchange. An Egypt/Sudan integration project will test simplified bulk-handling facilities in eastern Sudan in 1985. Designs for this project will be available to the KSU team.

Storage sites will be integrated with feeder road improvements in central Kordofan along a loop from Kadugli south to Talodi and north to Umm Ruwaba. The Kordofan Ministry of Agriculture has specified six major towns as potential storage sites: Kadugli, Talodi, Abu Gubeiha, Rashad, Umm Ruwaba and El Obeid. Final designation of storage sites must be done during PP design. The size and types of facilities will vary from site to site depending on total production in the area and the prevalent crops. USAID anticipates that a total storage capacity of approximately 30,000 tons will be provided through both flat and bulk facilities.

The storage component of the project begins at the village level. Rather than sell non-perishable surplus crops to merchants immediately after harvest, farmers would bring these crops to a central collection and storage facility in the village called a shuna. Village collection and storage of crops is a self-help component of the project to be facilitated by the ABS and the Kordofan Department of Cooperatives. The two groups have established 47 cooperatives in northern Kordofan and have received requests for funding from many selforganized cooperatives. Most villages have well developed local councils and a history of cooperative activity. USAID plans to request the services of Volunteers in Overseas Cooperative Assistance, through a centrally funded project, to determine measures for strengthening cooperative management, this will not be central to the team's responsibilities.

Once villages have gathered sufficient produce to fill a lorry, they will transport crops to central storage facilities in major towns and receive an "inventory loan" based on the value of their crops. The manager of the storage facility will act as an agent for the farmer and sell the crops once prices rise. The agent would receive a fee for maintenance, administrative costs, and other services such as pest control. A service charge as a percentage of total sales will be levied to maximize the agent's incentive to obtain the best price for the farmer. The remaining revenue from crop sales would then go to the farmer, as shown below.

Dynamics of Storage



Issues regarding ownership and management of the storage facilities must be resolved during the Project Paper design. USAID's principal objective is to maximize private sector participation and incorporate sound financial principles into the accompanying loan program. The availability of private capital for ownership of the storage facilities must still be explored, including options such as cooperative ownership by local growers associations. If capital is a constraint to private ownership, USAID will consider provision of credit through the Agricultural Bank of Sudan (ABS) or a lease/sale program where rents are applied to eventual purchase of the facilities. The design team may suggest other financing alternatives. The ABS is interested in both owning and running the storage facilities, but USAID considers this option a last resort. The ABS's principal role in storage will be to contact for procurement construction, and engineering supervision of the facilities. USAID will channel inventory credit through the ABS.

Objective

Kansas State University is requested to prepare both the technical and economic analyses of the storage component for the Kordofan Rainfed Agriculture Project Paper. KSU should also make recommendations on management and ownership of the storage facilities, including alternative financing schemes to maximize private sector participation.

Level of Effort

USAID will require two person months of services, beginning in mid-July, to be split by an agricultural engineer and an agricultural economist. The agricultural engineer should be familiar with alternative storage designs for rural areas where the main market crops are groundnuts, sesame and sorghum. The agricultural economist should have experience in assessing appropriate levels of storage and designing management schemes for storage facilities.

Duties and Responsibilities

1. General. Review the Kordofan Rainfed Agriculture PID and the "Kordofan Transport and Marketing Study" (Louis Berger, March 1983). USAID will provide KSU with other general documents on storage in the Sudan.

2. Agricultural Economist

- Review production data by crop for various parts of Kordofan Region to confirm the location of storage facilities and the proper levels of storage for each site.

- Evaluate the costs and losses associated with current commercial storage and handling techniques.

- Assess the availability of private capital for management and ownership of storage facilities under the project.

- Consider alternatives for ownership and management of storage facilities. If private ownership is technically and financially feasible, recommend financing schemes that would facilitate private ownership of storage facilities.

- Outline any regulations necessary to control and monitor storage prices if private ownership would result in geographic monopolies; suggest alternatives for enforcing these regulations.

- Evaluate the economic costs and benefits of technologies proposed for the project.

- Suggest means and junctures where quality control mechanisms could be introduced most effectively.

- Outline alternative procedures for providing inventory loans to farmers, including the extent to which storage facilities should be used as loan outlet and collections points.

3. Agricultural Engineer

- Present to USAID and the ABS a variety of storage and handling technologies showing costs and average loss data.

- Provide prototype designs for the most appropriate types of storage facilities given regional production levels and crop types. Emphasis should be placed on maximizing the use of local

materials to facilitate future expansion of the project with local currency funds.

- Specify the local currency and foreign exchange costs of storage facilities based on an analysis of the availability of materials on the Khartoum market.

- Work with the Agricultural Bank of Sudan to prepare an IFB package showing plans, quantities, costs, specifications and documents modified to meet AID host-country contracting requirements.

- Recommend procurement procedures, timing and sources for off-shore procurement. KSU should provide catalogues for off-shore procurement items.

- Suggest pre-qualification criteria for a local construction contractor.

- Discuss, evaluate and recommend alternative pest control measures for the recommended storage technologies.

Professional Relationships

The KSU team will report to and receive guidance from the USAID project design, agriculture and engineering offices, but will also work closely with Sudanese professionals. The Kordofan Ministry of Agriculture has the best production data for the region and will provide advice in finalizing the storage sites. The Agricultural Bank of Sudan will assist in the selection of storage designs and contract for procurement and construction of the facilities. USAID will assist in contacts with the appropriate GOS officials and will arrange for local support, as necessary, from the University of Khartoum faculty of agriculture.

Reports

KSU will prepare the economic and technical analyses for the storage component of the KORAG PP, including brief versions for the body of the PP and more extensive technical annexes. USAID will review drafts of these analyses while the KSU team is in Sudan.

APPENDIX B

TECHNICAL ANALYSIS

Bag versus Bulk Systems

Grain storage and handling systems can be divided into two general categories: bag systems and bulk systems. Each system has advantages and disadvantages, depending on the situation in which the system is used. The following is a comparison of the two systems according to applicable characteristics.

Capital expenditure. Construction costs for a bag system are less than those for a bulk system.

Power source. An electrical or mechanical power source is needed for the equipment used in a bulk system. For a bag system, all storage and handling functions may be accomplished by manual labor alone. However, electric lights and electrically or mechanically-driven handling and processing equipment may also be incorporated into a bag system.

Flexibility in operation. A bag system is more flexible and versatile, since various types of cereal grains, legumes, and oilseeds may be stored in the same storage facility. With a bulk system, only one type of product can be stored in any one storage bin.

Level of technology. The bulk system requires a higher level of technology than the bag system, because of the electrical and mechanical equipment involved in the bulk system. The bag system may or may not utilize this type of equipment.

Supporting infrastructure. For a bulk system the necessary requirements are good paved roads, bulk handling trucks or rail cars, and a bulk weighing system. For a bag system all that is needed is good roads and any conventional (general purpose trucks or rail cars) or traditional (manpower, animal power) transport system.

Construction. Extensive supervision by an expatriate organization is necessary with a bulk system. For a bag system, this supervision may be minimum.

Maintenance. Because of the electrical and mechanical equipment utilized in the bulk system, skilled workers such as millwrights and electricians are required for performing maintenance tasks. Such technicians may not be necessary for a bag system.

Foreign exchange. A bulk system involves mainly imported equipment and materials. A bag system relies less on imported materials and more on materials that can be procured locally.

Grain loss. The grain loss in a properly-managed bulk system may be less than 0.5 percent per year. In a bag system the loss is usually higher.

Storage space. Depending on the size of the warehouse, the loss of storage space in a bag system due to necessary aisle space ranges from 20 to 50 percent. In a bulk system, much less storage space is lost.

Operating expense. Because of manual labor involved in the handling of bags, a bag system requires more labor and management cost than a bulk system.

Inventory management. It is more difficult to manage a large number of bags in a warehouse than to manage bulk grain in bins.

Insecticide application. The application of insecticides in a bagged-product warehouse requires much effort and preparation. Insecticide application in bulk is relatively easy and more effective.

For most regions of the Sudan, especially project areas of the Kordofan Region where roads and power sources are not fully developed and skilled manpower is a scarce resource, the advantages of the bag system far outweigh the disadvantages, and they also outweigh the advantages of a bulk system.

Crop Production Patterns in the Kordofan Region

Sorghum production in the Kordofan Region is characterized by an upward trend over time as well as extreme variations in production level from year to year. These variations are mostly due to the impact of weather conditions. The data base for analyzing the two production sectors (mechanized[1] and traditional) is limited to a period of less than ten years. The available data reveal that production levels in the traditional sector of both North and South Kordofan have declined over this time period, while production levels in the mechanized sector have increased sharply. This is illustrated in Figure 1.

The primary factor in the increased sorghum production is the extensive increase in area under cultivation as shown in Figure 2. For the Kordofan Region, cultivated area has more than tripled since 1961. This increase in area has not resulted in a proportional increase in production. The increase in land area has been somewhat offset by the volatility of yields, as well as by a declining trend in yields, as illustrated in Figure 3. While the volatility of yields is most likely due to weather conditions, the downward trend in yields is possibly the reflection of declining soil fertility.

Sorghum is produced in North Kordofan by traditional practices only. The administrative divisions of Um Ruwaba and En Nahud produce nearly 90 percent of the total sorghum production, with the balance being produced in the El Obeid division. The production of sorghum in South Kordofan is characterized by both mechanized and traditional practices. The total production of sorghum within South Kordofan is equally divided between the mechanized and traditional sectors. Approximately 85 percent of the traditional production comes from the administrative divisions encompassed by the project area. Within this area, 25 percent is produced in the Dilling division, 40 percent in the Kadugli division, and the remaining 35 percent is spread over the eastern division.

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[1]Mechanized production schemes are large blocks of land, usually 1,000 to 1,500 feddans in size, cleared by the Mechanized Farming Corporation and leased to private-sector operators. The schemes are mechanized only to the extent of tillage, planting, and threshing. All other work is done with manual labor.

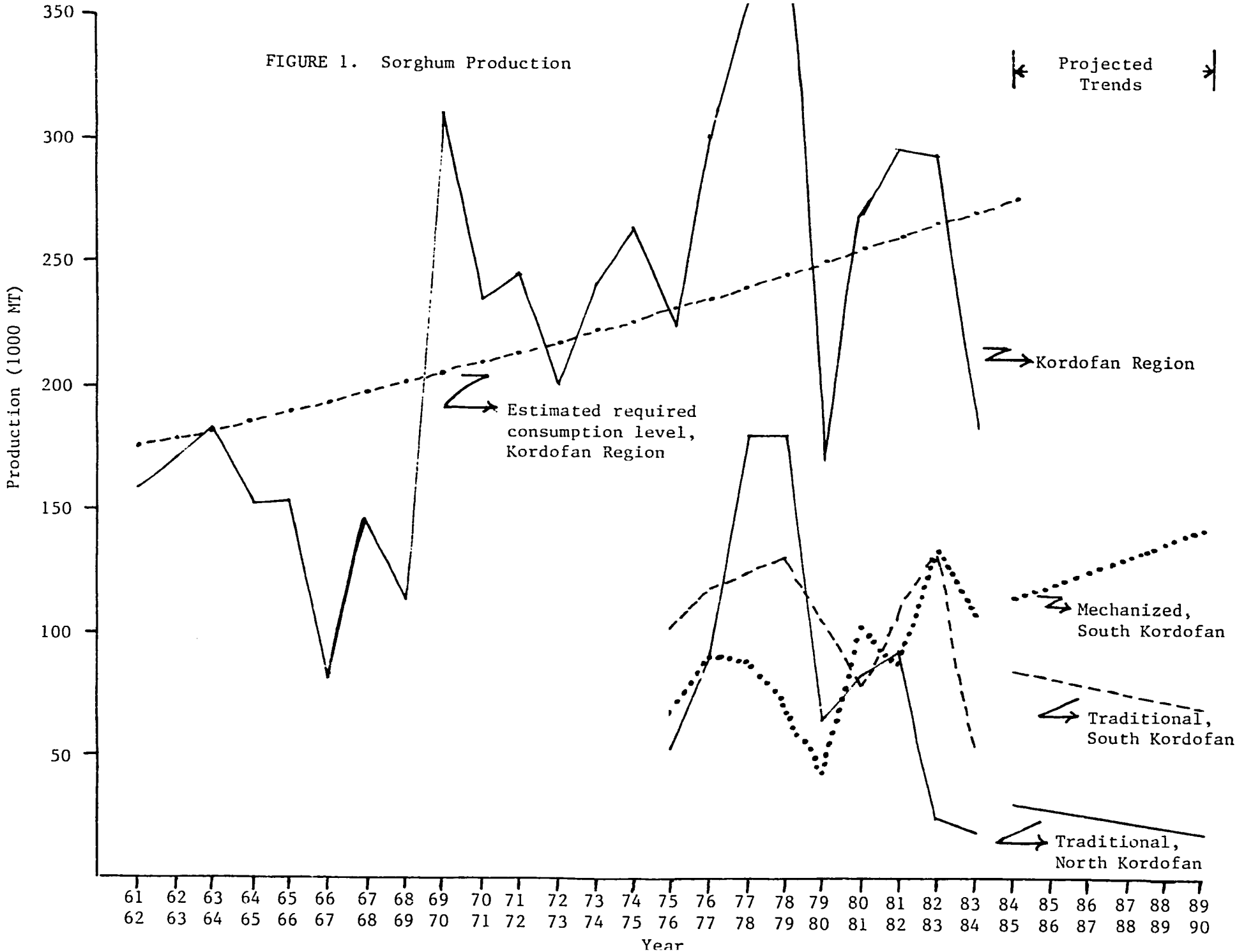


FIGURE 1. Sorghum Production

FIGURE 2. Sorghum Area

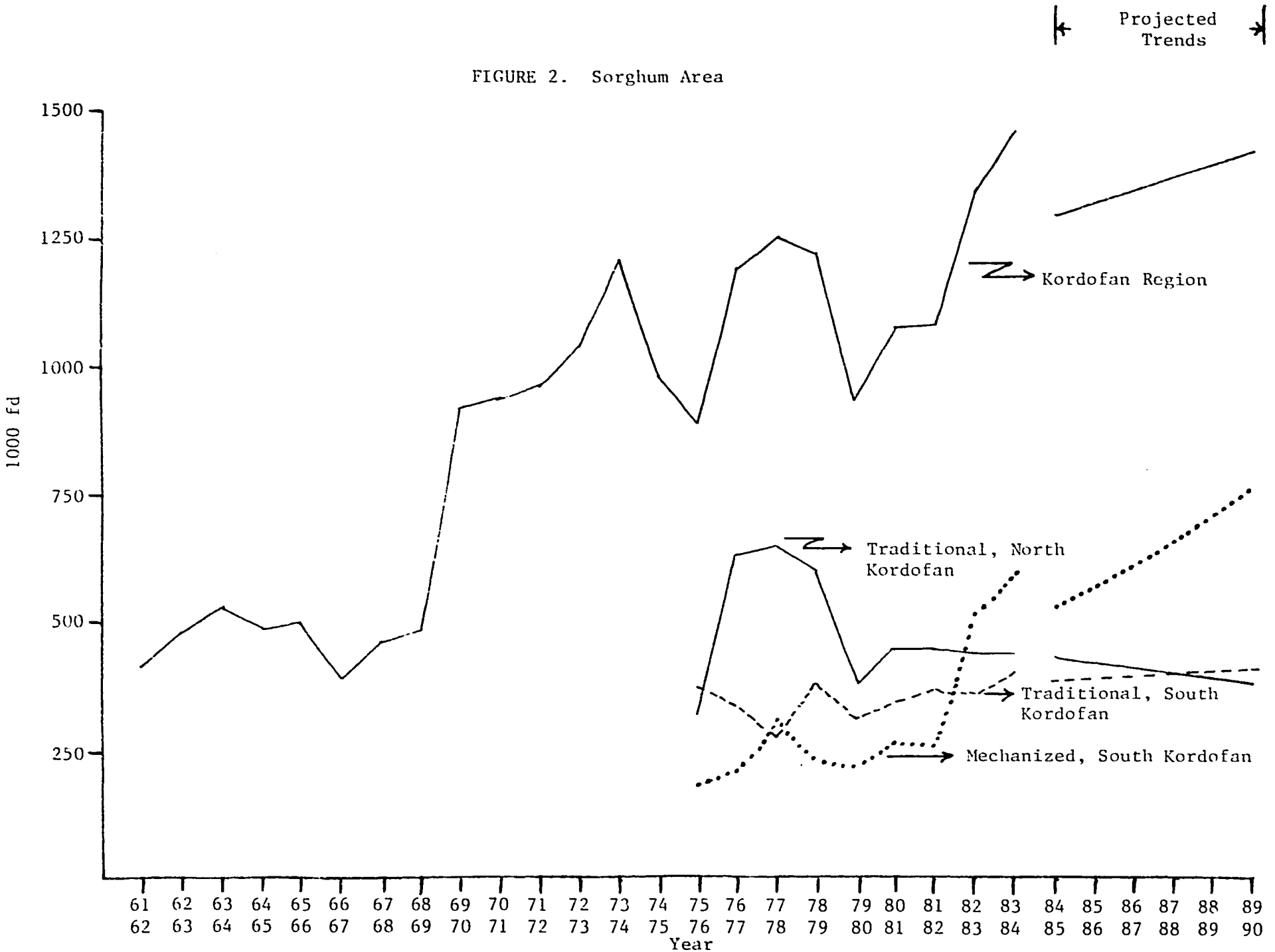
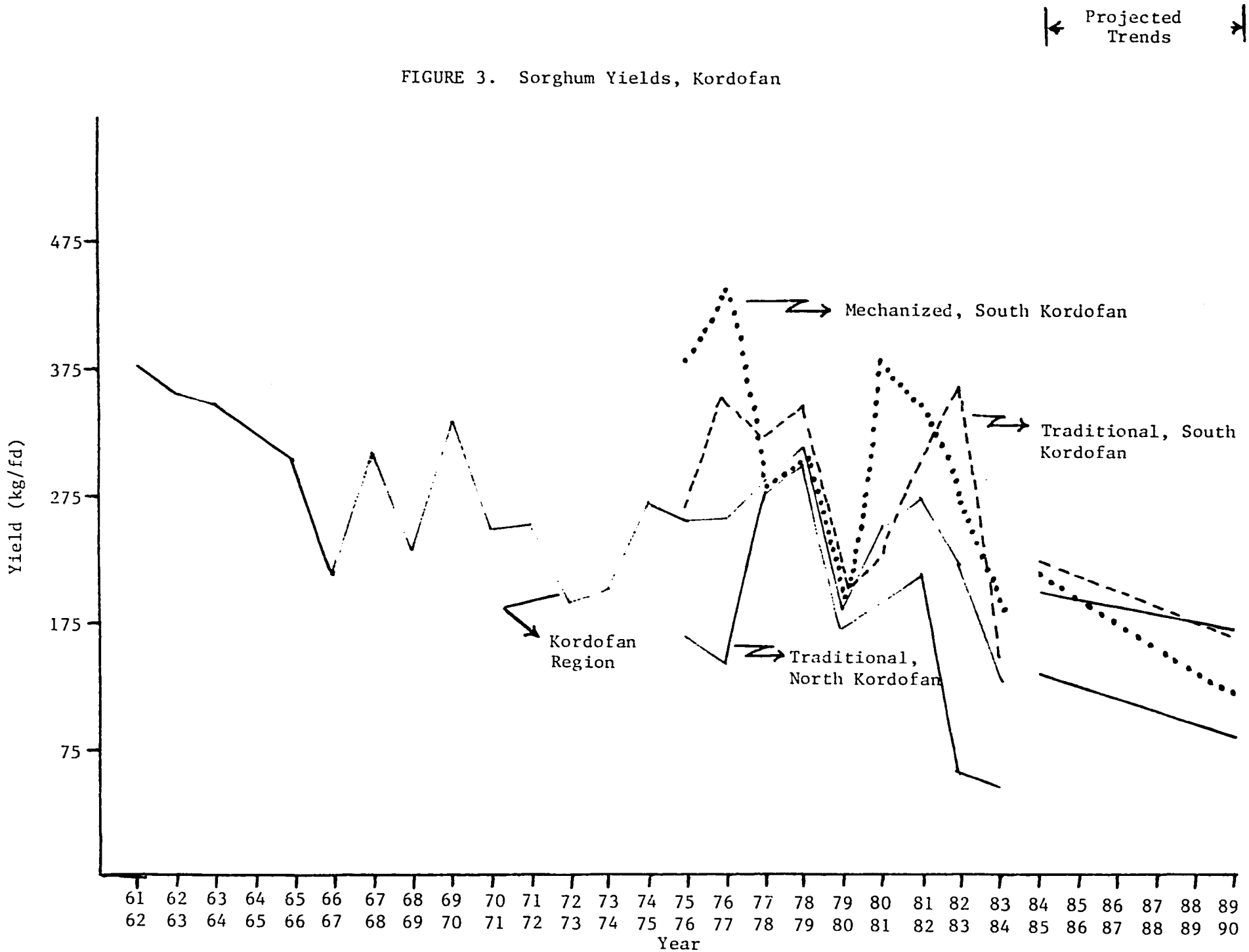


FIGURE 3. Sorghum Yields, Kordofan



Sorghum production in the mechanized sector is illustrated in Figure 4, which shows the approximate location of mechanized schemes. The Dilling division accounts for nearly 75 percent of mechanized production, and all but a small portion of the balance is located in the eastern division.

Groundnut production in the Kordofan Region has increased markedly, while sesame production has fluctuated around a slightly increasing long-term trend. These cash crops exhibit the same characteristics, as in sorghum production, of an increasing trend in area under cultivation and a downward trend and volatility of yields. In addition, cultivated area fluctuates greatly from year to year.

North Kordofan accounts for nearly 90 percent of the Kordofan region's groundnut production and 80 percent of the sesame production. The En Nahud administrative division accounts for nearly 98 percent of the groundnut production in North Kordofan. Over 50 percent of the sesame production occurs in the Um Ruwaba administrative division, with the balance being shared by the other three divisions.

Oilseed production in South Kordofan has declined to a very small percentage of total agricultural production. Groundnut production seems to be distributed mainly across the northern part of South Kordofan. Sesame production is more widely scattered, with some production even occurring in the valley areas of South Kordofan. Since oilseed production in South Kordofan is limited, these commodities will have a minor importance in project operations.

ABS Locations in the Kordofan Region

Within the project area, the Agriculture Bank of Sudan (ABS) has branch offices located at Um Ruwaba, El Obeid, and Dilling. The Dilling branch office operates a secondary office at Talodi. A proposed branch office at Abu Gubeiha is under consideration.

ABS Storage Performance

The ABS storage function currently consists of renting storage space for its clients. Once the commodity is stored, it is under the control of the ABS and is considered collateral for production loans which were previously granted. Inventory loans may be granted on the stored commodities if the value of the commodity exceeds the amount of the production loan. In limited cases, inventory loans are granted for commodities which have been placed in storage without a production loan from the ABS. This practice seems to be limited at present to the merchant sector since current conditions, as set forth in the project description, seem to preclude the majority of the production sector.

In Um Ruwaba and El Obeid, the rented storage space consists of small brick stores ranging in size from 5 x 6 to 20 x 6 meters. The ABS branch office at Dilling rents a large multipurpose warehouse at Dubeibat for storing its clients' production. In some instances sorghum from the mechanized sector has been stored at El Obeid and Um Ruwaba. In all cases, these facilities are totally inadequate for the correct storage of cereal grains and oilseeds because of unfinished floors and walls, leaking roofs, and poorly-fitting doors. This allows rodents and birds to enter the facility, prevents correct housekeeping, and provides an environment favorable to insect de elopment.

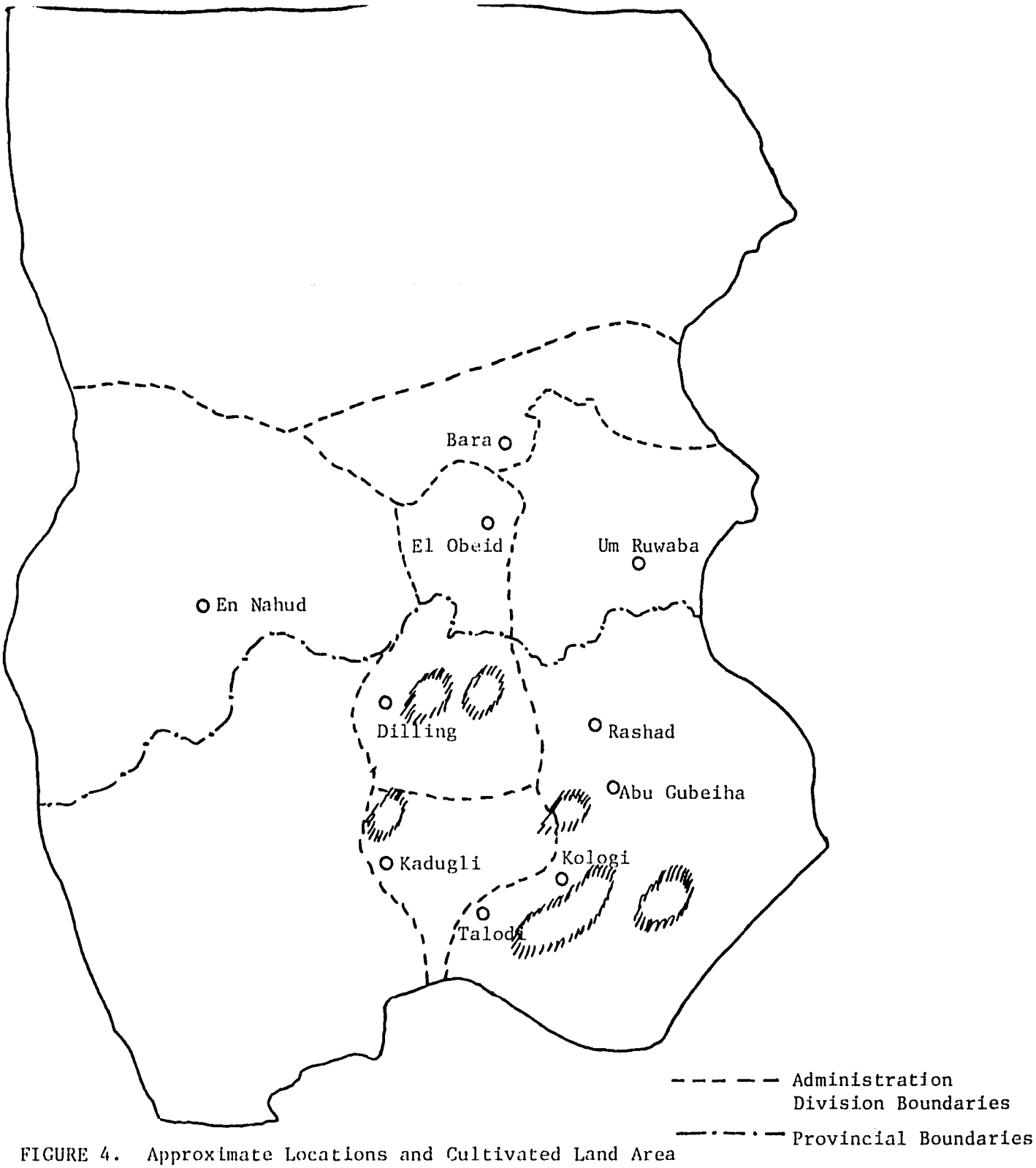


FIGURE 4. Approximate Locations and Cultivated Land Area of Mechanized Farming Schemes, Kordofan Region

1.	Habila	304,000 - 330,000 fd*
2.	Katara	140,000 fd
3.	Um Ruwaba	66,000 - 110,000 fd
4.	Karandal	18,000 fd
5.	Toussi	5,000 fd
6.	El Beda	72,000 - 150,000 fd
7.	El Duvoungassi	6,000 fd
8.	Proposed expansion area	

*Differences exist because of two separate sources within the Mechanized Farming Corporation.

Source: Mechanized Farming Corporation

FIGURE 5. Oilseed Production, Kordofan Region

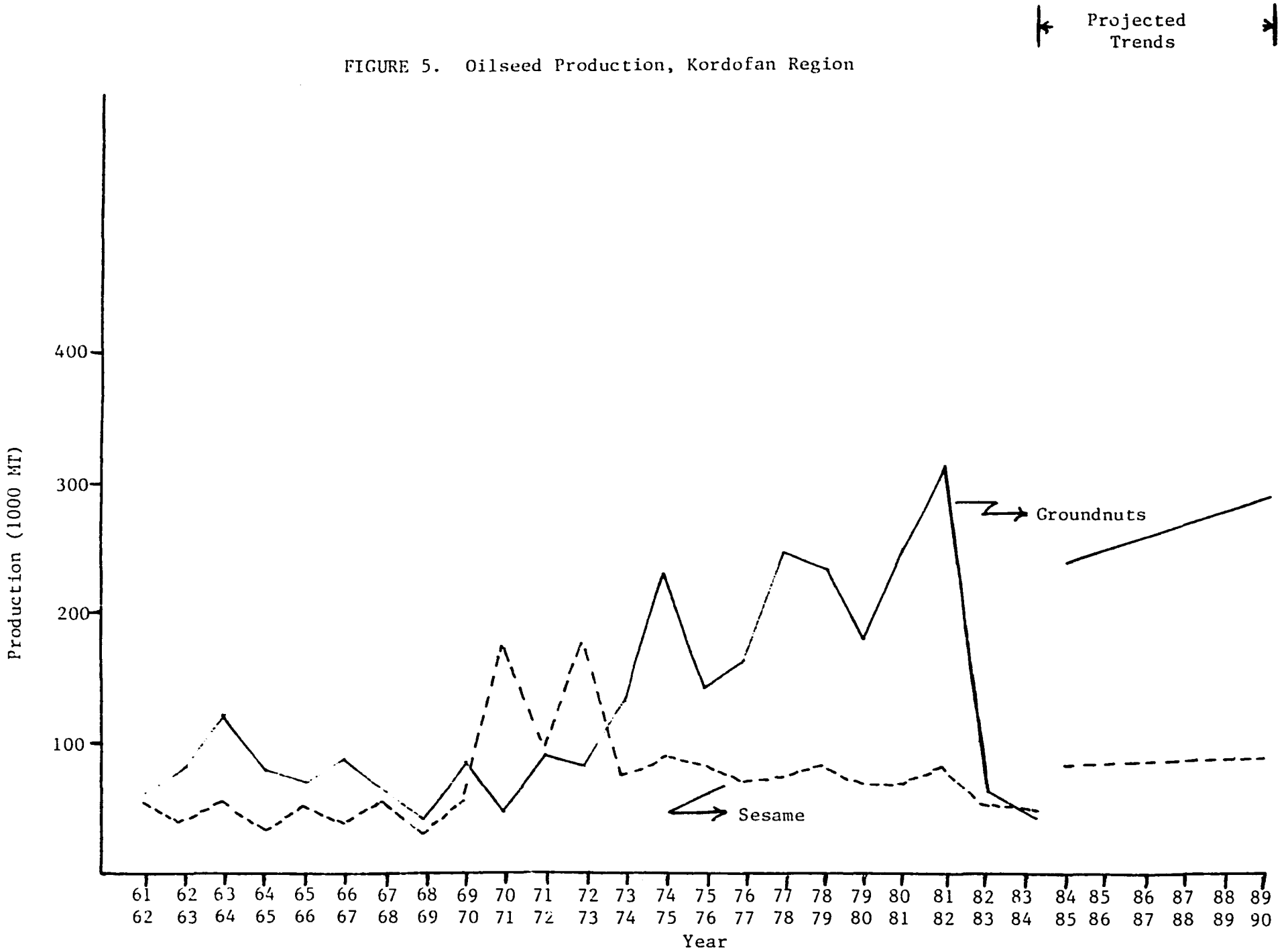


FIGURE 6. Oilseed Area Cultivated, Kordofan Region

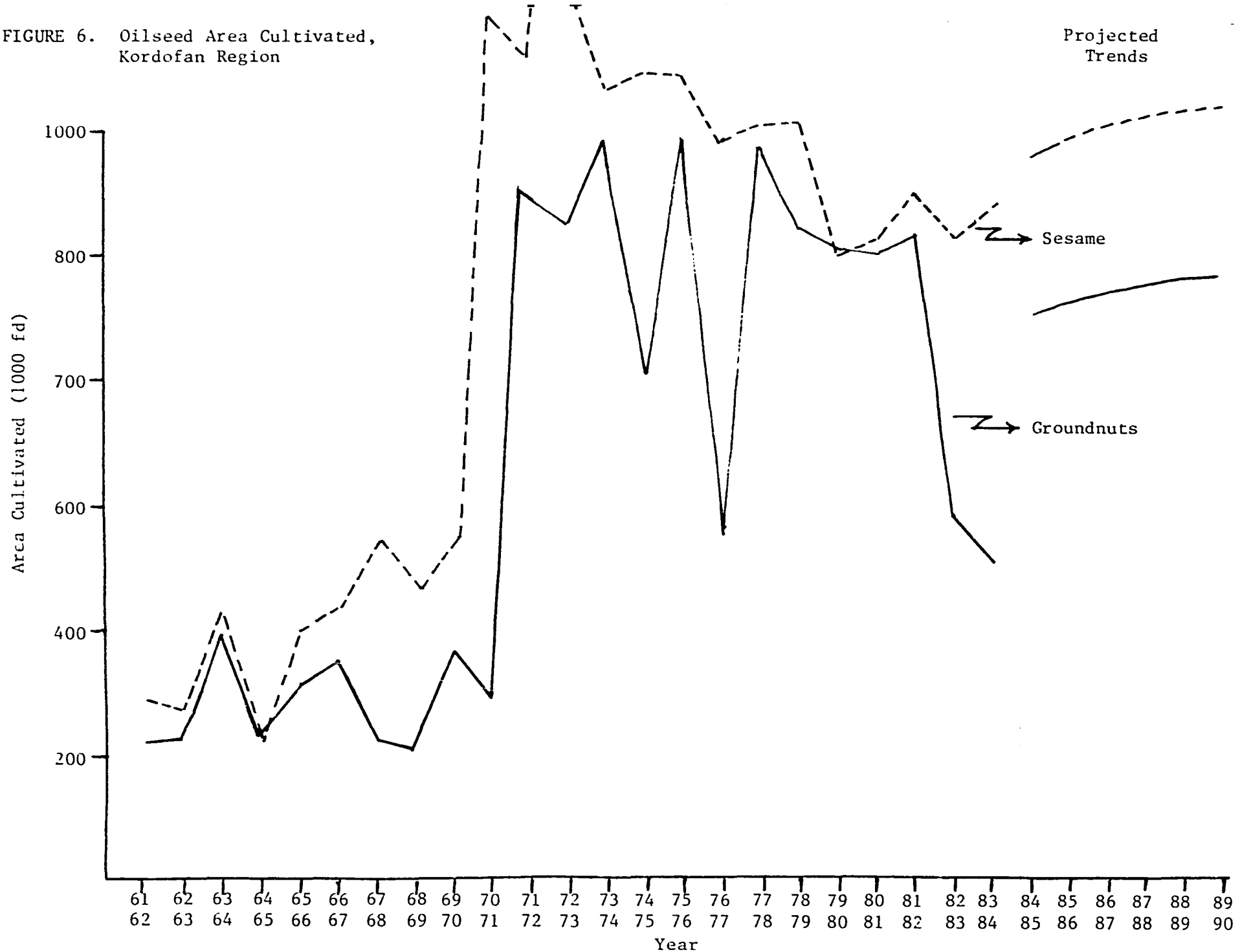
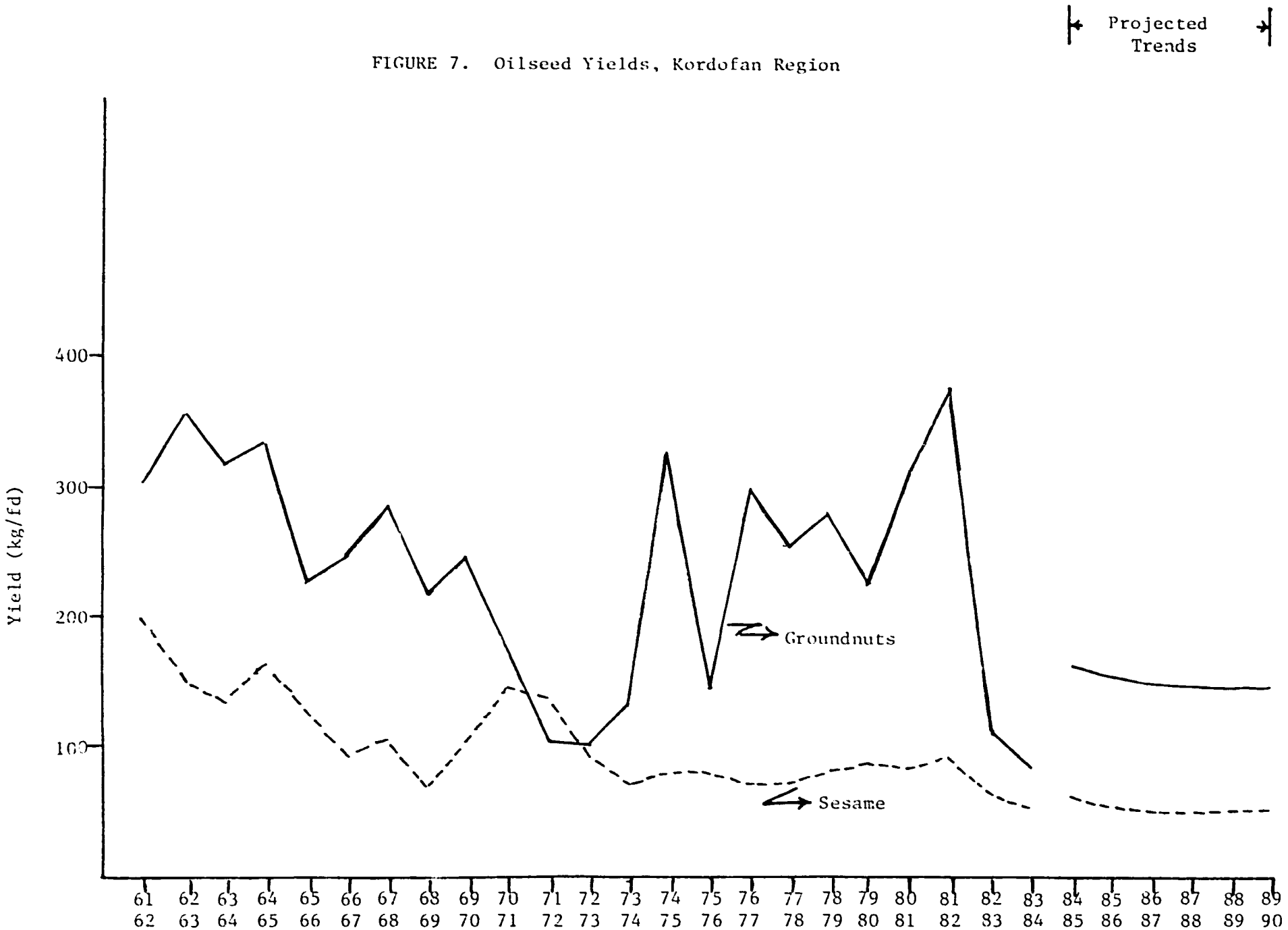


FIGURE 7. Oilseed Yields, Kordofan Region



There has been slow growth in the amount of commodities placed into storage by the ABS branch offices in Um Ruwaba, El Obeid, and Dilling during the limited time these loan operations have been in place. The Um Ruwaba and El Obeid branches are essentially pilot operations by the ABS for conducting production financing and performing storage functions for groups of traditional farmers organized into cooperatives. Cooperatives are a new concept in agricultural production in the Kordofan region. The branch office at Dilling concentrates on the mechanized sorghum production sector.

Table 1 shows the amount of commodities placed in storage as a percentage of total production and financed-area production. While year-to-year variations occur, most likely due to weather and market conditions, the overall growth rates are extremely good.

Future ABS Storage Locations and Sizes

The determination of future storage locations and the size of these facilities is dictated by five important elements: (1) the lack of road infrastructure over which to transport commodities during all seasons of the year, (2) the warehouses to be constructed by the International Development Agency (IDA) project, (3) the current and proposed locations of ABS branch offices and secondary offices, (4) the projected growth patterns of ABS storage operations in the Kordofan Region, and (5) the distribution of sorghum, sesame, and groundnut production.

The lack of road infrastructure limits the possible sites for construction of storage facilities. However, the proposed road projects in the Kordofan Region offer the possibility of locating warehouses at population centers on the proposed road network. Possible sites for warehouse construction are Um Ruwaba, El Obeid, Dilling, Kadugli, Talodi, Kologi, Abu Gubeiha, and Rashad.

Proposed warehouse construction under the IDA project will supply the ABS with a 10,000-MT (110,000 bags) storage facility at Um Ruwaba and a 5,000-MT (55,000 bags) warehouse at Dilling. The construction of the IDA-funded warehouse at Um Ruwaba will create sufficient storage capacity for this location for a number of years. Therefore, this site will no longer be considered as an ABS warehouse site. However, given the past levels of sorghum placed into storage by the Dilling branch office, the construction of a 5,000-MT warehouse at this location will still leave this branch with a storage capacity deficit of nearly 20,000 bags.

Current and proposed ABS locations within the project area reduce the site selections to Dilling, El Obeid, Abu Gubeiha, and Talodi. Dilling and Talodi can well cover a major portion of the Kadugli division, and Talodi will be able to extend operations into the Kologi region. In addition, the location at Abu Gubeiha can extend operations to portions of the Kologi and Rashad areas, and other portions of the Rashad area can be covered by the Um Ruwaba branch office.

This warehouse positioning in South Kordofan conforms with the calculated dispersion of the production of sorghum, which is the major crop. Since sorghum production appears to be highly dispersed in the eastern division, warehouse locations at Talodi and Abu Gubeiha will be able to reach a larger number of traditional farmers. Given the approximate locations of the mechanized schemes

TABLE 1

Estimates of Storage Performance

Agriculture Bank of Sudan
Kordofan Region Branch Offices

Quantity Placed in Storage

Year	As a Percent of Total Production			As a Percent of Financed-Area Production[1]		
	Sorghum	Sesame	Groundnuts	Sorghum	Sesame	Groundnuts
			Um Ruwaba			
1979-80	-	0.4	4.0	-	18.2	62.8
1980-81	-	1.0	1.3	-	24.7	5.8
1981-82	-	2.3	9.4	-	38.0	33.7
1982-83	-	5.0	6.3	-	47.0	33.0
1983-84	1.7	3.7	3.5	-	23.0	184.0
			El Obeid[2]			
1980-81	-	-	-	-	-	-
1981-82	-	1.5	1.3	-	14.0	20.0
1982-83	-	7.3	3.7	-	34.0	7.0
1983-84	-	5.0	1.4	-	17.0	13.0
			Dilling			
1979-80	16.3[3]	-	-	20.3	-	-
1080-81	4.3	-	-	12.7	-	-
1981-82	5.0	-	-	12.6	-	-
1982-83	7.4	-	-	23.2	-	-
1983-84	3.8	-	-	32.8	-	-

[1]Financed-area production is the production from the cultivated area financed by the ABS.

[2]Does not include stored sorghum which was produced on mechanized schemes.

[3]Total mechanized sector production, all schemes.

(Figure 4), the locations at Talodi and Abu Gubeiha have the opportunity to increase ABS participation in the mechanized sector. Therefore, four warehouse sites are selected: El Obeid, Dilling, Talodi, and Abu Gubeiha.

Based on the estimated levels of sorghum, sesame, and groundnut production in the above areas and the growth patterns of ABS operations at Um Ruwaba, El Obeid, and Dilling, a warehouse size of 3,000 MT (33,000 bags) was selected. Construction costs indicate that a smaller warehouse unit would greatly increase the investment cost per MT of storage capacity. A larger unit would be totally uneconomical at this time. A standard size for all locations will faciliatate the construction process and should reduce or at least stabilize the expected cost of construction.

ABS Warehouses

The ABS has an established planning, engineering, and construction program for building grain storage warehouses. During the period 1981-83 the ABS built warehouses in North Khartoum, Halfa, Wad Madani, Shandi, and Dongola, and intends to construct three warehouses in the near future, one each at Um Ruwaba, Dilling, and Abu Hamad, under an IDA credit program.

The ABS has engaged the consulting engineering firm of Elamin Muddathir on a long-term basis since 1976. This firm is paid 2.5 percent for engineering supervision and 5 percent for preparation of specifications, drawings, and tender documents, based on the total cost of the project. The consulting firm is capable of doing design, engineering, and supervision work of grain storage warehouses. However, the following design criteria should be carefully considered.

ABS Warehouses: Design Considerations

The capacity of the warehouse is one of the first facts which must be considered. The usable volume in a warehouse is less than the gross volume because of the fact that some space must be left clear for air circulation and ventilation. Aisleways preferably 1 m wide but not less than 0.6 m wide must be left between stacks of bags and between the stacks and the wall, and some space is lost between the bags themselves. The bulk volume of agricultural products varies considerably, from 1.37 m^3/MT for sorghum to 1.70 m^3/MT for sesame, to 4.59 m^3/MT for unshelled groundnuts. Because of these factors, the usable volume in a small warehouse (less than 500 MT capacity) can be less than 50 percent of the gross volume below eave level. The usable volume increases with warehouse size to 70-80 percent for warehouses of 5,000-10,000 MT capacity. Space that appears to be wasted in aisleways and headroom around and above stacks is actually essential for ventilation, access, housekeeping, and fumigation.

The suggested dimensions for a 3,000-MT warehouse are 1,596 m^2 of floor area with 5.5 m of height. One building size is 57 m x 28 m. The dimensions have a short perimeter for the given floor area and thus reduce the area of side walls and the length of roads around the building. However, other considerations may override this criterion, such as the configuration of the site or the transportation serving it.

Several factors can affect the siting of the warehouse. First, the soil load-bearing capacity of the site should be determined. Weak soils can substantially increase building costs. Some soils, such as black cotton soils,

should be avoided if possible. Excessively wet areas and areas which suffer from flash floods are not desirable. However, moisture permeation from the ground can be prevented by excavating drainage channels. The long axis of the warehouse should be oriented on an east-west axis ($\pm 10^{o}$) with the main doors located on the north and south sides. This orientation will enhance the air-flow through the warehouse when the doors are open, and keep the warehouse cooler than with other orientations. Sloping sites should be avoided, since it is expensive to cut into them and dig drainage trenches across the slopes uphill from the warehouse without causing soil erosion. Drains which cross the building site need to be set deep, the pipe should be covered with 150 mm of concrete, and the trench backfilled and tamped. Warehouse floors should be about 1 m above ground level so as to exclude rodents and facilitate bag handling to and from trucks. Vehicle access should be carefully considered in relation to the site. Roads should be at least 10 m wide, and turning circles and concrete aprons in front of doors need to be generously proportioned. An office for the store manager should be located near the main gate for security purposes. A well-ventilated storeroom for fumigation chemicals and a separate room for other equipment and materials may be provided in the warehouse. The availability of water, electric power, sewage disposal and general drainage may influence the choice of site. The future expansion or development of the site should also be planned so that it can be efficiently incorporated.

The specifications for the building are as follows. The required floor area is 1,600 m^2, however the length and span may vary. One suggested set is a length of 80 m and a span of 20 m. The height is 5.5 m from floor level to the top of the stanchions (pillars). The floor level should be 1 m above ground. The eaves should overhang 1 m along the length, except over doors where the overhang should be 5 m. The roof overhang at the gables is 1 m. The end door's awning is 3 m. The estimated storage capacity is 3,000 MT. The building will be of the frame type with mild steel universal section columns and portal rafters with galvanized pressed-steel or cold-rolled purlins, angle eave rails, wind struts, and side rails. Concrete columns may also be used with a conventional truss. Factory-made columns are more reliable. Columns poured on the site require careful control if they are to be satisfactory. In Sudan, making the column vertical is a problem. Erection of steel structures and steel walls is less costly in Sudan because less labor is involved than with concrete columns and brick walls. However, the foreign exchange requirement of a steel-walled warehouse is higher. For better storage conditions, smooth brick walls are more desirable than steel walls and frames because steel frames catch residual grain and dust while smooth walls do not. In addition, grain temperature with a masonry warehouse remains lower than with a steel warehouse. However, the overall cost of brick warehouse is much higher than for a steel building in Khartoum. The use of I-section steel columns, portal rafters, and galvanized iron roof and walls is recommended for the warehouse. However, a partial brick wall up to a height of 2 m above the floor may be used. The roof and awnings may be covered with corrugated sheeting of 22-gauge galvanized steel or aluminum. The minimum longitudinal lap should be 0.2 m, the side lap 0.15 m, and all laps should be sealed with mastic beading (or a layer of bitumen) to avoid leakage. Asbestos cement sheet is less satisfactory because of on-site breakage and because it is more prone to accidental breakage with age. Ideally, there should be no transparent panels in the roof, but it is acceptable to have up to 5 percent of the total roof area in transparent panels. Many transparent materials deteriorate rapidly in strong sunlight and have a

FIG. 8 3000 TON WAREHOUSE - PLAN AND SECTION

ALL DIMENSIONS IN METER

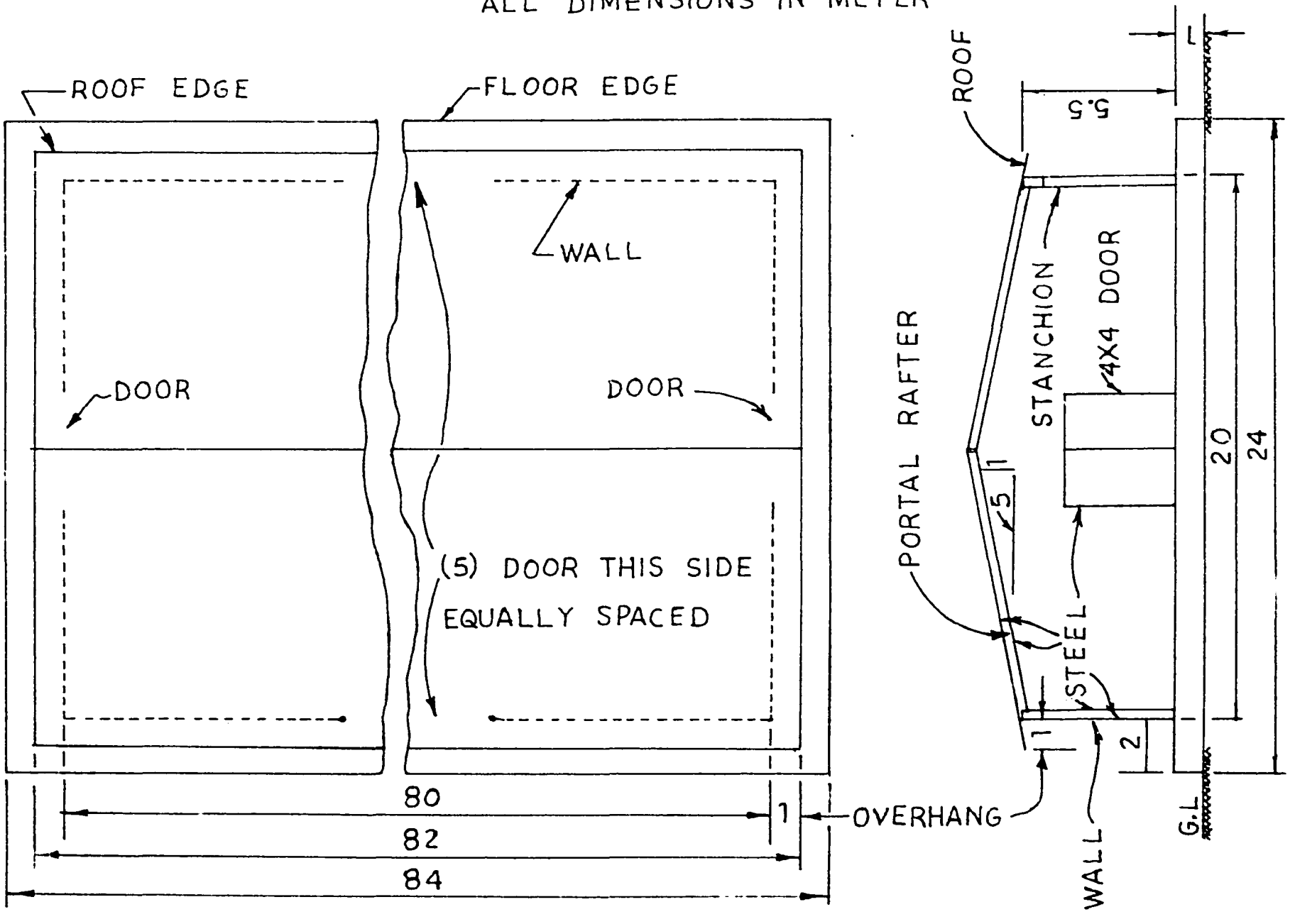
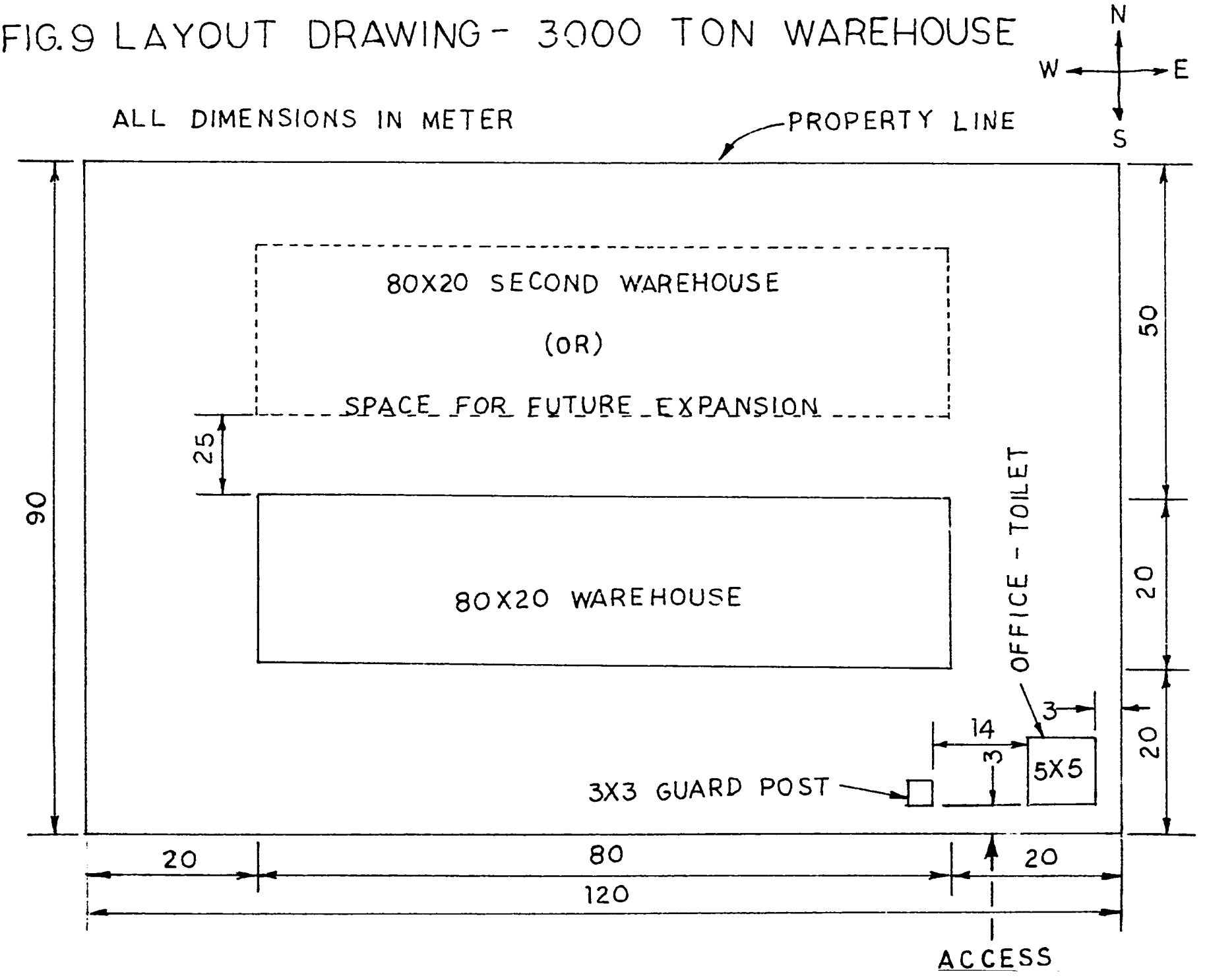


FIG. 9 LAYOUT DRAWING - 3000 TON WAREHOUSE



short life. The overhanging roof extension at eaves and gable ends is extremely important in shading both walls and ventilator openings from strong sunlight. The overhang should be at least 1 m. Any gaps between the top of the wall and adjoining roof sheets should be sealed, preferably with a flexible mastic substance which moves as the roof expands and contracts. Gutters on the roof can become inadequate, so it may be best to let rain run off the roof onto a wide concrete path (which slopes away from the wall) or onto a stone path or grassed-in drains. Ideally, the doors should be steel-framed, of a double-leaf sliding design and clad with 22-gauge galvanized steel or aluminum, giving a clear opening of approximately 4 x 4 m. Four doors on each 80 m side wall and one on each 20 m wall are the minimum for a 3,000-MT warehouses. If the doors are separated by a longer distance, the labor requirement for hauling and stacking the sacks will be high. In addition, ventilation will be restricted. The doors on opposite walls should be aligned rather than staggered, so as to facilitate easy air circulation. All doors should run outside the building and be supplied complete with all tracks and door gear, including locks, and door flashings. Doors are important for ventilation, lighting, entry of products and working convenience. However, they can also admit rodents and thieves. The ability to control ventilation is crucial. Each ventilator opening should be shut firmly when outside air is damper than air inside the warehouse. The most effective location for ventilators is high on the walls, close to the eaves. Ventilators 0.6-1 m high, running the full length of the building on the front and back sides, should be satisfactory. They must be convenient to open and bolt shut from ground level outside the store. The openings should be covered with a wire mesh fine enough to exclude mosquitoes. Windows may be incorporated into the ventilators. Windows may have galvanized steel frames with tropical-grade translucent sheeting. Exterior walls may be made of sheet steel cladding.

For the construction of foundation, floor, and walls, it is important to have a firm base. A loosely-compacted base will settle over time, most likely in an uneven manner. The floor or walls above are not sufficiently supported and eventually will crack. Cracks are impossible to clean and provide a shelter for insect infestation which can carry over from one lot of stored grain to the next. The organic matter in topsoil shrinks as it decays, so all topsoil should be removed from the site. The weight of the roof is transmitted to the ground by steel or concrete columns which rest in specially-constructed concrete foundations. The subsoil needs to be examined at every construction site and identified as to type. Foundations must be designed to suit the local conditions. The dimensions in Table 2 for wall foundations should be considered as guidelines only. The local consulting engineer may find it necessary to increase these dimensions to suit the local soil conditions.

The bottoms of the foundation trenches should be made level, firm and at the correct depth. Pockets of soft material need to be replaced with tightly-packed hard material. Trenches should not be dug until ready for filling with concrete. If the trench bottom is softened by rain, it is necessary to remove the soft layer before placing the foundation. Wet concrete should never be poured into standing water. Foundations, columns, beams and flooring should be reinforced by mild steel bars. The usual bar size ranges from 10 to 19 mm in diameter. It is best not to build masonry walls on an extension of the floor slab, but to build them directly on a wide concrete strip foundation. Vertical columns to carry roof rafters should have foundation pads that are deep and wide enough for all anticipated loads and stresses. Walls should not be bonded

TABLE 2

Minimum Foundation Requirements, Guideline Only

(Not to be used in warehouse in Kordofan)

Sub-base minimum thickness (mm)	Substrate	Type of soil	Depth of foundation below ground level (m)	Thickness of foundation (m)	Width of foundation (mm) for thickness of walls 300 mm	100 mm
150	Weak	Clay	1	0.2	600	300
		Soft, e.g. sand, silt	0.6	0.3	700	500
75	Stable	Normal	0.6	0.2	600	300
		Very firm, e.g. gravel, laterite	0.5	0.15	450	300

TABLE 3

Recommended Mixes for Foundations, Floors, and Reinforced Components

(Proportions by Volume)

Cement	Damp sand	Coarse aggregate (5-20 mm)	Water	Yield
1	2.0 - 2.5	4	0.6	4.75
1 bag	85 litres	140 litres	24 litres	170 litres
0.2 m^3	0.5 m^3	0.8 m^3	125 litres	1 m^3

to vertical columns. Bricks must be correctly bedded using the mixes shown in Table 3. Mortar for bricklaying and plastering should be mixed from cement and sand in a 1 to 8 ratio, plus mortar plasticizer. Plasticizers make the mortar more workable. A small spoonful of liquid dishwashing detergent per bucket of water may be used as mortar plasticizer. The inside surfaces of walls should be rendered with a thin layer of plaster mortar. Exterior surfaces need not be plastered. A thick coating of bitumen along the bottom of interior surfaces, from below the bottom of the floor slab to about 0.3 m above the final floor level, will ensure a dry wall (Figure 10).

The floor area should never be filled with loose earth or topsoil. If infill is necessary, sand, stones, rubble, or broken bricks should be used. These need to be thoroughly consolidated in layers 150-300 mm thick, using sand to fill in the gaps between larger stones. The surface may be covered with 5-8 cm of moist sand, well consolidated and firmly tamped. Particular care should be taken near foundations for walls and pillars. The floor concrete should be poured after the roof is built. The final floor level should be higher than the adjacent roadway and ground level (sloped away from the floor and walls) by about 1 m. An outfall slope to doors of 50 mm in 3 m is required for both the base and final floor surface. The final consolidated layer of sand or soil-cement (approximately 60-80 mm thick) should be treated against termites, and a moisture-proof membrane (Figure 10) of 4 to 6 mil thick polyethylene sheeting should be laid on top. The overlap of the polyethylene should be 0.5 m, with ends being brought 0.3 m up the wall. This membrane may be omitted if rainfall is less than 200 mm per year. The thickness of the floor concrete should be at least 0.15 m, and slightly thicker under the edges for additional strength. Expansion joints 10-20 mm wide (to be later filled with bitumen or mastic) should be left every 5 m and around the bases of columns or pillars. The best floor concrete is a 1:2:4 concrete mixture made with clean water and free of washed sand and aggregate, since clay, dirt, and salt in the sand or water weaken the concrete. If excess water is used in the mix, voids are formed as the water evaporates, reducing the final strength of the concrete by as much as 40 percent. Formwork into which the heavy, wet concrete is poured must be strong and extend the full depth of concrete slab. The concrete may be poured in convenient width bays (about 3 m), consolidating the concrete by pounding with the edge of a heavy plank, and finished with an appropriate surface treatment such as a medium-stiff broom. It is, however, important that freshly-poured concrete be prevented from drying rapidly. It needs to be kept damp for 10 days by covering with jute sacks which are moistened by spraying water on them. Keeping the concrete damp prevents cracking and ensures a strong, dust-free surface. Traffic should be kept off the concrete for at least 14 days. Concrete fillets or coving (Figure 10) may be laid in all corners and along the intersection of floors and walls to aid in housekeeping by preventing cracks and corners which are difficult to clean and which may therefore harbor infestation. Openings at joints caused by shrinkage must be filled with a flexible filler such as bitumen-based mastic. Mastic should also be forced into all small openings where steel meets masonry, such as under the roof. The final floor surface must be smooth to the touch and free of all cracks and crevices so as to facilitate cleaning since cracks and crevices collect residual grain and dust which can harbor infestation.

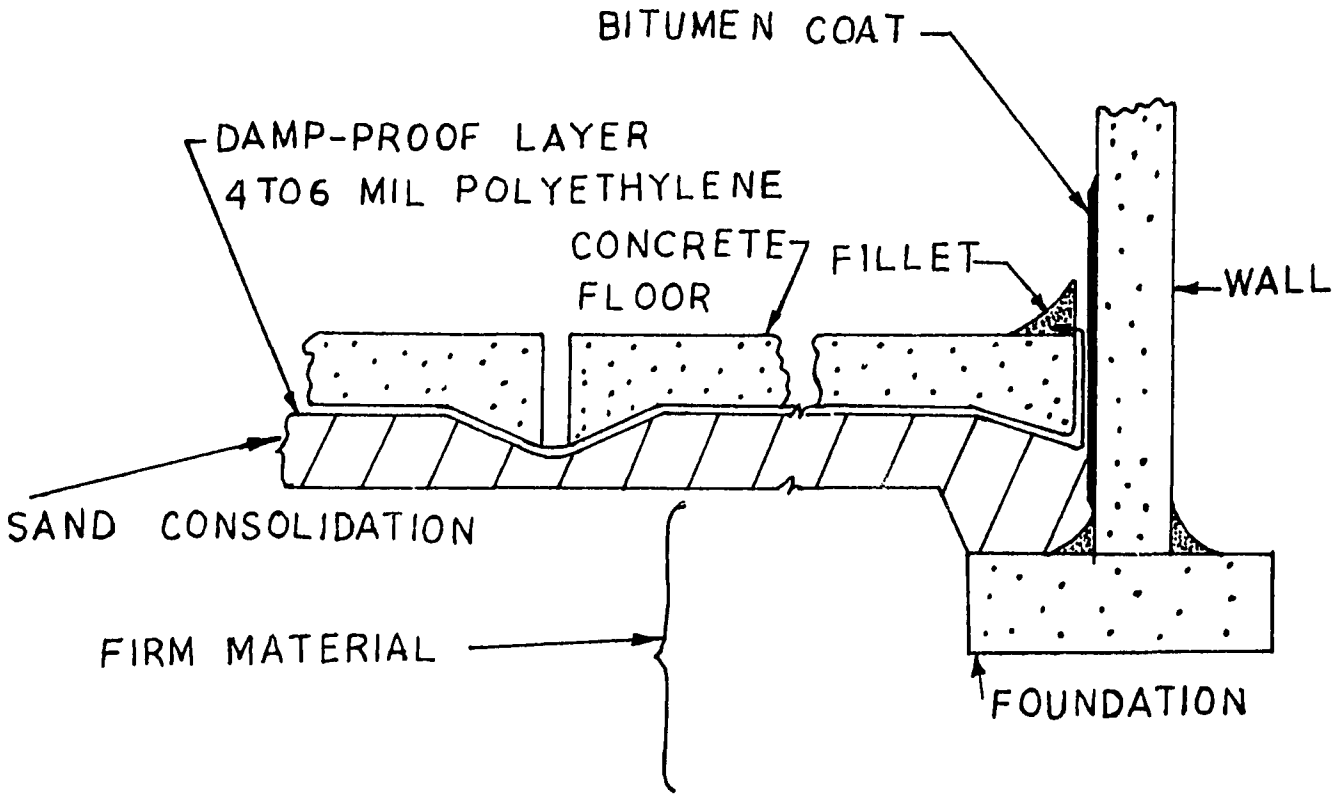


FIG.10 SCHEMATIC OF FLOOR SECTION

ABS Warehouses: Implementation Procedures

This project component will be implemented through the ABS. The ABS will select a qualified consulting engineering firm such as Elamin Muddathir to design warehouse facilities, specify materials, and supervise the construction.

Warehouse projects are generally divided into two contracts. The first contract is for foreign procurement items such as galvanized iron wall and roof sheets, steel stanchions, steel purlins, steel doors, windows, transluscent sheets on roof, and roof cladding. Designs and specifications for all the imported materials are to be furnished by the consulting engineering firm. The second contract is for actual construction of the warehouse. The first and the second contracts will be bid at the same time. The tenders will be open to international as well as local bidders.

Although the ABS does not at present have any pre-qualification criteria for the contractors, these criteria should be established according to the guidelines on page 51. Without this pre-qualification, one of the problems of offering the contract to the lowest bidder has been that when the price of building materials and labor increased, some of the contractors withdrew. The only penalty available to the ABS was to withhold the contractor's performance bond money, which amounts to only a small percentage of the value of the contract. The ABS has not required a more substantial performance bond because of the cash flow problems faced by many building contractors.

The first contractor will import the required building materials CIF Port Sudan and deliver these materials to the second contractor according to a joint agreement entered into by the two contractors and the ABS. The second contractor will transport the materials to the site, provide all other required materials and labor, and complete the construction work under the supervision of the consulting engineering firm. The first and second contracts may be let to the same company.

USAID should not release any foreign exchange to the first contractor for importing materials until a copy of an irrevocable letter of credit opened in favor of the supplier and a copy of the bill of lading for materials are submitted. In addition, the ABS and its consulting engineering firm must certify that the materials meet their specification and design. USAID should retain 50 percent of the contracted foreign exchange until the first contractor delivers all the imported items to the second contractor. If both contracts are let to the same company, this transfer is not necessary. In any case, both the ABS and its consulting engineering firm must testify that all the imported items are in the possession of the second contractor.

Overseas procurement in general requires at least 6 months from the date of opening the letter of credit. An 18-month period will be required from the allocation of funding to the completion of the warehouse. The ABS should not attempt to construct more than three warehouses in the first 18 months of the project. The first three warehouses to be constructed under the project are the ABS warehouse at El Obeid, the ABS warehouse at Dilling, and the private-sector warehouse at El Obeid[1]. The time schedule for these three warehouses

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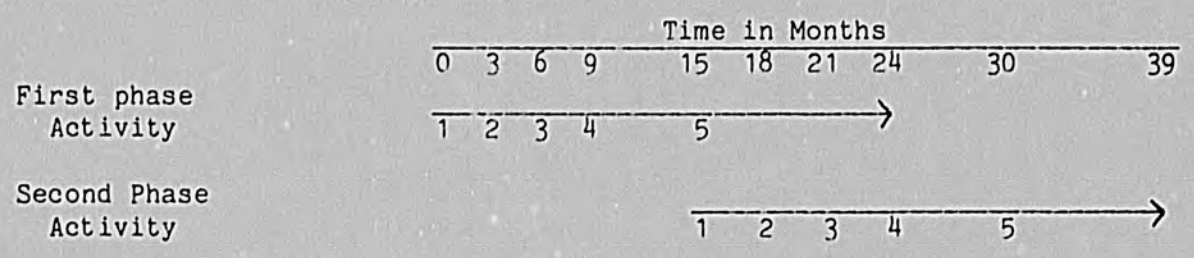
[1]Refer to page 58.

is: (1) pre-qualify the contractors and acquire site, 3 months; (2) design the warehouse, prepare specifications for imported and local items, and prepare tender documents, 3 months; (3) invite and let bids, 3 months; (4) import building materials, 6 months; (5) undertake civil, mechanical, and electrical construction, 9 months.

The remaining four warehouses are the ABS warehouse at Talodi, the ABS warehouse at Abu Gubeiha, and the two private-sector warehouses at El Obeid. The sequences and time requirements for the remaining warehouses are the same as for the first three warehouses, except that the construction activities for these warehouses begin 15 later as shown in the following diagram. This sequence is recommended to facilitate proper management of the project and to gather experience as to the problems encountered.



Procurement sources include the following foreign manufacturers:

Conder Structures Overseas
Wellington Road
Burton-on-Trent
Staffordshire D E142AA
U.K.

Ward Brothers (Sherburn) Ltd.
Sherburn, Malton
North Yorkshire Y 0178 PQ
U.K.

John Reid and Sons
Mill Lane Works, Mill Road
Christ Church, Hampshire
U.K.

ABS Warehouses: Responsibilities of the ABS and the Consulting Engineering Firm

The ABS and the consulting engineering firm will select and acquire the sites for each of the warehouses. The sites must be located close to the proposed feeder road of the project. Wherever possible, the sites must have nearby electric power and water lines.

The consulting engineering firm will design the foundation, columns, floors, walls, roof, ventilators, doors, windows, ancillary buildings, and roads and fences around the warehouse. The firm will make detailed construction drawings and specifications for all steel components such as columns, portal rafters,

purlins, struts, door and rail gear, roof and side-wall sheets and fittings. The firm will also estimate the cost of materials and construction.

The ABS and the consulting engineering firm will pre-qualify a number of contractors for both foreign procurement and local construction.

The consulting engineering firm will prepare all tender and contract documents.

USAID will seek technical assistance from a qualified storage management specialist from the U.S. to review the design and specifications of the warehouse. After the review, tenders will be invited by the ABS. These tenders will be evaluated and let by the ABS in conjunction with the consulting engineering firm. The selected contractors will procure and construct the warehouses. If required, USAID may seek technical assistance during the construction of the first three warehouses.

ABS Warehouses: Pre-Qualification Criteria for Local Construction Contractor

To facilitate project completion on schedule and according to design and specification, the ABS should establish certain pre-qualification criteria for contractors. The following are the requirements for consideration as a contractor under this warehouse project.

The contractor must have acted as principal contractor, rather than as a subcontractor, for the construction of a grain storage or similar warehouse of not less than 1000 m^2 in size within the last 5 years. The contractor must have constructed warehouses using reinforced foundation and columns, masonry walls, mild steel universal section columns, and portal rafters.

The contractor must demonstrate his technical ability by submitting the qualifications of any engineers who will be assisting the contractor in the construction work. The contractor must also submit a list of tools and equipment in his possession.

The contractor must submit references from owners of the warehouses and other parties by whom the contractor was engaged. The letters of reference must testify clearly that the contractor worked for the referee. The referee must indicate his level of satisfaction with the contractor's work, his willingness to cooperate with the referee, his general reputation and integrity, his ability to complete work on schedule, and his adherence to the design specifications and quality standard of the materials furnished.

The contractor must submit a letter from his banker showing the amount of his deposits in various accounts, with a maximum and minimum balance in a year for the last five years.

The contractor engaged for importation of materials must submit a proof of his experience in import activities under the import regulations of the Government of the Sudan (GOS).

These pre-qualification procedures should be completed at least one month prior to the invitation for bids. Tenders will not be accepted from contractors who have not applied for pre-qualification or have been rejected.

ABS Warehouses: Estimated Foreign Exchange Component

Each warehouse is designed for 1600 m^2 of floor area. The following cost estimate is based on the use of I-section steel stanchions, portal rafters and gable posts, galvanized iron roof, galvanized side-wall sheets, steel doors, Z-section steel purlins and rails. Estimated tonnage of the imported material is given below:

1.	A maximum of 22 I-section steel stanchions with approximate dimensions 305 mm x 165 mm x 40 mm, 1.5 tons each	33 tons
2.	A maximum of 22 I-section steel portal rafters with approximate dimensions 203 mm x 133 mm x 30 mm, 1.2 tons each	27 tons
3.	A maximum of 6 I-section steel cable posts with approximate dimensions 254 mm x 146 mm x 31 mm, 1.0 ton each	6 tons
4.	Galvanized iron roof (corrugated)	15 tons
5.	Galvanized side-wall sheets (corrugated)	8 tons
6.	Z-section steel purlins and rails	3 tons
7.	A maximum of 12 sliding doors and fittings, 500 lb each	3 tons
8.	Miscellaneous parts, fittings, nuts, bolts, washers, braces, brackets	2 tons
	Total	97 tons

Approximately 100 tons of imported material will be required for each warehouse. It should be realized, however, that the actual tonnage of materials will depend on the detailed structural and civil engineering design. In any case, the above estimate is expected to be close to the actual requirement.

The estimated C&F Port Sudan price of these imported materials is $200,000. According to the ABS engineer, the imported steel requirement will be approximately $70 per m^2 of floor area, or $112,000. However, this estimate is based on the lowest recent bid received by the ABS.

Provision is made for pesticide application, safety, and inspection equipment under the technical assistance and training section.

ABS Warehouses: Estimated Local Currency Component

These cost figures will depend on the final design and engineering. This estimate is prepared on the basis of construction experience of the ABS.

Item	Unit	Quantity	Price per Unit (Ls)	Total Cost (Ls)
Excavation for foundation	m^3	180	13	2,340
Excavation for external platform	m^3	100	13	1,300
Hard-core filling under floors and platform	m^3	1,700	32	54,400
Sand filling under floors and platform	m^3	300	16	4,800
Lean concrete under foundation	m^3	10	230	2,300
Lean concrete under grade beam	m^3	15	230	3,450
Lean concrete foundation to platform wall	m^3	45	230	10,350

Item	Unit	Quantity	Price per Unit (Ls)	Total Cost (Ls)
Reinforced concrete without steel in foundation	m^3	40	300	12,000
Reinforced concrete without steel in short columns	m^3	72	350	25,200
Reinforced concrete without steel to grade beams	m^3	80	350	28,000
Brickwork in cement mortar to floor level	m^3	675	40	27,000
Cement plastering	m^3	675	12	8,700
Brickwork retaining wall to platforms	m^3	325	40	13,000
Plain concrete in floors, platform, and ramps	m^3	425	250	106,250
Plain concrete final surface of storage area slab	m^3	60	250	15,000
Holes in columns for holding down bolts	m^3	92	5	460
Cement grouting to hold down bolts	m^3	92	5	460
Joint sealer between wall and floor	m^3	200	5	1,000
		Subtotal		315,410
M.S. bars in column bases	kg	3,400	1.8	6,120
M.S. bars in short column	kg	3,400	1.8	6,120
M.S. bars in grade beams	kg	6,750	1.8	12,150
Materials for 5 x 5 x 3 m office	Job	-	-	19,000
Materials and construction for security post 3 x 3 m	Job	-	-	2,500
Materials and construction for latrines and showers (possible sites)	Job	-	-	12,000
Materials and erection of fencing	m	360	45	16,200
Materials and fixing of steel gate	No	1	2,500	2,500
Transport and erection of steel structures	Job	-	-	50,000
Painting steel structures	Job	-	-	2,500
Lighting fixtures inside warehouse	No	40	100	4,000
Electrical outlets	No	10	50	500
Power distribution panel	No	1	500	500
Weatherproof external light	No	15	100	1,500
Lighting fixtures in office and lavatory	Job	-	-	300
Ceiling fan in office	No	1	200	200
Customs duty on import				182,000
		Total Ls		633,500

ABS Warehouses: Training and Technical Assistance

The success of the project will depend on the ability of the warehouse managers to preserve the quality and quantity of the stored products. The existing methods of grain storage are unsatisfactory. There is a definite need for training grain storage warehouse personnel.

The ABS does not have any specific methods and practices concerning grain storage. Although the ABS is currently in the process of organizing a pest control unit, at present there is no qualified stored-product entomologist on the ABS payroll. Rather than centralizing its pest control activities, the ABS should train individual warehouse managers in pest control methods and should execute the control program without having to depend on the central office. However, the ABS central office should ensure that proper chemicals, equipment, and supplies are available in each ABS warehouse.

The main objective of the training program is to train ABS warehouse managers and other ABS supervisors. The subject matter of the training should include: (1) insect and rodent biology, (2) insect and rodent identification, and (3) integrated pest control measures dealing with inspection, housekeeping, physical and mechanical controls, and chemical controls, including chemical control methods and practices, grain protectants and fumigants, pesticide application, pesticide safety, and rodenticides.

The training will consist of classroom sessions and field demonstrations to suit the needs of the target group. The maximum recommended number of trainees is 20 persons. Two trainers will present the training program, which will be conducted annually for two years, beginning in project year 2. The ABS may be asked to organize such local aspects of the training as selection of trainees, logistical arrangements and local support. A warehouse is necessary for the training and for demonstration purposes, and the training must be conducted at a time when there is sufficient grain in the warehouse. If the training is to proceed as soon as possible, Khartoum could be selected for the training site, since the ABS already owns a warehouse there.

The first step in implementing the training program is for USAID/Khartoum to appoint an appropriate trainer from the U.S. A pre-training trip by the selected trainer will be made to Khartoum/El Obeid to assess the specific training needs, select the training and demonstration sites, and create outlines for the development of training materials such as slides, transparencies, handouts and training manuals. This must be done jointly with an ABS counterpart. Local arrangements and logistics will be discussed at this time, and a definite training schedule will be set up. The trainer will advise USAID as to the type, quantity, and procurement source of pesticides to be regularly used in the projects and in the training program. Appropriate training materials will be prepared by the trainer in the U.S.

Pesticides and application and safety equipment should be made available at the training site prior to the training. The trainer may be asked to bring some of the needed equipment and materials. However, tarpaulins and sand snakes used for fumigation should be available locally.

After the training is completed, periodical technical assistance from the trainer is recommended to monitor the impact of training, assist the warehouse managers in installing a viable pest control and storage program, and collect data for USAID and the GOS on the technical and economic benefits of the program.

Cost Estimate for Training and Technical Assistance

Project Year 2	
Foreign exchange	
Pre-training trip Khartoum for 15 days	$11,500
Preparation of training materials, including printing, binding, translation into Arabic	8,000
Travel for two trainers to Khartoum for two weeks	28,000
Pest control equipment and chemicals for 4 ABS warehouses	8,000
Total	$55,500
Local currency	
Travel to training sites by trainees	Ls2,000
Per diem for trainees	1,000
English-Arabic-English interpreter	500
Local resource person	500
Local arrangements, vehicle and gas	1,000
	Ls5,000
Project Year 3	
Foreign exchange	
Preparation of training materials	$ 8,000
Travel for two trainers to Khartoum for three weeks	39,000
One technical assistance trip to Khartoum/El Obeid for 15 days	11,500
Total	$58,500
Local currency	
Travel to training sites by trainees	Ls2,000
Per diem for trainees	1,000
English-Arabic-English interpreter	500
Local resource person	500
Local arrangements, vehicle and gas	1,000
	Ls5,000
Project Year 4	
Foreign exchange	
One technical assistance trip to Khartoum/El Obeid for 15 day s	$11,500
Total	$125,500
	Ls10,000

ABS Warehouses: Pest Control Measures

Effective pest control requires an integrated program. No one method will suffice to ensure adequate control. Therefore, various methods are used in conjunction with one another. Emphasis is placed on preventive methods rather than corrective measures.

There are four major types of control: inspection, housekeeping, physical and mechanical methods, and chemical methods. Inspection is used with both the grain and the storage facility in order to locate potential sources of infestation and contamination, uncover existing infestation or contamination, indicate the control measures needed, and evaluate pest control programs. Inspection is primarily a preventive measure.

Grain should be inspected when received for storage and regularly while in storage. The frequency of inspection depends on climatic conditions, the condition of the grain when placed in storage, and the potential for infestation. Inspection will determine the moisture content and temperature of grain; presence of insects, molds, and foreign material; and rodent and bird contamination. Moisture can be determined by a reliable moisture meter. Temperature can be measured by a thermometer. Insects, molds, foreign material, rodent and bird contamination may be determined by visual examination. Hidden infestation may be detected by staining, flotation, and x-ray methods.

The area surrounding the storage facility should be inspected for accumulations of grain, debris, tall weeds, and evidence of insects, rodents, and birds. The exterior of the storage structure should be inspected for openings through which rodents, birds, and insects can enter. The interior of the storage structure should be inspected for general condition of cleanliness, neatness of stacking, evidence of pest activity, and structural defects.

Housekeeping is the most important and effective means of preventive pest control. It includes eliminating accumulations of debris and grain around the storage facility, properly storing materials and equipment outside the storage facility, cleaning the interior of the storage facility, cleaning handling equipment, and properly storing equipment and materials inside the facility. Materials and equipment outside the facility should be stored in an orderly fashion at least 1 m from the facility and 1/2 m above the ground. Grain residues and dust should be removed from the storage areas before restocking with grain for storage. Aisleways and areas between stacks and along walls should be cleaned regularly with emphasis on cracks, ledges, and obstructions. Roof support structures should be cleaned periodically. Cleaning emphasis should also be placed on ventilators and areas where the roof contacts the support structures. Handling equipment should be cleaned regularly to remove residual grains and dust. Grain in sacks should be stored on pallets off the floor to prevent moisture or contaminant adsorption from the floor. Stacks of bags should be 1 m from walls, support columns, roof structures, and other grain in order to facilitate inspection, inventory, and insect and rodent control. Used sacks should be fumigated, cleaned, and repaired before being stored separately in the warehouse. New and used sacks should be stored in the same way as sacked grain.

Housekeeping must be conducted on a regularly-scheduled basis. The frequency depends on the type of operation and observed need. If grain is being handled on a daily basis floors and other areas should be cleaned daily. If grain is handled only occasionally, cleaning can be less frequent, but never less than once a month. Cleaning schedules should be in written form to provide a reminder of the cleaning tasks and facilitate scheduling of workers. Schedules and instructions should be changed as needed to improve their effectiveness. Once cleaning schedules are established, inspections will indicate whether the desired level of cleanliness is obtained. If not, the schedules should be changed.

If pockets of high moisture exist in stored grain because of moisture migration or physical deficiencies of the structure, warehouse ventilators should be opened during cool periods to help dry the grain. For rodent control, harborage and food sources should be eliminated by the use of sound housekeeping practices. The use of physical barriers is also recommended, such as foundations with footings at least 60 cm deep to prevent entry by burrowing, smooth crack-free outer walls to limit cl ng, seals around entry holes for pipes or wires, drain covers of perforated m al, screens on windows, louvers, and ventilators, doors with tight closure, overhanging docks, and rodent-proof building materials such as 26-gauge or thicker galvanized steel and solid concrete walls and floors.

Chemical control in stored grain includes the use of insecticides and fumigants. The contact insecticide recommended for the project is Malathion, both in form of an emulsifiable concentrate (EC) and a dust. Premium grade malathion 57 percent EC should be used. One pint (0.473 l) should be mixed with 3 gallons (11.4 l) of water. One gallon (3.8 l) of spray should be used for 500 square feet (46 m^2) of surface. Liquid spraying is suggested for cracks, crevices and vertical surfaces such as walls. Malathion dust (1 or 2 percent formulations) may be used on floors, flat surfaces, and sacks to control crawling insects. The application rate varies with formulation.

The recommended fumigant is aluminum phosphide. The brand Phostoxin is widely used. The formulation is 55 percent active ingredient (aluminum phosphide) and 45 percent inert material, such as ammonium carbamate and edible paraffin. Phostoxin is sold in two forms, tablets and pellets. The tablets weigh 3 g and release 1 g of hydrogen phosphide gas. They are packaged in resealable flasks containing either 100 or 500 tablets. The pellets weigh 0.6 g and release 0.2 g of hydrogen phosphide gas. They are packaged in resealable flasks containing 1,600 pellets. These are restricted-use pesticides and must not be used by inexperienced personnel.

Private-Sector Pilot Project

The study team's discussions with the private-sector grain traders indicated the need for improved storage facilities. However, the merchants were not interested in building the warehouses themselves, because they do not possess the necessary expertise, experience, and supervision capability for such an undertaking. If another organization would build the improved warehouses, the merchants would use the facilities under purchase or lease options, if the price were right.

Besides storage facilities, the merchants also stressed the need to clean grain before marketing. Even though no grain grading factors exist in the Sudanese buying and selling norms, some subjective criteria as grain cleanliness do exist in pricing the grain during a normal production year. When grain is scarce, the consumers do not have much choice as far as grain quality available on the market. Clean and better varieties of sorghum, such as Safra, Dabar, and Tetron, are in great demand in the cities. Clean Feterita is preferred by local consumers. The traders showed a strong desire to have grain cleaners in storage installations. Grain cleaning is necessary before grain is stored for many reasons. Given the fact that sorghum yield in the region varies from about 40 kg to 340 kg per feddan, it is likely to contain immature, light, and shrunken kernels which must be removed. Clean grain requires less storage

space, and keeps better because fungal and insect activities are less. Transport costs for unusable grain or foreign material are high. Finally, the export market demands clean grain. When considering the location of grain cleaners, sites should be examined near the production point, near the consumption point, and at the point immediately prior to domestic sale or overseas shipment.

For a bag system, the grain cleaner should be located as far back in the grain system as possible. The lack of a power source and other infrastructures make it impractical to install grain cleaners at the production point. The next best location for the cleaners is in a city such as El Obeid where a power source and other infrastructure is available. It is recommended that grain cleaners be installed in all private-sector pilot project storage facilities.

The pilot project will consist of three storage facilities: a 3,000-MT bag warehouse, a 6,000-MT bag warehouse, and a 2,000-MT bulk storage facility (or a 3,000-MT bag warehouse, depending on the economic feasibility of each alternative). The size of the storage facilities is dictated by the fact that the ABS warehouses will have a capacity of 3,000 MT and so will facilitate the construction process. The 3,000-MT size fits the needs of an individual merchant, and the 6,000-MT size will allow a group of merchants to jointly use this facility to market their grain. The 2,000-MT bulk storage facility is included as a prototype to test the technical and economic feasibility of such a facility. In order for bagged grain to be cleaned, the bags must be emptied before the grain passes through the cleaner. After cleaning, the grain can either be rebagged for storage in the warehouses, or it can be stored in bulk for rebagging immediately prior to shipment. In the latter case, any benefits accruing from the bulk storage can be achieved. Therefore, the use of bulk storage is a logical alternative when cleaning is to be done.

Private-Sector Pilot Project: Bag Warehouses

The proposed 3,000-MT warehouse is described and defined in the technical analysis section on ABS warehouses. The 6,000-MT facility is simply a multiple of the 3,000-MT design. The design criteria and implementation procedures are identical to those set forth for the ABS warehouses.

Private-Sector Pilot Project: Bulk Storage Facility

The layout drawing for the bulk storage facility is shown in Figure 11. The numerical notation on the illustration corresponds to Table 4. The equipment specifications and costs are presented in Table 5. The numerical notations correspond to Figure 11.

When implementing a bulk storage project, there are three alternatives from which to choose for construction of the facility. The first alternative involves the selection of a consulting engineering firm to do the engineering work on the project. The consultant prepares all drawings and specifications for the equipment, material, and plant. USAID procures the specified materials and equipment directly from the U.S. and has the material and equipment shipped directly to the project site in El Obeid or to Port Sudan. Prior to the shipment of material and equipment to Sudan, USAID and the consulting engineering firm select a building contractor from the U.S. The building contractor takes over the shipped material and equipment from USAID at El Obeid or Port Sudan, and constructs the facility.

FIG. 11 LAYOUT DRAWING - PILOT PROJECT NO-1

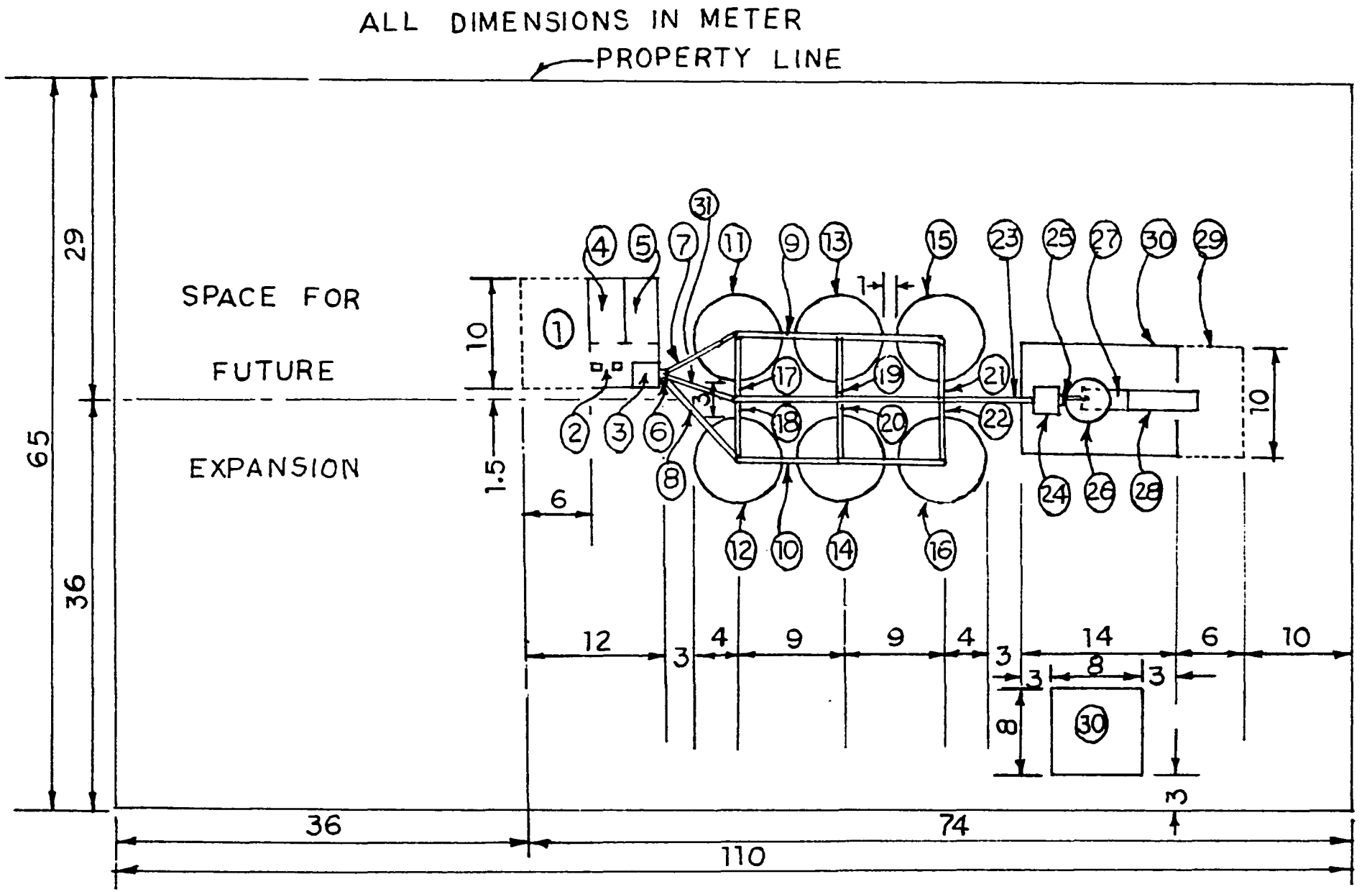


TABLE 4

Layout Description

Bulk Storage Facility

Illustration Number	Description
1	Truck receiving area. This area should be 10 m x 6 m x 5 m to accomodate one truck, head room, and working space. The area may remain open, however a roof is advisable for shade on sunny days and protection during rain.
2	Portable beam scale
3	All-metal seed and grain cleaner
4,5	Storage space for chemicals, spare parts, and supplies such as empty sacks. This area must be secured with walls, roofs, and a wide door to facilitate transfering bags from the truck to cleaner (3) with ease. This area should be 10 m x 6 m x 4.5 m. It may be constructed of reinforced concrete and masonry with provision for sunlight during the day and electric light at night.
6	Bucket elevator
7,8	Steel spout
9,10	Overhead screw conveyor mounted on bin top
11-16	Galvanized corrugated iron grain bins
17-22	Bin unloading screw conveyor (auger)
23	Transport auger to bagging area
24	Pit (hopper)
25	Bagging elevator
26	Bagging bin (elevator)
27	Bagging machine and conveyor
28	Portable bag conveyor
29	Truck load out area
30	Bagging house
31	Screw conveyor

TABLE 5

Specification and Cost Estimate

Bulk Storage Facility

Illustration Number	Equipment Description and Specification[1]	Required No. of Units	Unit Cost, $US	Total Cost CIF Port Sudan, $US
2	Portable beam scale Platform size: Not less than 19" x 28" Capacity: Total 450 kg Loose weights: 2 of 50 kg 1 of 100 kg 1 of 200 kg Easy-reading triangular beam Offset steel column head	4	1,200	4,800
3	All metal seed and grain cleaner Capacity: Not less than 200 bushel/hr of sorghum Charging hopper and elevator required Bagging elevator not required 3 sets of 2 screens for sorghum 3 sets of 2 screens for sesame Complete with 1 HP motor single phase 220 V 50 cycles (2 motors) Motor must withstand ambient temperature up to 120°F	1	10,000	10,000
6	Bucket elevator, 80 ft discharge height 500 bushel per hour capacity, complete with head, inspection section, boot with hopper, motor mount counter shaft drive, at least a 3 HP motor, leg casing, belts, cups, and bolts 3 HP reducer drive, attach bracket and 600 ft 3/8" guy cables, cover for inlet hopper, 6"-4 spout distributor manually operated from the ground, adapter for head to distributor complete with mounting brackets, safety case assembly for the entire elevator height, all bracket and attachment kits	1	18,500	18,500
7,8	6" steel spout and 10 flanges	140		200

[1]All electrical equipment must conform to 220 V 50 HZ system.

TABLE 5 (cont.)

Illustration Number	Equipment Description and Specification	Required No. of Units	Unit Cost, $US	Total Cost CIF Port Sudan, $US
9,10	Screw conveyor 6"-60 ft long complete with 3 HP motor and drive unit, pulleys, belt, at least 500 bu/hr capacity	2	4,500	9,000
11-16	24 ft dia x 33 ft eave height 2 2/3" corrugated grain storage bins complete with 30° heavy duty roof with truss support, anchor bolts and brackets, bin wall and roof ladders, walk-in door, door step, perforated floor (grain sorghum) and supports, transition for aeration fan 7 1/2 HP motor 2400 CFM axial flow fan complete with all fittings, 5/16" or 3/8" Gr 5 bolts with integral sealing washers, bead sealants, etc.	6	19,000	114,000
17-22	6" unloading auger, tube, well, gate, gate control, 1 HP motor complete with drive and all fittings for the storage bins at least 500 bu/hr capacity	6	775	4,650
23	8" U-trough auger reversible 95 ft long complete with 5 HP motor, drive, and all fittings at least 500 bu/hr capacity	1	7,500	7,500
25	20' discharge height bagging elevator to load grain into 26, complete with belts, buckets, 3/4 HP motor drive and fittings at least 500 bu/hr capacity	1	2,000	2,000
26	Open roof 6 ft dia 1 ring high bulk feed tank (bagging bin) with 60° hopper bottom, elevated 8 to 10 ft above ground level to accommodate a semi-automatic bagging machine underneath	1	2,000	2,000
27	A semi-automatic bagger-belt conveyor portable-type suspended bag closers complete with fittings and motors at least 2 bags/min	1	7,500	7,500

TABLE 5 (cont.)

Illustration Number	Equipment Description and Specification	Required No. of Units	Unit Cost, $US	Total Cost CIF Port Sudan, $US
28	Portable belt conveyor 10' long to lift bags 6' onto trucks	1	4,000	4,000
31	Screw conveyor - 8" U-trough, 500 bu/hr minimum, 2 HP motor complete with drive, screw	1	2,000	2,000
Misc.	Fumigation application and safety equipment and lab equipment	1 pkg		2,000
				188,150
	Electrical controls with electrical interlocking system and wiring supplies, 20 percent of cost of equipment			37,630
			Cost of Equipment	$225,780
Spare parts for equipment, 10 percent of cost of equipment				$ 22,578
Turnkey execution of the project				
	Import tax, 70 percent of cost			173,850
	Engineering, preparation of drawings, specifications, operating and maintenance manuals, drawings to be submitted to the operator and USAID/Khartoum, 75 percent of cost			186,270
	Mobilization of office, staff, warehouse at El Obeid, transportation of equipment to El Obeid, and civil, mechanical, and electrical construction of equipment			248,358
	Training of operator by the turnkey contractor for 15 days			25,000
			Subtotal	$881,836
Technical assistance by a grain storage specialists in U.S. and Sudan, 1 month in U.S. and two 15-day trips to Sudan				14,500
			Total	$896,336

TABLE 5 (cont.)

Local currency component (to be disbursed to turnkey contractor)	
Plant building, office, security post, and lavatory	Ls230,000
Gravel road around plant	15,000
Fence	14,000
Total	Ls259,000

The second alternative involves basically the same process as the first, with one exception. In the second alternative, USAID selects a procurement agent in the U.S. rather than procuring the materials directly. USAID then takes over the materials and equipment in the U.S., ships them to Sudan, and the process continues as in the first alternative.

The third alternative is the turkey approach in which USAID hires a turnkey contractor from the U.S. based on competitive bids. USAID may also use short-term technical assistance from a grain storage specialist to assist USAID in evaluating the capability of the turnkey contractor during the selection process. The prerequisite for the turnkey contractor is experience in designing and constructing corrugated galvanized steel bulk storage bins, screw conveyors, pits, semi-automatic bagging machines, and associated electrical wiring and controls, in the U.S. and preferably in developing countries. The responsibility of the turnkey contractor is to prepare layout drawings, foundation drawings for the specified soil conditions of the project site, mechanical and electrical drawings, and plant and ancillary building drawings with detailed specifications. The selected contractor will make a preliminary trip to El Obeid to inspect the site and obtain information, and will make a second trip to establish final design criteria for the storage facility. The contractor also provides two sets of operation and maintenance manuals and mechanical and electrical drawings of the plant, along with two weeks of operation and maintenance training for the operator. It should be realized that no single manufacturer provides all the equipment listed in this project. In order to integrate all the equipment into one system, it will be necessary for the contractor to modify design dimensions and specifications. USAID must approve all designs and specifications. After approval of the drawings and specifications, the turnkey operator procures the necessary material and equipment from different manufacturers, ships all materials to Port Sudan, pays custom duties, transports materials to the construction site at El Obeid and builds the facility. USAID will request technical assistance from the storage engineer in the ABS warehouse component to monitor the progress during construction.

The time schedule for construction of the bulk storage facility is: (1) select grain storage specialist in the U.S. and construction site in El Obeid, 2 months; (2) invite bids and assign contract to turnkey contractor, 3 months; (3) design facility, procure and ship materials to Sudan, 4 months; (4) mobilize resources at construction site, 4 months; (5) transport materials to construction site, 1 month; (6) undertake construction, 4 months. The time sequence for construction activities is shown in the following diagram.

	Time in Months						
	0	2	5	9	13	14	18
Activity	1	2	3	4	5	6	

Many sources of bulk storage, handling, and processing equipment are available in the U.S., including the following:

1. Butler Manufacturing Company
   7400 East 13th Street
   Kansas City, Missouri 64126

2. Chief Industries, Inc.
   West Highway #30
   Grand Island, Nebraska 68801

3. Seedburo Equipment Co.
   1022 W. Jackson Blvd.
   Chicago, Illinois 60607

4. PASCOE/YORK
   1301 East Lexington Ave.
   Pomona, California 91766

5. Hutchinson Division of Lear Siegler, Inc.
   514 West Crawford
   Clay Center, Kansas 67432

6. Baughman
   P.O. Box 368
   Route 48
   West Taylorville, Illinois 62568

7. Blount World Trade Corporation
   Agro-Industrial Division
   201 Alhambra Circle, Suite 505
   Coral Gables, Florida 33134

8. Overseas Systems Corp.
   Palm Springs Center
   1840 West 49th Street
   Suite 101
   Hialeah, Florida 33012

Private-Sector Pilot Project: Grain Cleaners

Each of the three storage facilities will have a grain cleaner included in its equipment. These grain cleaners are to be imported from the U.S. The specifications are given below.

All-metal seed and grain cleaner (scalping and cleaning grain).

Capacity: Not less than 200 bu/hr of sorghum.

Charging hopper about 2 bu capacity and elevator required.

3 sets of two screens (one top and one bottom) for sorghum.

3 sets of two screens (one top and one bottom) for sesame.

Elevator-bagger complete with power attachment and two-way bag holder.

Complete with 1 HP motor single phase 220V 50 cycle motor. Motor must withstand ambient temperature up to 120°F.

Caster mounting.

Spare parts: 1 motor belt, brush, and bearings used in the cleaner.

Each cleaner unit costs $12,000. The total cost for three cleaners is $36,000.

Private-Sector Pilot Project: Training and Technical Assistance

Training is a key element in order to be able to achieve the goals set forth for this project. The selected operator should be involved with the construction phase of the facility. He should work informally with the contractor, since seeing how the facility is built will benefit him during later operations.

In the case of the bulk storage facility, the operator should recruit a millwright and an electrician who will also observe construction of the facility. After the construction is completed, the contractor will train the millwright and electrician to operate and maintain the equipment. For mechanical and electrical maintenance, it is crucial to (1) retain an experienced and qualified millwright and electrician, and (2) maintain a stock of spare parts, tools, and supplies.

Technical assistance under the private-sector pilot project will be provided to accomplish the tasks set forth in Section IV on implementation considerations. Technical assistance will be provided by a grain storage management specialist and a grain marketing specialist. The training package will be the same as that set forth for the ABS warehouse segment of the project. However, it will also include the use, maintenance, and repair of the cleaners in the private-sector pilot project, as well as training in the operation of the bulk storage facility. The training is directed towards the merchants and their employees. At total of 25 trainees can be accomodated during the first training phase, and 35 during the second phase.

The cost estimates of required technical assistance and training are as follows.

Project Year 1		
4 MM technical assistance	$74,700	
		$74,700
Project Year 2		
2 MM technical assistance	$37,350	
Training package		
Material preparation	4,000[1]	
Training at El Obeid	40,000	
		$81,350

[1]This assumes that both the ABS training component and the private-sector pilot project technical assistance and training component will be undertaken by the same group. If two different groups, are involved these costs should be increased by $6,000 in Project Year 2.

Project Year 3		
4 MM technical assistance	$ 74,700	
Training package		
Material preparation	2,000	
Training at El Obeid	42,000	
		$118,700
Project Year 4		
3 MM technical assistance	$ 56,025	
		$ 56,025
Project Year 5		
3 MM technical assistance	$ 56,025	
		$ 56,025
		$386,800

APPENDIX C

ECONOMIC ANALYSIS

Storage Losses

Storage losses in cereal grains and oilseeds can be classified as quantity losses (weight) or quality losses (damaged kernels due to insects, molds, or rodents). Very little accurate information is available as to the level of losses which occur in the postharvest system for cereal grains and oilseeds in Sudan. Many statements are made that losses range from 20 to 30 percent, but these statements seem to be merely guesses, rather than being based on close observation of the situation.

The available loss research study done on sorghum indicates that losses are not as high as many people believe. Available data[1] indicate that weight loss in stored sorghum will reach nearly 6.5 percent after one year's storage, while the percentage of damaged kernels reaches nearly 13 percent at the end of a one-year storage period. Figures 1 and 2 illustrate the progression of losses for sorghum held in storage over a one-year time period.

The above levels of loss are further supported by a study of maize losses in on-farm storage in southern Sudan.[2] Weight losses in this study did not exceed 6 percent unless the grain was contaminated by the presence of infested stocks in the same storage unit. In addition, private-sector merchants in the Kordofan area estimate 5-6 percent weight loss over a storage period of one year. Merchants also state that the percent of damaged kernels is very high at the end of a year's storage period, but they would not estimate percentages.

For oilseeds, no loss data were discovered. Statements have been made that there is no loss of sesame in storage and only small amounts of losses in groundnuts (with the exception of the problem of aflatoxin). Again, these statements are not based on visual observations or on specific knowledge of insect pests which attack oilseeds. In discussions with merchants, it appears that there are storage losses with oilseeds, but actual loss levels could not be determined. It can only be assumed that oilseed losses are of the same magnitude as losses in stored sorghum.

Climatic conditions in Sudan are positive for the storage of cereal grain and oilseeds. Low humidity levels allow commodities to remain at low moisture levels. The low moisture levels reduce the amount of insect activity in stored products. These conditions are represented by a research study[3] in which sorghum was stored at 7.5 percent moisture. The moisture content during storage increased to only 9.6 percent during the rainy season, and declined to 6.6 percent during the dry season. Other studies indicate that sorghum in storage will range from 8.2 to 9.4 percent moisture.

[1] E. El Khider.

[2] Anne Itto.

[3] A. M. Abdalla.

FIGURE 1. Percent Weight Loss During Storage

Brick Store

Uncleaned Sorghum

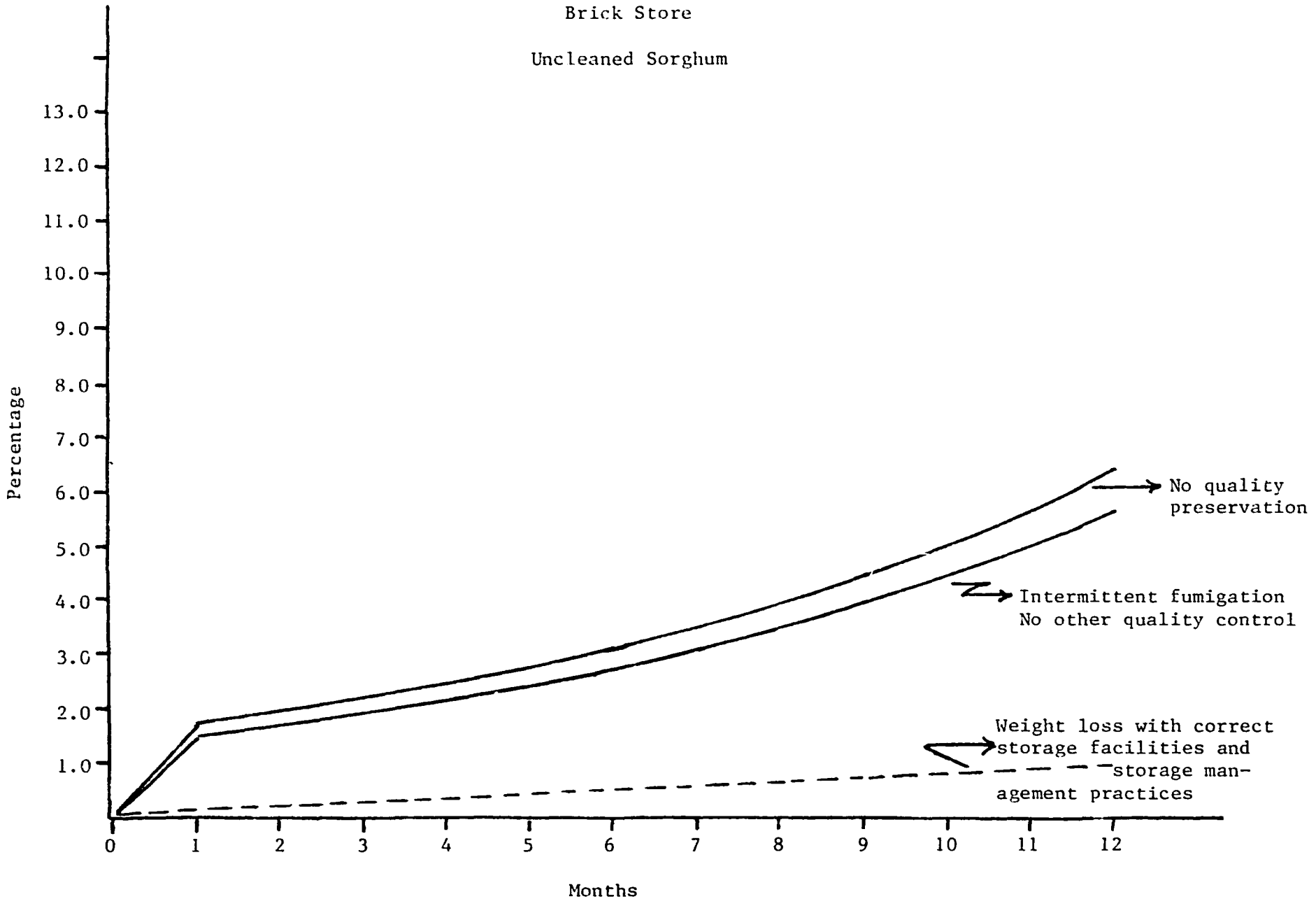
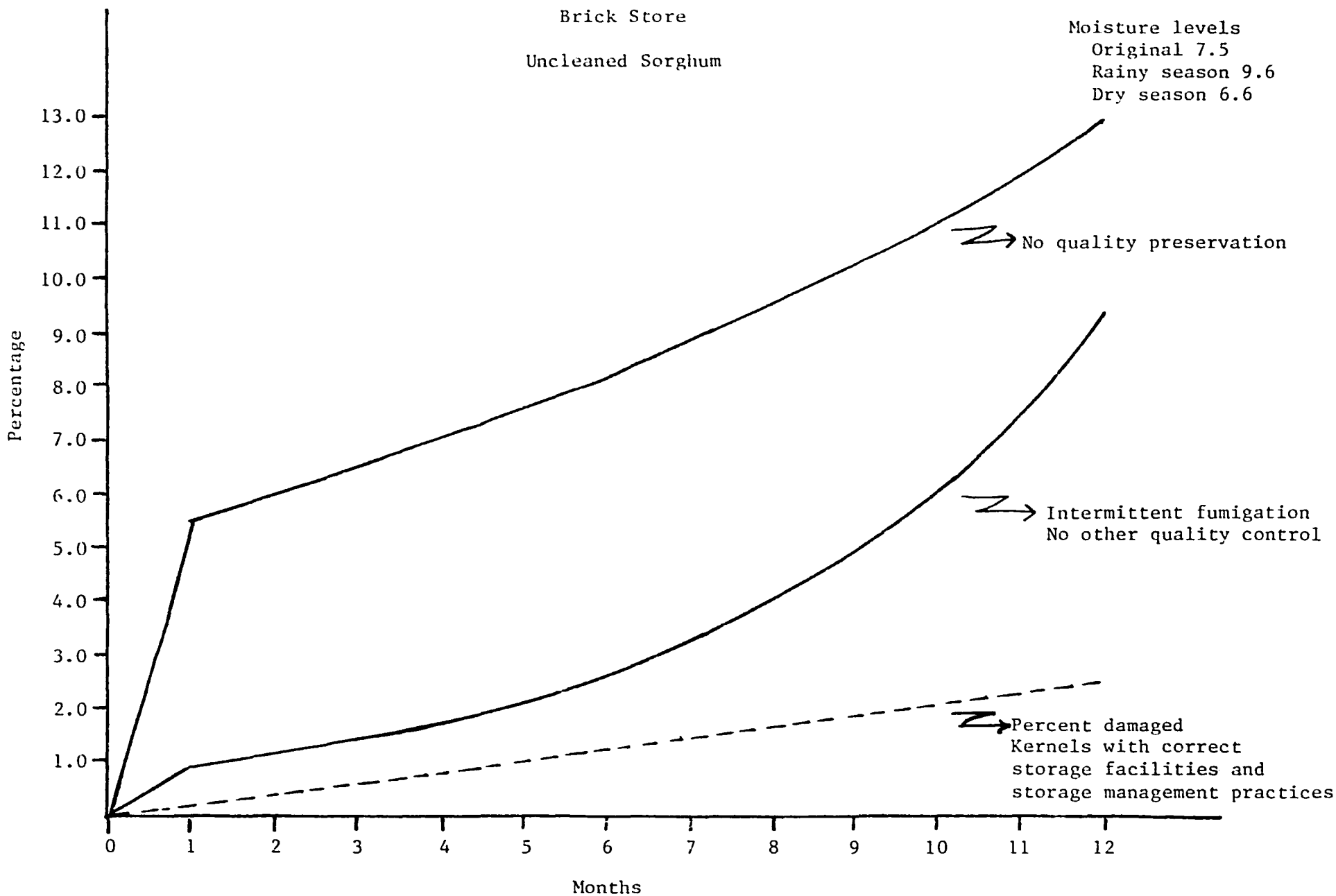


FIGURE 2. Percentage Damaged Grains During Storage



Handling losses can not be addressed because of the total lack of information and knowledge about such losses.

Reduction of Storage Losses

Adequate storage facilities and improved storage practices should reduce weight losses to no more than one percent and quality losses to no more than 2.5 percent at the end of a one-year storage period. This is illustrated in Figures 1 and 2. For the purposes of project analysis, weight loss percentage and percentage of damaged grains will be added together to constitute a total loss figure. The basic assumption underlying this approach is that the merchant sector will discount the price of grain based on visual inspection. Indications are that this price discounting occurs on a direct one-to-one basis in the trading of cereal grains and oilseeds. No consideration is given for normal weight loss due to the reduction of moisture levels in stored grain. Only in the case of groundnuts may moisture shrink be significant. Groundnuts are probably already being discounted in the marketplace for high moisture, so such shrinkage should not affect the general price levels received.

Current Storage Costs

Table 1 below shows the current storage costs based on Agriculture Bank of Sudan (ABS) information and rental charges per month for different size brick stores. There is a range of cost by location and also among locations. This is apparently due to the availability of space at any one location and the differing levels of economic activity between locations.

TABLE 1

Cost of Storage
Brick Stores

(piastres per month per bag)

Location	Rate
Um Ruwaba	7-9
El Obeid	9-15
Dilling	10

Seasonal Price Movements

Price movements for groundnuts, sesame, and sorghum all exhibit seasonal tendencies, beginning with a low at harvest time and a specific upward movement throughout the marketing year. These levels and the timing of seasonal cycles vary by commodity.

Sesame prices show a gradual upward increase, with a peak in May. However, the slight increase between March and May indicates that sesame should be held in

storage for no longer than four months to achieve the maximum net margin.[1] Groundnuts have a very steep increase in price during the first two months after harvest, with the peak price occurring in April. This indicates that groundnuts should be held no longer than four months to achieve the maximum net margin. Depending on the year, it may be preferable to store groundnuts for only two months. Sorghum has a seasonal price curve that increases throughout the year, however the major price increases occur within the first seven months, indicating that the maximum storage period should be in the range of five to seven months. These seasonal price cycles are illustrated in Figure 3.

Seasonal price fluctuations for sorghum are more volatile than for sesame or groundnuts. This primarily due to the fact that sorghum is a major food staple for the Kordofan Region. The volatility of seasonal price cycles is directly related to the level of sorghum production. Based on this relationship, the average percentage price increase for sorghum in a normal year (when demand is more or less equal to production) should be in a range of 50 to 62 percent. The changes in year-to-year volatility are shown in Figure 4.

The data base used to construct seasonal price movements has been influenced by the strong upward trend in the prices of commodities over the past five years. Seasonal prices cycle around this long-term trend and, as a result, there is only a slight decrease in prices for the last six months of the marketing year in the seasonal cycles of sesame and groundnuts. There is no decrease in the seasonal price cycle for sorghum, it has merely moved on to a higher plateau. This trend and cyclic effect is illustrated in Figure 5.

The crop prices used in the rate of return analysis of this project component are the price cycles illustrated in Figure 3 and detailed in Appendix D. Harvest period prices, shown in Table 13, are an estimate of the expected market prices for this harvest season. This estimate is based on Table 11, Appendix D, and the cycles and long-term price movements as shown Figure 5.

In order to determine the viability of the ABS project component, it is necessary to measure the direct benefits to storage, such as warehouse operating margins (storage fees and rentals less operating costs), financial gain to the production sector (traditional and mechanized farmers), and loss reduction (financial gain) for commodities stored as food reserves.

Viability must be measured in terms of direct benefits to different segments in agriculture. Market prices must be used rather than a proxy price such as an import parity price. The reason that domestic market prices must be used is that sorghum will be the principal crop stored. An import parity price can not be calculated for the sorghum, because the sorghum on the world market is a different product destined for a different end use. The same situation applies to sesame, since different world markets exist for different types of sesame. Trying to compare domestic crops and world market crops is futile in this case.

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[1]The net margin equals the price increase minus the storage cost.

FIGURE 3. Average Percentage Seasonal Increase in Market Price

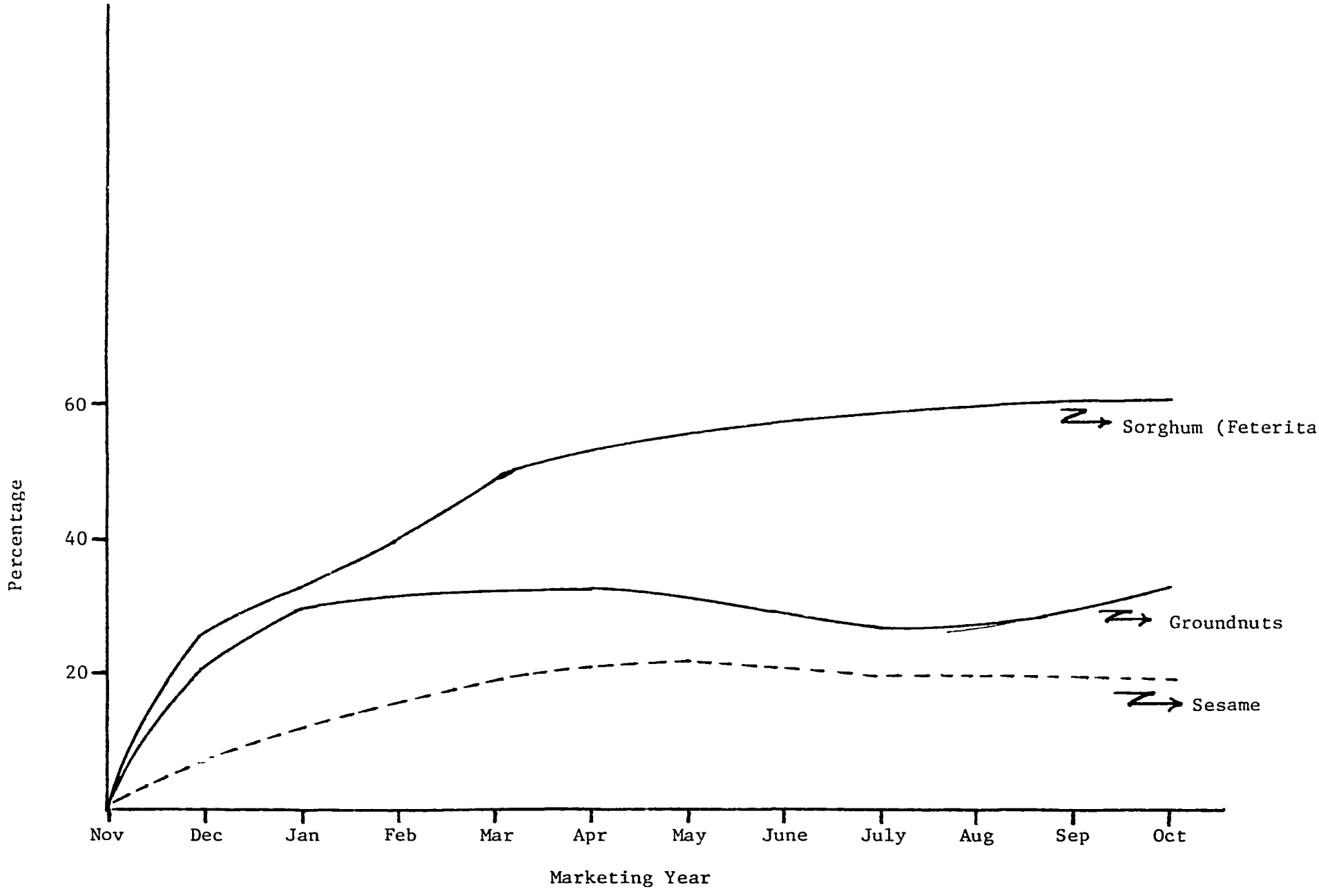


FIGURE 4. Percentage of Seasonal Price Increase for Sorghum

Kordofan Region

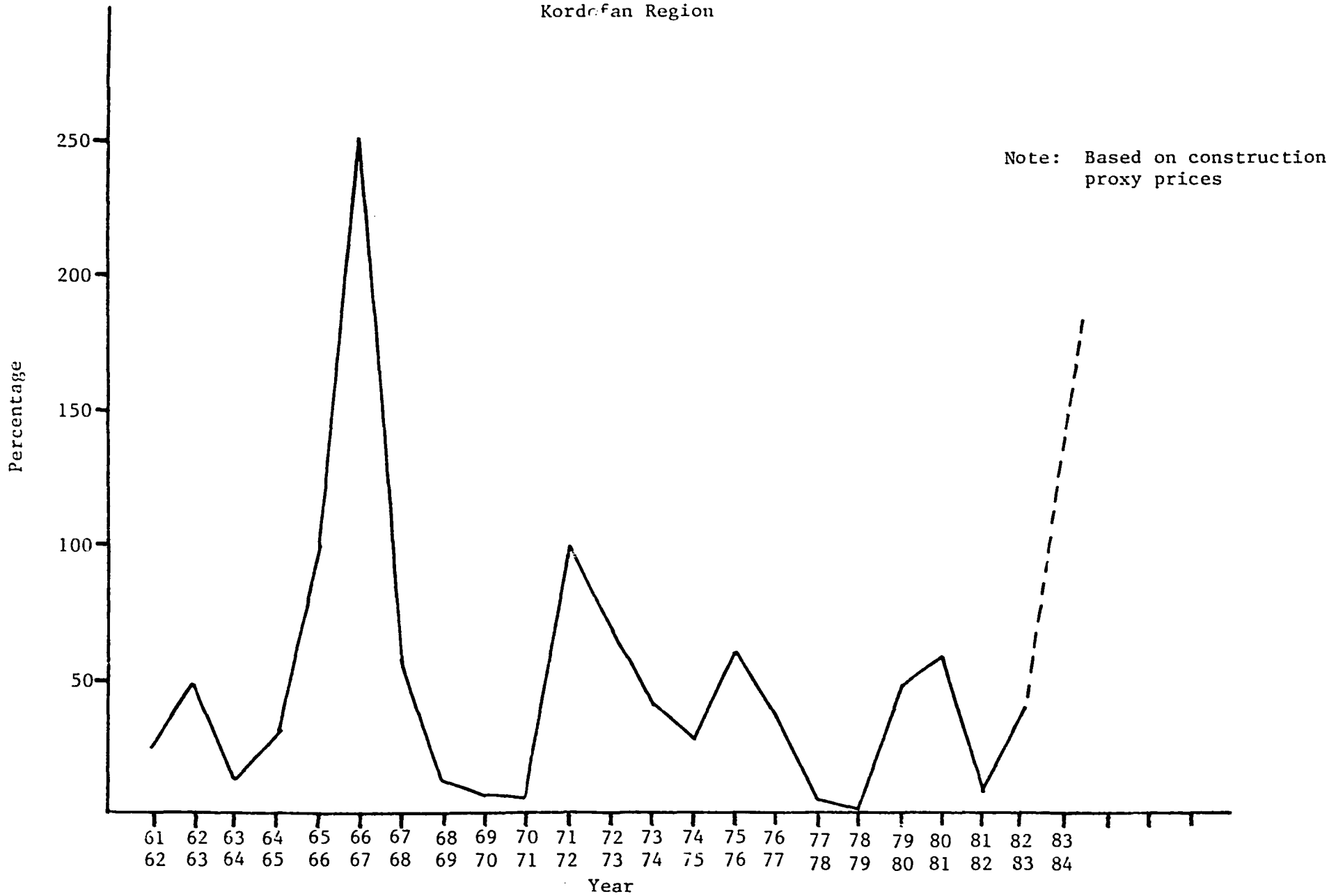
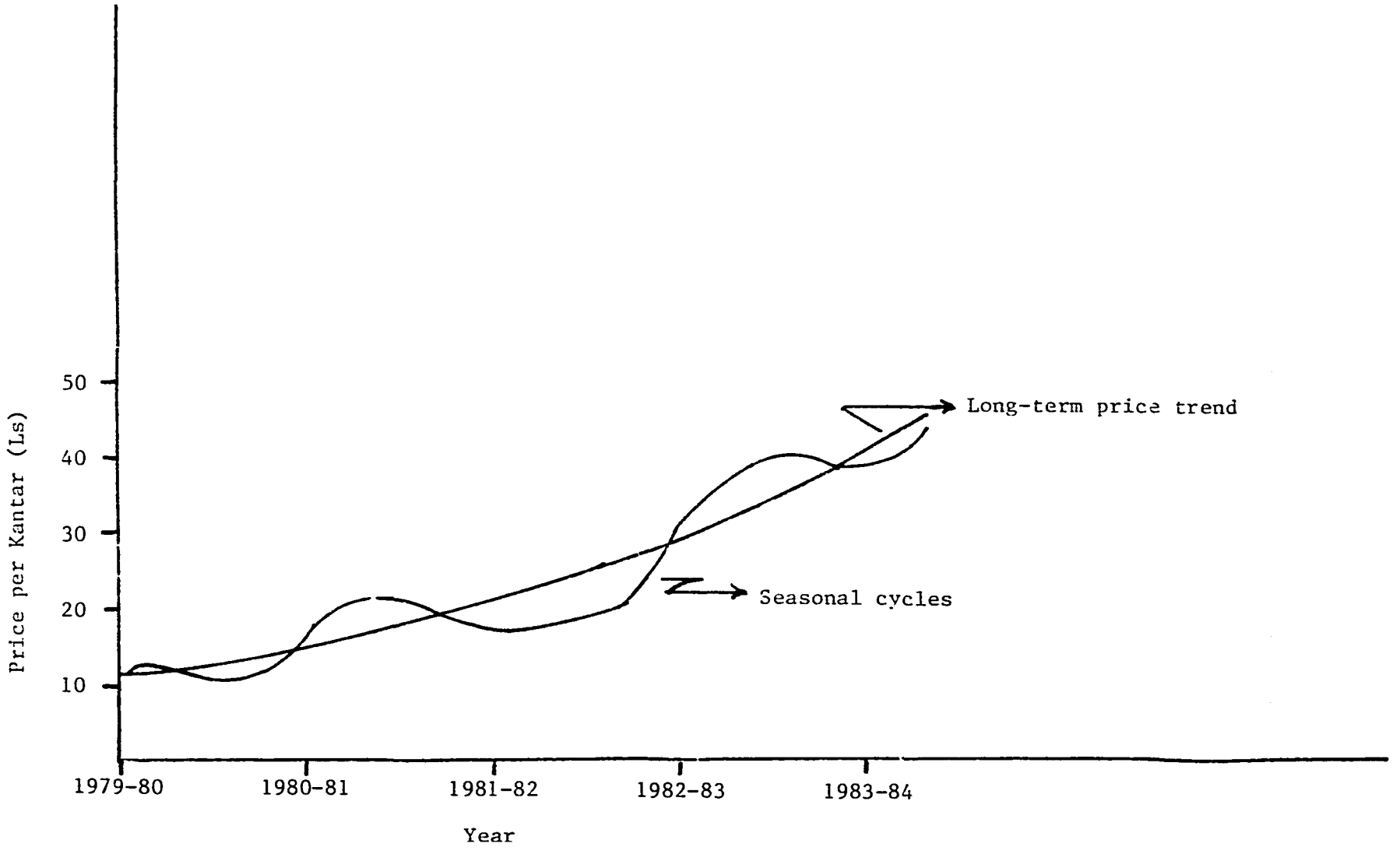


FIGURE 5. Trend of Prices and Seasonal Price Cycles for Sesame



Trade-Off Between Reduced Losses and Increases in Storage Costs

A reduction in both weight loss and percentage of damaged kernels in stored grain will result from the construction of suitable cereal grain and oilseed storage facilities and the application of correct storage management practices in these facilities. Costs for construction of facilities and the necessary training and technical assistance will require that storage fees be raised to reflect the cost levels associated with such facilities and operations. Therefore, the relationship between loss reduction and potential increases in storage costs must be analyzed.

The projected annual operating costs shown in Table 2 reveal that the expected storage costs will be 19 piastres per bag per month. An analysis of the trade-off between the value of losses and the storage fees shown in Table 3 indicates that storage fees could be increased by as much as 70 piastres per bag per month and still maintain the same relationship as exists in current ABS operations. This relationship between loss reduction and the ability to increase storage fees is further illustrated in Figure 6.

A fair approach to the setting of storage fees by the ABS would be to allocate the maximum storage fee of 80 piastres per month to the ABS and to the client-farmers in the following manner. The farmer will pay 23 piastres to the ABS, thus covering the 19 piastres of projected operating costs plus a margin of 4 piastres for return on revenues. The remaining 57 piastres will be received by the farmer in the form of payment for commodity which would have been lost under the current system. This should create an additional incentive for the farmer to participate in ABS credit programs and thereby increase the utilization rate of warehouse capacity.

Storage Capacity Utilization

Because of the nature of this project component and its focus on increasing farmer income in the traditional sector and to a lesser degree in the mechanized sector, the projected storage capacities will not be fully utilized. Projected trends for quantities to be stored under ABS loan operations are detailed in Table 4. These trends are based on historical performance of the ABS as well as the location of the mechanized farming schemes.

ABS loan storage operations will be in effect for no more than 4 to 5 months out of the year, depending on the commodity in storage. The overall utilization rate of warehouses will be extremely low until late in the projected time period. Even in the latter part of this time period, turnover rates will not exceed 0.45.

To overcome what could be a serious constraint to the economic viability of the project, the storage capacity must be utilized for the remaining 7 to 8 months of the marketing year. Two possibilities exist for the alternative use of the storage facilities when they are not being utilized for ABS loan and storage. The first is the use of storage capacity for food grain reserves. Historically, the Kordofan Region has been deficit in sorghum for 3 out of 10 years (Figure 2, Appendix B). Therefore, these facilities could be used to store food grain reserves on the average of every third year. Secondly, the lack of adequate private sector cereal grain and oilseed storage capacity in the Kordofan Region presents the opportunity to rent the storage facilities to the private (merchant) sector during the period of non-use by the ABS. Since the capacity to

FIGURE 6. Relationship Between Loss Reduction and Ability to Increase Storage Costs

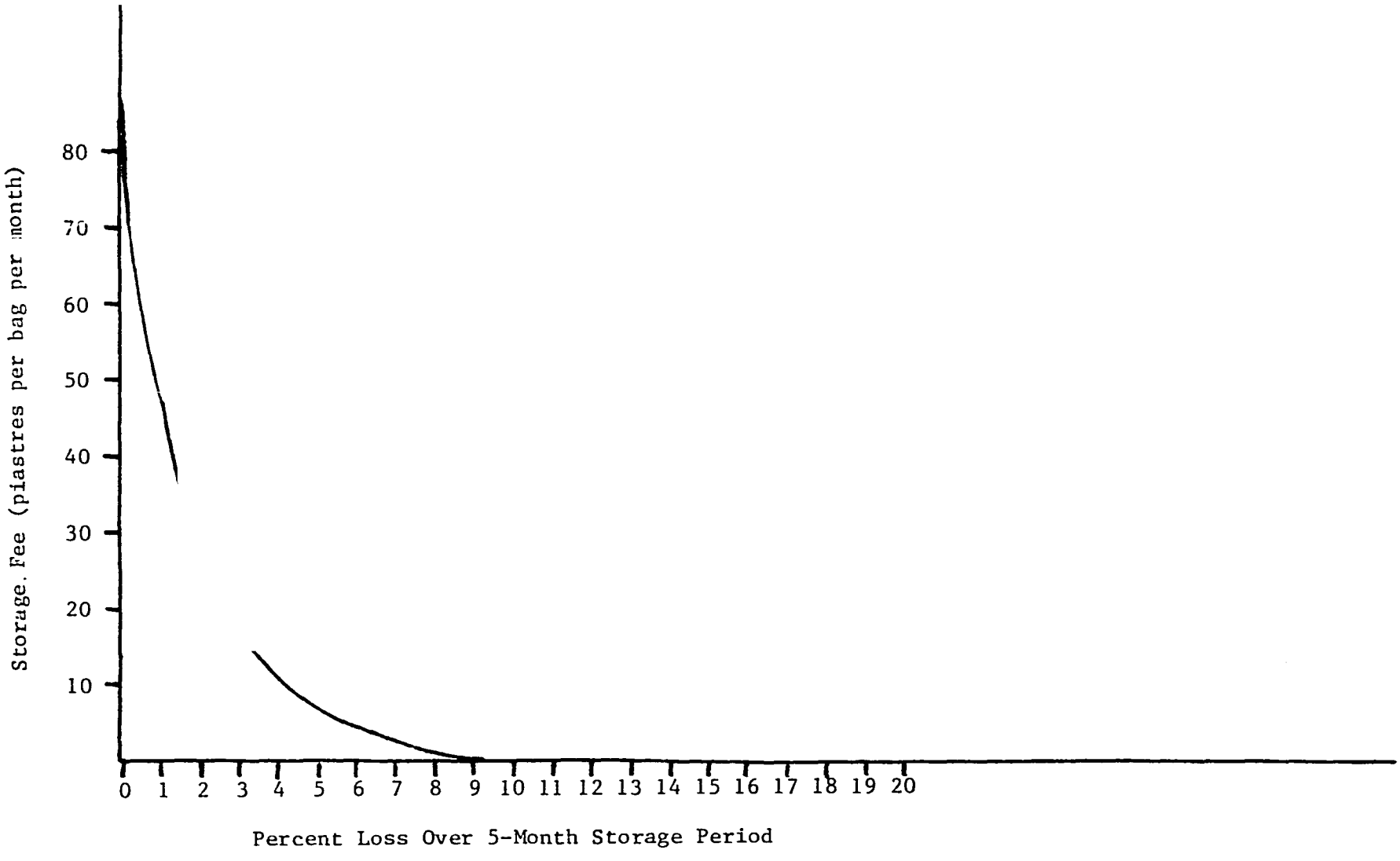


TABLE 2

Projected Annual Operating Costs

3,000-MT (33,000 bag) Warehouse

Variable Costs	Ls per MT	Ls per Bag
Chemicals	2.60	
Supplies	0.33	
	2.93	0.27

Fixed Costs	Ls	Ls per Bag
Salaries	5,100	
Labor	1,800	
Equipment amortization[1]	440	
Maintenance costs[2]	15,303	
Warehouse amortization[3]	44,237	
	66,880	2.03

Operating Cost

Ls per bag per year 0.27 + 2.03 = 2.30

Ls per bag per month $\frac{2.30}{12}$ = 0.19 (19 piastres)[4]

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[1]Ls4,400 for 10 years.

[2]1.4 percent of original warehouse construction cost.

[3]Ls1,327,115 for 30 years.

[4]1 Ls = 100 piastres.

TABLE 3

Relationship Between Storage Fees and Commodity Losses

	Storage Fees	Value of Losses
	(Piastres per month per bag)	
Sorghum		
Current operations	10.1	87.8
Future operations with new facilities and training	84.0[3]	13.9
Sesame		
Current operations	10.1	189.9
Future operations with new facilities and training	69.8[3]	130.1
Groundnuts		
Current operations	10.1	93.8
Future operations with new facilities and training	87.8[3]	16.1

Average maximum storage fee
80.5 piastres per month

Current storage fee
10.1 piastres per month

Maximum increase in storage fee
70.4 piastres per month

Allocation of 80 piastres

ABS	23 piastres[4]
Farmer	57 piastres

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[1]Based on expected value of non-harvest season price (Table 13). Five months storage for sorghum and four months storage for sesame and grounduts.

[2]9.5 percent loss for sorghum (2.5 percent weight loss plus 7.0 percent damaged kernels) and 8.75 percent for sesame and sorghum (Figures 1 and 2). Losses reduced to 1.5 percent (0.5 percent weight loss plus 1.0 percent damaged kernels, Figures 1 and 2).

[3]Maximum storage fee for farmer to maintain current financial situation.

[4]Based on cost of 19 piastres plus 4 piastres margin (17 percent return on revenues.

Source: Table 13 and 14.

TABLE 4

ABS Warehouses

Projected Trends in Storage

Loan Operations

(number of bags)

Project Year	El Obeid[1]	Abu Gubeiha[2]		Talodi[2]		Dilling[3]	Total
	Traditional	Traditional	Mechanized	Traditional	Mechanized	Mechanized	
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	4,900	-	-	-	-	17,000	21,900
4	5,800	1,800	4,000	1,800	4,000	18,300	35,700
5	6,800	2,500	8,000	2,500	8,000	19,700	47,500
6	8,100	3,400	12,000	3,400	12,000	21,200	60,100
7	9,500	4,700	16,000	4,700	16,000	22,800	73,700
8	11,300	6,500	20,000	6,600	20,000	24,600	89,000
9	13,300	8,900	20,000	9,100	20,000	26,500	97,800
10	15,700	12,300	20,000	12,500	20,000	28,500	109,000
11	18,500	16,900	16,100	17,300	15,700	30,700	115,200
12	21,900	23,200	9,800	23,900	9,100	33,000	120,900
13	21,900	32,000	1,000	33,000	-	33,000	120,900
Commodity mix:							
	50% sesame 50% groundnuts	90% sorghum 5% sesame	100% sorghum	95% sorghum 5% sesame	100% sorghum	100% sorghum	

[1]Initial level based on average current storage operations, continuing to 10 percent of division production, at the growth rate of 17 percent, equivalent to the 18 percent growth in current operations.

[2]For the traditional sector, the initial level is based on operations in Um Ruwaba, continuing to 10 percent of area production (or 40 percent of calculated marketable surplus). The growth rate is 32 percent, equivalent to Um Ruwaba. Figures for the mechanized sector are based on the area available in mechanized schemes (Figure 4, Appendix B).

[3]Based on an average of the last five years of operation minus the capacity of the IDA warehouse (55,000) bags) with a growth rate of 7 percent.

[4]Commodity mixes taken into account in calculating projected trends.

be rented will not be continuously available to the renter, it is imperative to establish competitive rental rates.[1] The suggested rates could possibly be increased as much as 100 percent, depending upon location and demand. With the all-weather road network and the setting of competitive rental rates, revenues will be generated to assist in improving the economic viability of the warehouses.

Investment Costs and Flows

Investment costs for the four ABS 3,000-MT warehouses are estimated at Ls 5,308,460. The breakdown of investment costs per warehouse is as follows:

Foreign exchange $200,000 x 2.2[2]	Ls 440,000
Local currency	633,500
Engineering fee (7.5 percent)	80,513
Contingency (15 percent)	173,102
Total	Ls1,327,115

Other investment costs involved in the ABS storage component are for training and technical assistance. Training costs, including related technical assistance, will total $116,000 plus Ls10,000 in local currency. Technical assistance for overseeing the construction will total $55,000.

Investment cost flows for facilities will follow the staged pattern of construction as diagramed below.

Months

0 — 15 — 24 — 30 — 39

2 warehouses: El Obeid and Dilling

Procurement → Construction →

2 warehouses: Talodi and Abu Gubeiha

Procurement → Construction →

Based on this staged construction pattern, facility investments will be Ls 1,012,000 for project year 1, Ls2,654,230 for project year 2, and Ls1,642,230 for project year 3.

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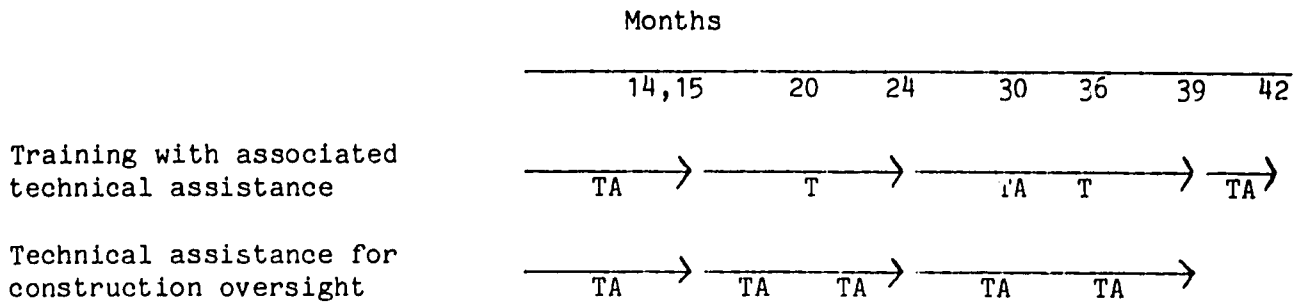
[1]Suggested minimum rental rates are: El Obeid: 10 piastres per month per bag (Ls3,300 per month for the warehouse), Dilling: 8 piastres per month per bag (Ls2,640 per month for the warehouse), and Abu Gubeiha and Talodi: 7 piastres per month per bag (Ls2,310 per month for the warehouse).

[2]Dollar costs converted to Sudanese Pounds at a rate of 2.2 Sudanese Pounds to 1.0 U.S. dollar (approximate open market rate).

Investment for training and technical assistance will follow the implementation schedules diagramed below.



Based on the above schedule, investment costs[1] for training will be Ls127,100 for project year 2, Ls133,900 for project year 3, and Ls25,300 for project year 4. Investment costs[1] for technical assistance in construction oversight will be Ls24,200 for project year 1, Ls48,400 for project year 2, and Ls48,400 for project year 3.

Farmer Benefits

The benefits to the production sector are (1) an increase in income due to the ability store crops for later sale when prices are higher, and (2) an increase in income due to loss reduction of the crop while in storage. These benefits are calculated in Tables 12 and 13. Under the current storage situation of the ABS, farmers would gain additional net revenue of 33, 6, and 16 percent per bag of commodity for sorghum, sesame, and groundnuts, respectively. This is due to the ability to store crops while waiting for prices to increase, which is essentially an income transfer from the merchant to the production sector.

With the placement of proper storage facilities and management practices, additional net revenue is increased to 44, 14, and 24 percent per bag of commodity for sorghum, sesame, and groundnuts, respectively. This is due to increased prices from non-harvest season sales plus the reduction of losses due to good storage facilities and management practices. Contrary to the income transfer benefits from storing the crops until the non-harvest season, the loss reduction benefits to the farmer are new benefits. Proportionally, depending on the commodity, one-fourth to two-thirds of the total net additional income consists of income transfer, and the balance consists of new benefits.

For any individual farmer, the impact of these benefits can not be accurately determined. As previously stated, individual production in the traditional farming sector is small and extremely variable. No knowledge exists as to the amount of marketable surplus of sorghum, if any, in the traditional sector. If the prototype[2] presented in the PID is used as an example, then the individual traditional farmer could increase his revenue from crop sales by an average of 21 percent. For the mechanized sorghum production sector, it appears that increased revenue from crop sales could amount to 44 percent, since sorghum is the only crop.

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[1]Dollar costs converted to Sudanese Pounds at a rate of 2.2:1.

[2]Table 6, page 29, PID.

Direct Benefits

The direct benefits of the ABS warehouse and inventory loan project component are (1) positive net operating margins (storage fees and rentals greater than operating costs) generated by ABS storage activities and rentals, (2) increased incomes for farmers, and (3) loss reduction in security grain reserve stocks.

Revenues generated by ABS warehouse operations are (1) storage fees charged to client-farmers (Table 5)[1], (2) storage fees charged for security grain reserve stocks (Table 6), and (3) revenues from renting warehouses during periods of non-use by the ABS (Table 7). Total revenues are summarized in Table 8. Since the staging of construction will result in warehouses being constructed first at El Obeid and Dilling, revenues are distributed accordingly. The revenues will begin in project year 3 for El Obeid and Dilling, and in project year 4 for the Abu Gubeiha and Talodi warehouses, which will be finished in the second construction phase.

Operating costs for ABS warehouses for the inventory loan storage operations are detailed in Table 9. Operating costs for the storage of food reserves by the ABS are shown in Table 10. These costs are scheduled according to the same format as revenues. The resulting operating margins for the ABS are described in Table 11.

Farmer benefits of the ABS inventory loan storage program are summarized in Table 12 with specific details presented in Tables 13 and 14. As indicated in the project description and the subsection on storage capacity utilization, ABS loan operations involving the mechanized sector are expected to strongly support this warehouse system in the early years. Due to the growth trends in storage (Table 4), benefits to the traditional sector will exceed benefits to the mechanized sector by project year 12.

The final direct benefit category, loss reduction in food grain reserve stocks, is presented in Table 15. The value of loss reduction is based on the quantity stored times the percentage of loss reduction times the current harvest market value of sorghum.

Direct Rate of Return[2]

Calculation of the direct rate of return (DRR) to this project component is conservatively biased. In the investment flow, an open market exchange rate was used to convert dollar costs to Sudanese Pounds. This rate is nearly double the current official rate. In addition, all training and technical assistance costs were included in the investment flow. Benefits are conservatively biased in that projected trends for volume stored are based on

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[1]Any increase in storage fees will decrease benefits to farmers in increased incomes and therefore will not change the rate of return.

[2]The direct rate of return is used to measure the earning power of the total capital investment in a project that has direct benefits that are internal as well as external. In this case, the external benefits are increased income to farmers and loss reduction in security food reserve stocks. Benefits calculated are based on financial rather than economic returns.

TABLE 5

ABS Warehouses

Storage Revenues

ABS Loan Storage Operations

(Ls)

Project Year	Warehouse Location				Total
	El Obeid[1]	Abu Gubeiha[1,2]	Talodi[1,2]	Dilling[2]	
1	-	-	-	-	-
2	-	-	-	-	-
3	4,508	-	-	19,550	24,058
4	5,336	6,629	6,649	21,045	39,659
5	6,256	12,018	12,046	22,655	52,975
6	7,452	17,631	17,671	24,380	67,134
7	8,740	23,697	23,750	26,220	82,407
8	10,396	30,326	30,353	28,290	99,365
9	12,236	33,030	33,360	30,475	109,101
10	14,444	36,862	37,231	32,775	121,312
11	17,020	37,561	37,751	35,305	127,367
12	20,148	37,416	37,675	37,950	133,189
13	20,148	37,214	37,570	37,950	132,882

[1]Average of 4 months storage for sesame and groundnuts.

[2]Average of 5 months storage for sorghum.

Source: Tables 3 and 4.

TABLE 6

ABS Warehouses

Storage Revenues

Food Security Reserve Stocks[1,2]

(Ls)

Project Year	Warehouse Location				Total
	El Obeid	Abu Gubeiha	Talodi	Dilling	
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	30,360	26,565	26,565	26,565	110,055
6	-	-	-	-	-
7	-	-	-	-	-
8	30,360	26,565	26,565	26,565	110,055
9	-	-	-	-	-
10	-	-	-	-	-
11	30,360	26,565	26,565	26,565	110,055
12	-	-	-	-	-
13	-	-	-	-	-

[1]Production-consumption relationships reveal that food grain reserves are necessary for 3 out of every 10 years in the Kordofan Region.

[2]Calculated at 23 piastres per bag per month for 33,000 bags in each warehouse with a declining rate as reserves are distributed. Storage of grain for 8 months at El Obeid and 7 months for Abu Gubeiha, Talodi, and Dilling.

TABLE 7

ABS Warehouses

Revenues Generated from Rental of Facilities[1]

Non-Use Periods[2]

(Ls)

Project Year	Warehouse Location				Total
	El Obeid	Abu Gubeiha	Talodi	Dilling	
1	-	-	-	-	-
2	-	-	-	-	-
3	21,120	-	-	14,784	35,904
4	21,120	12,936	12,936	14,784	61,776
5[3]	-	-	-	-	-
6	21,120	12,936	12,936	14,784	61,776
7	21,120	12,936	12,936	14,784	61,776
8	-	-	-	-	-
9	21,120	12,936	12,936	14,784	61,776
10	21,120	12,936	12,936	14,784	61,776
11[3]	-	-	-	-	-
12	21,120	12,936	12,936	14,784	61,776
13	21,120	12,936	12,936	14,784	61,776

[1]Rental revenues calculated at current market rates or less, so as to create an incentive for rental of unused storage capacity. Rental fees of 10, 7, 7, and 8 piastres per bag per month for El Obeid, Abu Gubeiha, Talodi, and Dilling, respectively.

[2]Storage period of 8 months for El Obeid and 7 months for Abu Gubeiha, Talodi, and Dilling.

[3]Warehouse capacity utilized for food security reserve stocks.

TABLE 8

ABS Warehouses

Total Revenues

(Ls)

Project Year	Warehouse Location				Total
	El Obeid	Abu Gubeiha	Talodi	Dilling	
1	-	-	-	-	-
2	-	-	-	-	-
3	25,268	-	-	34,334	59,962
4	26,456	19,565	19,585	35,829	101,435
5	36,616	38,583	38,611	49,220	163,030
6	28,572	30,567	30,607	39,164	128,910
7	29,860	36,633	36,686	41,004	144,183
8	40,756	56,891	56,918	54,855	209,420
9	33,356	45,966	46,296	45,259	170,877
10	35,564	49,798	50,167	47,559	183,088
11	47,380	64,126	64,136	61,870	237,692
12	41,268	50,352	50,611	52,734	194,965
13	41,268	50,150	50,506	52,734	194,658

Source: Tables 5, 6, and 7.

TABLE 9

ABS Warehouses

Operating Costs[1]

Loan Storage Operations

(Ls)

Project Year	Warehouse Location				Total
	El Obeid	Abu Gubeiha	Talodi	Dilling	
1	-	-	-	-	-
2	-	-	-	-	-
3	23,508	-	-	26,731	50,239
4	23,748	23,748	23,748	27,077	98,321
5	24,014	25,000	25,000	27,450	101,464
6	24,361	26,305	26,305	27,850	104,821
7	24,733	27,716	27,716	28,276	108,441
8	25,213	29,261	29,288	28,756	112,518
9	25,746	29,901	29,954	29,262	114,863
10	26,385	30,807	30,860	29,795	117,847
11	27,131	30,993	30,993	30,380	119,497
12	28,036	30,993	30,993	30,993	121,015
13	28,036	30,993	30,993	30,993	121,015

[1]Variable costs plus fixed costs of salaries, labor, and maintenance. Fixed costs do not include building and equipment amortization.

Source: Tables 2 and 4.

TABLE 10

ABS Warehouses

Operating Costs[1]

Food Reserve Storage Operations

(Ls)

Project Year	Warehouse Location				Total
	El Obeid	Abu Gubeiha	Talodi	Dilling	
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	8,790	8,790	8,790	8,790	35,160
6	-	-	-	-	-
7	-	-	-	-	-
8	8,790	8,790	8,790	8,790	35,160
9	-	-	-	-	-
10	-	-	-	-	-
11	8,790	8,790	8,790	8,790	35,160
12	-	-	-	-	-
13	-	-	-	-	-

[1]Variable costs only (chemicals and supplies.)

Source: Tables 2 and 6.

TABLE 11

ABS Warehouses

Operating Margin[1]

(Ls)

Project Year	Warehouse Location				Total
	El Obeid	Abu Gubeiha	Talodi	Dilling	
1	-	-	-	-	-
2	-	-	-	-	-
3	2,120	-	-	7,603	9,723
4	2,708	-4,183	-4,163	8,752	3,114
5	3,812	4,793	4,821	12,980	26,406
6	4,211	4,262	4,302	11,314	24,089
7	5,127	8,917	8,970	12,728	35,742
8	6,753	18,840	18,840	17,309	61,742
9	7,610	16,065	16,342	15,997	56,014
10	9,179	18,991	19,307	17,764	65,241
11	11,459	24,343	24,533	22,700	83,035
12	13,232	19,359	19,618	21,741	73,950
13	13,232	19,157	19,513	21,741	73,643

[1]Before building and equipment amortization.

Source: Tables 8, 9, and 10.

TABLE 12

Summary of Farmer Benefits

(Ls)

Project Year	Warehouse Locations: El Obeid[1] Traditional	Abu Gubeiha Traditional	Abu Gubeiha Mechanized	Talodi Traditional	Talodi Mechanized	Dilling[1] Mechanized	Total Traditional	Total Mechanized	Total
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	17,175	-	-	-	-	51,850	17,175	51,850	69,025
4	25,203	22,788	52,320	23,274	52,320	68,854	71,265	173,494	244,759
5	34,123	31,650	104,640	32,325	104,640	87,166	98,098	296,446	394,544
6	45,719	43,044	156,960	43,962	156,960	106,786	132,725	420,706	553,431
7	58,207	59,502	209,280	60,771	209,280	127,714	178,480	546,274	724,754
8	74,263	82,290	261,600	85,338	261,600	151,258	241,391	674,458	916,349
9	92,103	112,674	261,600	117,663	261,600	176,110	322,440	699,310	1,021,750
10	113,511	155,718	261,600	161,625	261,600	202,270	430,854	725,470	1,156,324
11	138,487	213,954	210,588	223,689	205,326	231,046	576,130	646,990	1,223,120
12	168,815	293,712	128,184	309,027	119,028	261,130	771,554	508,342	1,279,896
13	168,815	405,120	13,080	426,690	-	261,130	1,000,625	274,210	1,274,835

[1]The base for year 3 is calculated on the differential between current operations and future operations with new facilities. This differential is carried throughout the time period analyzed. Increase in volume stored is calculated at the full increase value.

TABLE 13

Realized Net Gain by Farmers
Current ABS Operations
Rented Storage

Increase in Gross Revenue Due to Storage

	Average Storage Time (Months)	Average Increase in Market Price (Percent)	Harvest Period Price (Ls per bag)	Price Increase Due to Storage (Ls per bag)
Sorghum	4-6	54	30.0	16.2
Sesame	4	19	72.0	14.7
Groundnuts	4	32	32.4	10.4

Current Average Storage Costs per Bag at ABS Facilities

Storage: 10.1 piastres per month[1]
Insurance: 1.0 piastres per month
Interest: 14 percent on loan of 70 percent harvest value

Storage Costs by Commodity

(Piastres per Month per Bag)

	Sorghum	Sesame	Groundnuts
Storage	10.1	10.1	10.1
Insurance	1.0	1.0	1.0
Interest	24.5	58.8	26.5
	35.6	69.9	37.6

Storage Losses[2]

	Loss (Percent)		Increased Price Level (Ls per bag)		Total Loss (Ls per bag)
Sorghum	9.5	x	46.2	=	4.39
Sesame	8.75	x	86.7	=	7.59
Groundnuts	8.75	x	42.8	=	3.75

Summary of Farmers' Gains

	Added Revenue Due to Storage (Ls per bag)		All Costs of Storage (Ls per bag)		Losses (Ls per bag)		Net Additional Revenue (Ls per bag)	Net Gain (Percent)
Sorghum	16.2	-	1.78	-	4.39	=	10.03	33
Sesame	14.7	-	2.80	-	7.59	=	4.31	6
Groundnuts	10.4	-	1.50	-	3.75	=	5.15	16

[1]Weighted average cost.

[2]Weight loss 2 percent plus damaged kernel loss of 7.5 percent for 5 months for sorghum. Weight loss of 1.75 percent plus damaged kernel loss of 7.0 percent for sesame and groundnuts for 4 months.

TABLE 14

Realized Net Gain by Farmers

New Storage Facilities

Storage Cost by Commodity

(Piastres Per Month)

	Sorghum	Sesame	Groundnuts
Storage	23.0	23.0	23.0
Insurance	1.0	1.0	1.0
Interest	24.5	58.8	26.5
	48.5	82.8	26.5

Storage Losses[1]

	Loss (Percent)		Increased Price Level (Ls per bag)		Total Loss (Ls per bag)
Sorghum	1.5	x	46.2	=	0.69
Sesame	1.5	x	86.7	=	1.30
Groundnuts	1.5	x	42.8	=	0.64

Summary of Farmers' Gains

	Added Revenue Due to Storage (Ls per bag)		All Costs of Storage (Ls per bag)		Losses (Ls per bag)		Net Additional Revenue (Ls per bag)	Net Gain (Percent)
Sorghum	16.2	-	2.43	-	0.69	=	13.08	44
Sesame	14.7	-	3.31	-	1.30	=	10.09	14
Groundnuts	10.4	-	2.02	-	0.64	=	7.74	24

[1]Weight loss of 0.5 percent plus 1.0 percent damaged kernel loss for all commodities.

Source: Figures 3, 4, and 5.

TABLE 15

Loss Reduction

Food Security Reserve Stocks

(Ls)

Project Year	Value of Loss Reduction[1]
1	-
2	-
3	-
4	-
5	237,600
6	-
7	-
8	237,600
9	-
10	-
11	237,600
12	-
13	-

[1]Damaged grain from the current crop received at ABS warehouses in month 5 for El Obeid and months 6 in other locations. Applicable quality preservation control should reduce weight loss by 2.75 percent and damaged kernels by 3.25 percent, for a total loss reduction of 6.0 percent. Market value per bag at harvest: 30 Ls.

Source: Tables 6 and 14 and Figures 1 and 2.

historical performance of current operations. Reductions in storage losses are conservatively estimated within the ranges of 6 to 8 percent, based upon the analysis of actual storage losses. Net income gain to farmers was discounted by the volumes stored under current operations as well as by average seasonal price movement construction. Warehouse rental revenues are based on current rental rates for less than adequate storage facilities.

The resulting direct rate of return, presented in Table 16, is 12.02 percent. While by some standards this may be considered low, there are several basic factors which need to be taken into account. First, investment and benefit flows are conservatively biased. Second, because of the need to stage construction of facilities, benefits are not generated until the third and fourth year of the project. Third, the slow growth in volume stored during the 15-year time period analyzed reflects the reality of the situation when such an undertaking is a new concept in a marketing system.

Sensitivity Analysis

A sensitivity analysis of the base case was performed. The results, given below, illustrate that the conservatively-biased base case annual rate of return is extremely stable, given the levels of possible divergence in investment costs and benefits.

Sensitivity Analysis

	Alternative	Percent Annual Rate of Return
1.	Base case	12.02
2.	Investment costs for facilities increased 25 percent	9.59
3.	Benefits increased 15 percent	13.80
4.	Benefits increased 15 percent	10.11
5.	Warehouse rental revenues increased by 100 percent	12.64
6.	Worst case example: investment costs for facilities increased 25 percent and benefits decreased 15 percent	7.88

Associated Benefits[1]

Benefits associated with project activities are (1) the value of construction labor, other employment, and engineering fees, (2) the value of training incorporated into the project, (3) the value of the facilities as role models which can be replicated by the private sector, and (4) the value of improving the institutional performance of the ABS. The first three benefits can be quantified, but the fourth is only an abstract benefit.

The impact of labor wages and engineering fees as well as money generated by reducing losses are generally measured by a multiplier effect, which determines the impact of money flowing into other parts of the economy. In general, multiplier effects are on the order of 1.3 to 7, meaning that for each 1 Ls generated by wages or fees or recovered from losses, an additional 1.3 to 7 Ls would be generated in other segments of the economy. Since the multiplier effect is unknown, it is assumed to be a conservative one-to-one relationship.

TABLE 16

Direct Rate of Return

ABS Warehouses

(Ls)

Project Year	Investment: Facilities	Investment: Training	Investment: Technical Assistance	Investment: Total	Direct Net Benefits: ABS Warehouse Margins	Direct Net Benefits: Net Farmer Gain in Income	Direct Net Benefits: Loss Reduction Security Reserves	Direct Net Benefits: Total
1	1,012,000		24,200	1,036,200				
2	2,654,230	127,100	48,400	2,829,730				
3	1,642,230	113,900	48,400	1,804,530	9,723	69,025		78,748
4		25,300		25,300	3,114	244,059		247,873
5					26,406	394,544	237,600	658,550
6					24,089	553,431		577,520
7					35,742	724,754		760,496
8					61,742	916,349	237,600	1,215,691
9					56,014	1,021,750		1,077,764
10					65,241	1,156,324		1,221,565
11					83,035	1,223,120	237,600	1,543,755
12					73,950	1,279,896		1,353,846
13					73,643	1,274,835		1,348,478
14					73,643	1,274,835	237,600	1,586,078
15					73,643	1,274,835		1,348,478
16	-2,654,230							

Base Case

Annual rate of return = 12.02 percent

Associated Rate of Return[1]

The annual rate of return to investment in ABS warehouses from associated benefits is 9.97 percent. The assumptions used to construct the associated rate of return are detailed in Table 17. Given the direct rate of return of 12.02 percent annually and the associated rate of return of 9.97 percent annually, the annual social rate of return[2] for this project component is 21.99 percent.

Preliminary Analysis: Private-Sector Pilot Project

This preliminary analysis is constructed to derive an indication of the economic and financial feasibility of the storage units encompassed by the private-sector pilot project. As stated in the section on implementation considerations, more precise information needs to be collected and analyzed in order to properly present the potential results of each ownership or lease option.

Investment costs for facilities, presented in Table 18, use the official rate of exchange for converting the dollar component to Sudanese Pounds. Operational costs are presented in Table 19.

The turnover rate of stored commodities is the necessary condition by which unit costs can be reduced. The higher the turnover rate per year, the greater the reduction in unit cost. The turnover rates in this case are based on the capacity of the facility. For example, the 3,000-MT capacity bag warehouse would have turnover rates of 1, 2, and 3 times per year for storage of 3,000, 6,000, and 9,000 MT per year, respectively. The effect of turnover on operational costs is detailed in Table 20 and illustrated in Figure 7. Substantial reductions in unit costs are achieved by increasing turnover from 1 to 3. The reduction in unit costs after 3 turnovers becomes very small for every additional increase in turnover. Figure 8 presents the per unit cost reductions in terms of quantity stored by each of the different facilities. Again, this emphasizes the need to achieve a significant rate of stock turnover. Discussions with the private sector seem to indicate that stock turnover may be as high as 2.5 to 3 times. A turnover rate of 3 is used in constructing preliminary rates of returns for various options.

Gross revenues generated by the new facilities are not storage revenues as such, because the storage operations are internal to the merchandising activities. The revenues generated by a storage facility in this type of situation are (1) rent expenses defrayed by ownership or lease of the facility, (2) value of loss reduction in terms of the original purchase price of stocks, and (3) value of loss reduction in terms of the sales margin. With this type of

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[1]The associated rate of return (ARR) is used to measure the additional earnings to total capital investment resulting from benefits to other sectors of the economy that arise from project activity.

[1]The social rate of return is used to measure the combined direct and associated benefits to total capital investment in the enterprise. It is additive because the total capital is the same for the DRR and ARR calculations, whereas the benefits are separate.

TABLE 17

Associated Rate of Return
ABS Warehouses

(Ls)

Project Year	Investment: Facilities	Investment: Training	Investment: Technical Assistance	Investment: Total	Associated Benefits[1]: Labor and Fees[2]	Associated Benefits[1]: Value of Training[3]	Associated Benefits[1]: Value as Role Model[4]	Associated Benefits[1]: Total
1	1,012,000		24,200	1,036,200	75,900			75,900
2	2,654,230	127,100	48,400	2,829,730	369,502			369,502
3	1,642,230	113,900	48,400	1,804,530	369,502	86,505		456,007
4		25,300		25,300		141,015		141,015
5						187,625		187,625
6						237,395	97,680	335,075
7						291,115	195,360	486,475
8						351,550	293,040	644,590
9						386,310	390,720	777,030
10						430,550	488,400	918,950
11						455,040	586,080	1,041,120
12						477,555	683,760	1,161,315
13						477,555	787,440	1,264,995
14						477,555	879,120	1,356,675
15						477,555	976,800	1,454,355
16	-2,654,230							

Annual rate of return = 9.97 percent

[1]Based on multiplier effect of 1:1.

[2]Engineering fee of 7.5 percent and a labor content of 15 percent of total construction costs.

[3]Based on the difference between current operations and improved storage techniques which will generate a monetary gain due to loss reduction. This monetary gain will be available for farmers to spend on crop and livestock production costs or family expenses. Calculated on standard mix for all warehouses (12 percent sesame, 10 percent groundnuts, 78 percent sorghum) times the value of loss reduction between current operations and future operations with new facilities times the volume stored.

[4]Value of loss reduction due to replication of warehouse design (3,000-MT) beginning in project year 6, with one warehouse constructed per year, loss reduction of 9 percent per warehouse, with the value based on harvest-time market prices for sorghum.

TABLE 18

Preliminary Analysis
Private Sector Pilot Project

Investment Costs

(Ls)

3,000-MT bag warehouse	
Foreign exchange $200,000 x 2.2[1]	440,000
Local currency	633,500
	1,073,500
Engineering fee (7.5 percent)	80,513
	1,154,013
6,000-MT bag warehouse	
Foreign exchange $400,000 x 2.2[1]	880,000
Local currency	1,248,000
	2,128,000
Engineering fee (7.5 percent)	159,600
	2,287,600
2,000-MT bulk storage facility	
Foreign exchange $886,336 x 2.2[1]	1,949,939
Local currency	259,000
	2,208,939

[1]Open market rate.

TABLE 19

Preliminary Analysis
Private Sector Pilot Project

Operating Costs[1]

3,000-MT bag warehouse	
Variable costs	Ls per MT
Chemicals	2.60
Supplies	0.33
	2.93
Fixed costs	Ls per year
Salaries	3,570
Labor	1,260
Maintenance[2]	13,403
	18,233
Cost per year = 2.93 x MT stored + 18,233	
6,000-MT bag warehouse	
Variable costs	Ls per MT
Chemicals	2.60
Supplies	0.33
	2.93
Fixed costs	Ls per year
Salaries	7,140
Labor	2,520
Maintenance[2]	26,832
	33,492
Cost per year = 2.93 x MT stored + 33,492	
2,000-MT bulk storage facility	
Variable costs	Ls per MT
Chemicals	2.08
Supplies	0.22
Power	0.30
	2.60
Fixed costs	Ls per year
Salaries	3,570
Labor	1,260
Maintenance[3]	29,351
	34,181
Cost per year = 2.60 x MT stored + 34,181	

[1]Amortization for equipment and buildings not included in operational costs, to allow calculation of IRR.

[2]1.25 percent of construction cost, Table 17.

[3]10.0 percent of equipment cost, Appendix B.

FIGURE 7. Relationship between Turnover and Operational Cost

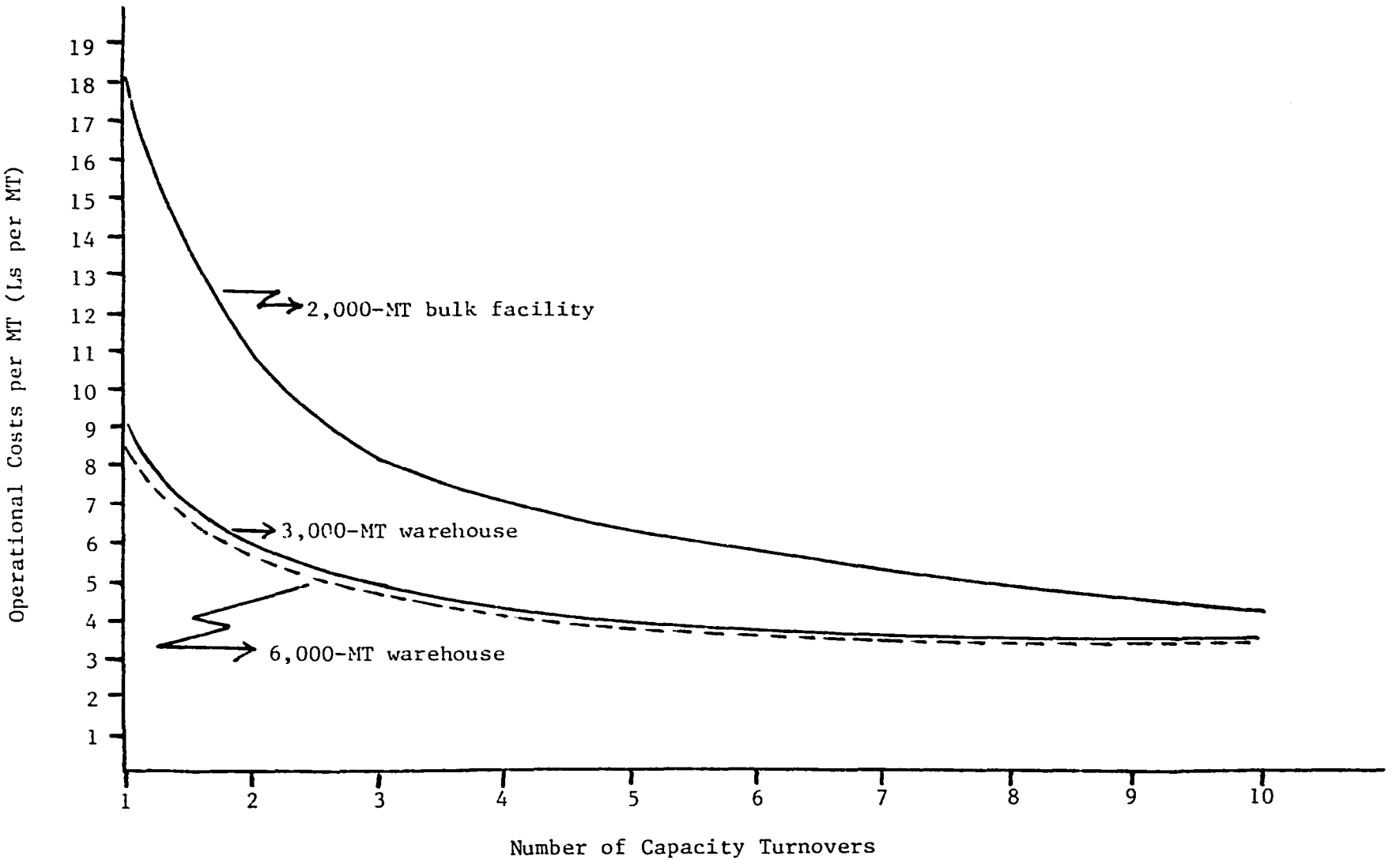

FIGURE 8. Relationship between Quantity Stored and Operational Cost

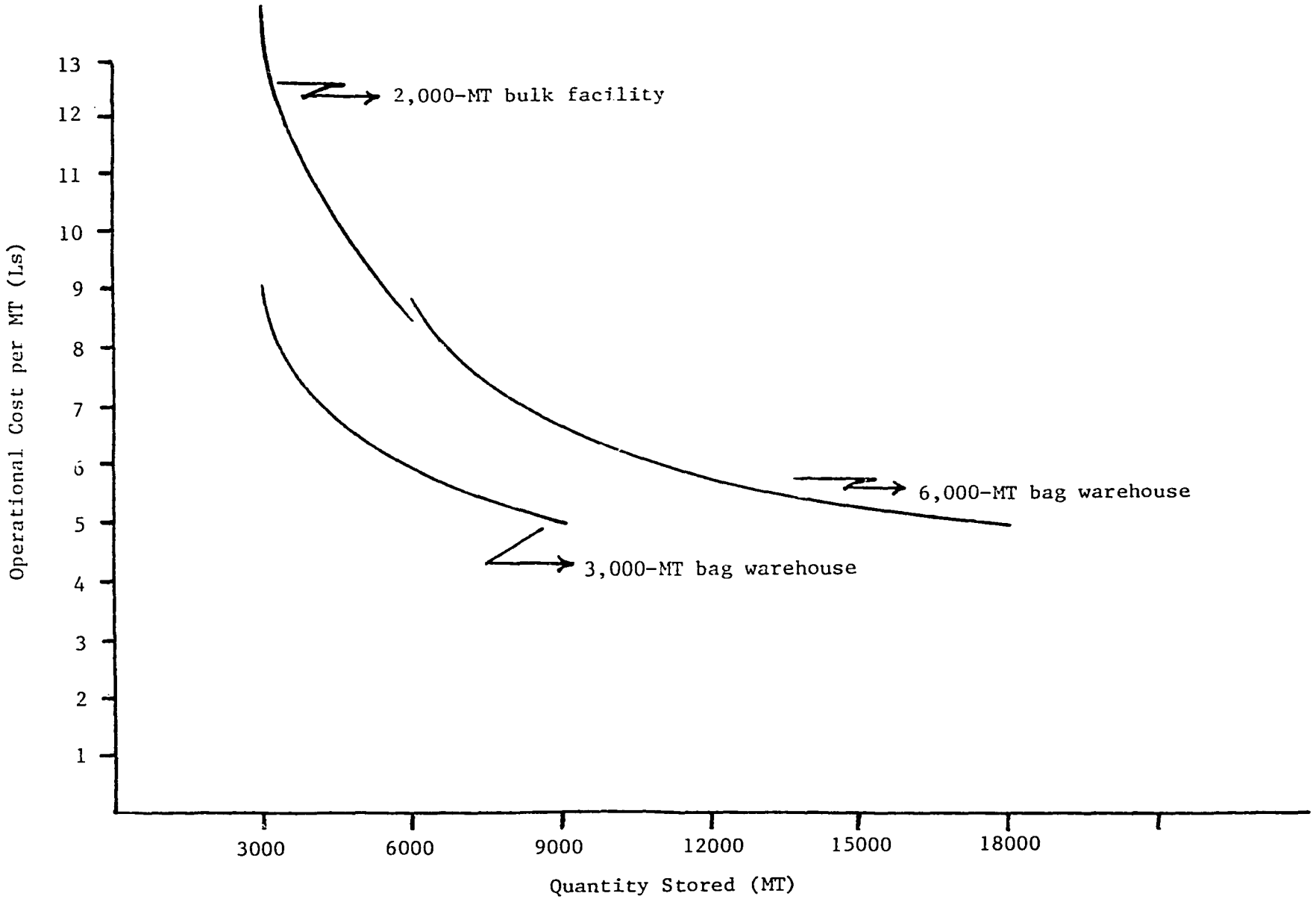

TABLE 20

Preliminary Analysis

Private Sector Pilot Project

Effect of Turnover on Operational Costs

Turnover Rate	Year: Cost per MT (Ls)	Year: Cost per Bag (Ls)	Month: Cost per Bag (p)
3,000-MT warehouse			
1.0	9.01	0.82	6.8
1.5	6.98	0.64	5.3
2.0	5.97	0.54	4.5
2.5	5.36	0.49	4.1
3.0	4.96	0.45	3.8
6,000-MT warehouse			
1.0	8.51	0.77	6.4
1.5	6.65	0.61	5.0
2.0	5.72	0.52	4.3
2.5	5.16	0.47	3.9
3.0	4.79	0.44	3.6
2,000-MT bulk facility			
1.0	19.69	1.79	14.9
1.5	13.99	1.27	10.6
2.0	11.15	1.01	8.4
2.5	9.44	0.86	7.1
3.0	8.30	0.75	6.3

storage facility, other benefits acquired are reduced handling costs and the ability to spread margins due to availability of storage. These latter benefits were not considered in the analysis of rates of return.

An analysis of rates of return is detailed in Table 21 by two ownership options and a lease option. For the bag warehouses, the results of the purchase options indicate that for cash sale, the internal rate of return (IRR) and the financial rate of return (FRR) may not be attractive to the private sector. In the case of financed sale, the FRR is almost zero. The major obstacle to financed purchases is the interest rate of 21.5 percent, which is substantially above the IRR. The FRR is nearly zero because there is no return to equity capital since all net income is being expended for interest costs. AID should take special note of the fact that high interest rates will tend to discourage development in the private sector. In the case of the lease option, attractive returns on gross revenue are generally indicated.

The bulk storage facility does not warrant further consideration for any of the possible options at this time. The IRR and FRR in the purchase options, and the returns to gross revenues in the lease option, reveal that this facility is not financially viable. Therefore, it is deleted from the project description and is replaced by a 3,000-MT bag warehouse unit. It should be recognized that the bulk storage pilot facility was originally considered as a facility minimally designed to test its technical and economic operations. The reason for its high cost is that it must be constructed by means of an external turnkey process.

In any event, as stated in Section IV, further information collection and economic and financial analysis must be done before presenting the options to the private sector.

Table 22 presents a breakdown of investment and operating costs for grain cleaner units. The cost of cleaning grain is calculated at 17.3 piastres per bag. No further analysis can be conducted since the foreign material percentages in grain and the premiums paid in the marketplace (in a normal year) for clean grain are unknown.

TABLE 21

Preliminary Analysis
Private Sector Pilot Project
Rates of Return

(Annual Percentage)

	Purchase Options[1]					
	3,000-MT Warehouse		6,000-MT Warehouse		2,000-MT Bulk Facility	
	Cash Purchase	Financed Purchase[2]	Cash Purchase	Financed Purchase[2]	Cash Purchase	Financed Purchase[2]
IRR[3]	17.7	17.7	18.0	18.0	2.8	2.8
FRR[4]	14.1	0.9	14.4	1.2	-1.3	N/C

	Lease Option[5]		
	3,000-MT Warehouse	6,000-MT Warehouse	2,000-MT Bulk Facility
Return on additional gross revenue[6]	34.0	35.0	-121.0
Return on additional gross revenue plus working capital release[7]	43.0	44.0	-44.0

[1]Net revenues are based on (1) turnover of 3 times per year of warehouse capacity, (2) defrayed rental costs at 15 piastres per bag per month, (3) 5.2 percent average weight and damaged kernel loss reduction at 30 Ls per bag cost value, (4) 5.2 percent loss reduction at 9 Ls per bag yearly average marketing margin, and (5) operating costs subtracted from gross revenues.

[2]Financed terms are 10 percent down payment, 30-year mortgage in equal installments at 21.5 percent annual rate of interest.

[3]The IRR measures the earning power of total capital investment, regardless of how the enterprise is financed and how earnings are distributed.

[4]The FRR measures the earning power of equity capital in the enterprise after payment of all amortization and interest.

[5]The lease rates are based on minimum 12 percent annual carrying charge for 30-year period.

[6]Net revenue from footnote 1 minus lease payments, divided by gross revenues. This can be construed as return on sales.

[7]Assume a 30-percent return on working capital release, where minimum working capital release is the 10-percent down payment in the above financed purchase option.

TABLE 22

Preliminary Analysis

Private-Sector Pilot Project

Grain Cleaners

Investment cost: $12,000 x 2.2 = Ls26,400

Life: 20 years

Maintenance costs: 10 percent of investment annually

Power: .746 KWH x .155 Ls per KWH + Ls per year

Capacity: 500 bushels per hour = 13.61 MT per hour

Operating Cost

	Ls per MT	Piastres per Bag
Labor	1.10	10
Power[1]	0.02	0.19
Maintenance	0.52	4.7
Amortization	0.26	2.4
	1.90	17.3

[1]Based on 3,000 MT annually.

APPENDIX D

DATA

TABLE 1

Unit of Measurement

1 sack of groundnuts (unshelled)	=	45 kg
1 sack of groundnuts (shelled)	=	73 kg
1 sack of millet	=	85 kg
1 sack of sesame	=	81 kg
1 sack of sorghum	=	85 kg
1 Ardeb	=	2 85-kg sacks
Kantar	=	45 kg
Ruba	=	14 lb
Feddan	=	4,200 m^2
Feddan	=	.42 ha or 1.038 acres
Muhammas	=	1.75 feddans
100 piastres	=	1 Sudanese pound

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TABLE 2

Sorghum

Kordofan Region

	Area (1,000 fd)			Yield (kg/fd)			Production (1,000 MT)		
	South	North	Total	South	North	Total	South	North	Total
1961-62			418			378			158
1962-63			481			356			171
1963-64			529			348			184
1964-65			486			325			153
1965-66			502			305			153
1966-67			389			211			82
1967-68			468			310			145
1968-69			484			233			113
1969-70			923			336			310
1970-71			936			250			234
1971-72			968			252			244
1972-73			1,048			191			200
1973-74			1,204			199			240
1974-75			978			268			263
1975-76	558	329	887	306	164	254	171	54	225
1976-77	550	631	1,181	304	144	256	211	91	302
1977-78	599	650	1,249	299	277	287	179	180	359
1978-79	616	600	1,216	326	300	313	201	180	381
1979-80	545	386	931	193	168	183	105	65	170
1980-81	623	450	1,073	295	189	251	184	85	269
1981-82	631	450	1,081	317	209	272	200	94	294
1982-83	894	448	1,342	299	56	218	267	25	292
1983-84	1,012	445	1,457	162	45	126	164	20	184

Source: Department of Statistics.

TABLE 3

Sorghum

South Kordofan

	Mechanized			Traditional			Total		
	Area	Yield	Production	Area	Yield	Production	Area	Yield	Production
1975-76	182	379	69	376	271	102	558	306	171
1976-77	209	440	92	341	350	119	550	304	211
1977-78	319	279	89	280	321	90	599	299	179
1978-79	231	299	69	385	343	132	616	326	201
1979-80	224	196	44	321	190	61	545	193	105
1080-81	273	381	104	350	229	80	623	295	184
1981-82	256	344	88	375	299	112	631	317	200
1982-83	524	258	135	370	357	132	894	299	267
1983-84	605	180	109	407	135	55	1,012	162	164

Source: Department of Statistics.

TABLE 4

Groundnuts

Kordofan Region

	Area (1,000 fd)			Yield (kg/fd)			Production (1,000 MT)		
	South	North	Total	South	North	Total	South	North	Total
1961-62			211			303			64
1962-63			232			358			83
1963-64			400			315			126
1964-65			243			333			81
1965-66			313			224			70
1966-67			356			244			84
1967-68			228			285			65
1968-69			214			215			46
1969-70			366			246			90
1970-71			290			172			50
1971-72			897			104			93
1972-73			858			101			87
1973-74			985			137			135
1974-75			706			327			231
1975-76	133	852	985	360	111	145	48	95	143
1976-77	108	448	556	398	275	299	43	123	166
1977-78	115	860	975	313	248	255	36	213	249
1978-79	102	740	842	353	270	280	36	200	236
1979-80	35	772	807	200	170	226	7	175	182
1980-81	50	750	800	300	300	313	15	225	250
1981-82	50	780	830	240	387	378	12	302	314
1982-83	20	562	582	250	109	113	5	61	66
1983-84	16	499	515	125	85	85	2	42	44

Source: Department of Statistics.

TABLE 5

Sesame

Kordofan Region

	Area (1,000 fd)			Yield (kg/fd)			Production (1,000 MT)		
	South	North	Total	South	North	Total	South	North	Total
1961-62			291			196			57
1962-63			279			151			42
1963-64			430			135			58
1964-65			227			163			37
1965-66			404			129			52
1966-67			449			94			42
1967-68			554			106			59
1968-69			464			71			33
1969-70			557			108			60
1970-71			1,180			148			175
1971-72			1,117			139			99
1972-73			1,891			95			180
1973-74			1,064			72			78
1974-75			1,091			83			92
1975-76	136	951	1,087	132	74	82	18	71	89
1976-77	80	900	980	125	70	74	10	63	73
1977-78	55	950	1,005	110	74	76	6	70	76
1978-79	110	900	1,010	128	77	83	14	70	84
1979-80	75	724	799	147	83	89	11	60	71
1980-81	100	725	825	120	83	87	12	60	72
1981-82	105	798	903	133	97	93	14	70	84
1982-83	150	675	825	93	60	67	14	41	55
1983-84	180	695	875	120	40	57	22	28	50

Source: Department of Statistics.

TABLE 6

Estimates of Sorghum Production for Traditional and Mechanized Sectors

(Number of Bags)

	Area							
Year	Kadugli	Talodi	Kologi	Dilling	Lagawa	Abu Gubeiha	El Abbasia	Um Rumbita
1975-76	101,716	38,753	38,937	38,752	21,982	42,941	58,516	36,341
1976-77	96,876	39,508	37,295	10,166	23,200	41,128	48,466	37,633
1977-78	69,721	26,003	37,051	20,193	25,464	34,305	40,521	33,781
1978-79	91,291	23,780	41,965	20,088	21,500	49,160	58,224	36,864
1979-80	92,855	21,421	29,821	38,733	31,500	39,779	37,521	17,130

Source: Nuba Mountain Corporation.

TABLE 7

Production by Administrative Division

Year	Sorghum Area (fd)	Sorghum Production (MT)	Sorghum Yield (MT/fd)	Millet Area (fd)	Millet Production (MT)	Millet Yield (MT/fd)	Groundnut Area (fd)	Groundnut Production (MT)	Groundnut Yield (MT/fd)	Sesame Area (fd)	Sesame Production (MT)	Sesame Yield (MT/fd)
El Obeid												
1982-83	58,124	2,386	.041	99,513	2,786	.028	16,743	804	.048	96,346	1,784	.019
1983-84	65,266	2,154	.033	115,392	3,155	.027	17,156	635	.037	109,108	3,382	.031
Bara												
1982-83	-	-	-	295,958	16,870	.053	-	-	-	181,201	3,230	.018
1983-84	-	-	-	268,803	6,720	.025	-	-	-	182,632	4,748	.026
Um Ruwaba												
1982-83	126,179	11,037	.087	55,893	2,718	.049	15,179	638	.042	280,643	9,122	.032
1983-84	134,829	9,303	.069	54,561	3,274	.060	15,009	420	.028	305,077	15,252	.050
En Nahud												
1982-83	264,111	11,688	.044	646,236	33,604	.052	530,351	59,283	.112	116,667	3,410	.029
1983-84	244,776	8,562	.035	761,440	54,062	.071	466,456	41,328	.089	98,102	4,415	.045

Source: Economic Division, Kordofan Region Ministry of Agriculture, El Obeid.

TABLE 8

Storage and Financing

El Obeid ABS Branch Office

Year	Number of Cooperatives	Number of Bags Stored: Sorghum (Mechanized Only)	Sesame	Groundnut	Area (Muhammas)
1980-81	3	7,533	-	-	1,328
1981-82	11	3,433	1,457	1,593	5,978
1982-83	12	1,449	1,599	154	13,320
1983-84	20	75	2,074	321	20,653

Source: ABS, El Obeid Branch Office.

TABLE 9

Storage and Financing

Dilling ABS Branch Office

Year	Number of Mechanized Schemes	Area (fd)	Estimated Production (bags)	Number of Bags Stored
		Mechanized		
1979-80	180	177,784	414,519	84,133
1980-81	219	195,666	408,816	52,088
1981-82	251	180,320	407,350	51,492
1982-83	200	200,000	510,000	118,252
1983-84	206	195,064	147,769	48,395
		Cooperatives		
1979-80	11	8,800	13,200	-
1980-81	11	6,350	18,700	1,100
1981-82	12	9,600	13,800	-
1982-83	12	13,000	19,500	4,256
1983-84	9	8,400	4,200	-

Source: ABS Dilling Branch Office.

TABLE 10

Storage and Financing

Um Ruwaba ABS Branch Office

Year	Number of Cooperatives	Number of Bags Stored		
		Sorghum	Sesame	Groundnut
1977-78	2	-	900	962
1978-79	5	-	3,565	5,547
1979-80	6	-	1,670	2,876
1980-81	17	-	3,976	1,166
1981-82	28	13,523*	10,719	11,717
1982-83	17	15,903*	5,676	554
1983-84	26	1,900	6,915	201

*Received from Habila.

Year	Area Financed	
	Sesame	Groundnut
	(Muhammas)	
1977-78	4,975	621
1978-79	7,321	939
1979-80	8,971	1,967
1980-81	16,101	4,883
1981-82	23,532	6,562
1982-83	17,364	1,664
1983-84	27,918	163

Source: ABS Um Ruwaba Branch Office.

TABLE 11

Average Monthly Prices

El Obeid Market

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
	Marketing Year											
	Sesame (Ls per Kantar)											
1979-80	-	-	12.5	12.0	11.3	11.8	11.9	11.8	11.2	11.2	11.5	14.2
1980-81	15.0	18.9	20.4	20.5	21.6	21.6	21.9	21.9	22.2	-	-	17.8
1981-82	17.5	17.3	18.2	20.8	20.2	19.9	19.4	19.4	20.1	23.3	24.2	26.3
1982-83	32.7	34.9	35.0	36.7	39.4	38.9	40.4	41.8	40.2	39.4	-	-
1983-84	43.7	41.5	41.5	44.6	43.5							
	Groundnuts (Ls per Kantar)											
1979-80	-	-	4.5	4.7	4.8	4.7	4.6	4.9	4.9	5.0	4.9	5.9
1980-81	11.7	17.3	19.2	16.3	17.4	16.7	16.4	12.5	9.0	-	-	9.6
1981-82	7.5	8.6	8.9	9.9	10.0	10.3	9.5	9.1	10.4	10.5	12.0	12.6
1982-83	15.2	16.4	18.1	19.5	19.3	20.2	20.0	19.0	19.3	23.6	-	-
1983-84	24.1	21.1	20.7	21.6	21.7							
	Sorghum (Feterita) (Ls per Ardeb)											
1977-78	-	-	-	-	15.4	15.7	17.2	17.5	-	-	-	-
1978-79	-	-	14.5	12.2	13.4	12.9	12.6	11.3	12.4	13.3	12.9	11.9
1979-80	12.9	13.0	16.7	20.1	20.2	21.4	-	-	-	-	-	-
1980-81	-	-	17.3	18.9	18.2	18.5	18.5	25.9	28.0	27.1	28.0	28.0
1981-82	-	34.5	36.1	37.4	36.7	35.4	35.0	35.0	35.0	-	-	35.9
1982-83	-	-	-	-	-	-	46.1	47.4	47.8	48.0	47.0	50.2
1983-84	-	62.3	61.7	61.8								

Sources: Ahmed Humeida Ahmed Ali
Louis Berger International, Inc.
Russell Gregg

Raw data files, Department of Statistics, Ministry of Agriculture, Khartoum.

TABLE 12

Price and Quantities

El Obeid Market

Year	Quantity in the Market (Kantars)	Highest Price	Lowest Price	Average Price
		(Ls per Kantar)		
		Sesame		
1973-74	103,181	6.290	3.00	5.880
1974-75	214,579	5.845	4.00	5.56
1975-76	159,518	6.040	4.00	5.3
1976-77	186,716	6.770	4.00	6.4
1977-78	106,201	7.170	4.50	6.9
1978-79	118,581	13.280	6.50	9.987
1979-80	40,174	-	-	12.982
1980-81	66,449	-	-	18.5
1981-82	104,340	-	-	22.0
1982-83	63,235	-	-	32.9
		Groundnuts		
1973-74	124,022	4.45	3.71	4.07
1974-75	171,981	3.76	2.79	3.058
1975-76	234,998	4.15	3.2	3.45
1976-77	103,674	4.50	3.27	3.7
1977-78	74,826	5.0	3.5	4.5
1978-79	89,605	6.0	3.25	5.262
1979-80	87,888	-	-	5.48
1980-81	158,285	-	-	15.0
1981-82	143,248	-	-	9.0
1982-83	181,961	-	-	16.2

Source: Department of Statistics, Kordofan Ministry of Agriculture.

TABLE 13

Monthly Average Sesame Prices

El Gedarif Market

(Ls per Kantar)

Month	Marketing Year 1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
Nov		2.290	2.600	2.840	3.420	5.560	5.023	5.254	5.115
Dec		2.250	2.520	2.930	4.200	5.560	5.121	5.775	5.115
Jan	2.896	2.240	2.520	2.850	4.580	5.140	5.170	5.265	
Feb	2.995	2.350	2.700	2.930	4.900	5.260	5.150	5.375	
Mar	2.950	2.490	2.690	2.620	4.550	5.200	5.000	5.295	
Apr	2.690	2.560	2.700	2.890	4.280	5.250	5.950	5.281	
May	2.950	2.550	2.640	2.910	4.280	5.250	4.950	6.173	
June	2.950	2.840	2.600	2.900	4.220	5.250	4.950	5.115	
July	2.850	2.840	2.600	2.900	4.150	5.250	4.950	5.115	
Aug	2.220	2.840	2.600	2.900	4.200	5.250	4.950	5.115	
Sep	2.200	2.840	2.600	2.900	5.800	5.250	4.950	5.115	
Oct	2.190	2.600	2.800	3.540	5.560	5.250	5.015	5.115	

Source: Raw data files, Department of Statistics, Ministry of Agriculture, Khartoum.

TABLE 14

Monthly Average Sorghum (Feterita) Prices

El Gedarif Market

(Ls per Ardeb)

Month	Marketing Year 1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
Nov		2.248	2.478	1.764	2.520	4.263	5.460	5.830	6.200
Dec		2.210	1.953	1.911	3.738	4.263	5.460	5.830	6.200
Jan	3.170	2.520	2.142	1.985	3.906	5.460	5.460	5.460	
Feb	3.340	2.626	2.520	1.985	4.242	5.460	5.460	5.460	
Mar	3.340	2.826	1.890	1.985	4.284	5.460	5.830	5.460	
Apr	3.340	2.714	1.848	2.520	4.263	5.460	5.830	5.460	
May	3.340	2.520	1.785	2.520	4.263	5.460	5.830	5.460	
June	3.340	2.478	1.764	2.520	4.263	5.460	5.830	5.460	
July	3.340	2.478	1.764	2.520	4.263	5.460	5.830	5.460	
Aug	3.340	2.478	1.764	2.520	4.263	5.460	5.830	5.460	
Sep	3.340	2.478	1.764	2.520	4.263	5.460	5.830	5.460	
Oct	3.340	2.478	1.764	2.520	4.263	5.460	5.830	6.200	

Source: Raw data files, Department of Statistics, Ministry of Agriculture, Khartoum.

APPENDIX E

REFERENCES

Abdalla, A.M., Investigation of Grain Storage in Underground Pits, National Grain Storage Seminar - Sudan, November 1982.

Abdalla, A.M., Investigations on Grain Storage in Sheet Metal Bins Under the Climatic Conditions of North Central Sudan, National Grain Storage Seminar - Sudan, November 1982.

Abdel Rahan A. Elagib and Mustafa A. Hummeida, Appropriate Technology for Grain Storage Structures in the Sudan (A Review), National Grain Storage Seminar - Sudan, November 1982.

Agriculture Bank of Sudan, Note on ABS Crop Handling and Storage Project.

Agriculture Bank of Sudan, Board of Directors' Report and Balance Sheet for the Year ended 31st December 1980, Monitoring and Evaluation Department, Agriculture Bank of Sudan, December 1981.

Ahmed Hummeida Ahmed Ali, Agriculture Finance and Credit in the Sudan, Research Bulleting No. 33, Department of Rural Economy, Faculty of Agriculture, University of Khartoum, February 1984.

Ahmed Hummeida Ahmed Ali and Mohamed Mirgani Alsalam, Price Policy and Production of Sorghum (Dura) in Sudan, Research Bulleting No. 34, Department of Rural Economy, Faculty of Agriculture, University of Khartoum, February 1984.

Baker, A. A., A Review of Grain Storage Practices and Losses in the Northern and Western Regions of the Sudan, National Grain Storage Seminar - Sudan, November 1982.

Bashir Omer Mohamed Fadalla, et al., A Rural Credit Institution for Kordofan Region, Kordofan Regional Ministry of Economics and Finance, September 1982.

China National Complete Plant Export Corporation, Report on the Feasibility Study of Establishing Grain Stores, July 1982.

Department of Statistics, Area, Yield, and Production, 9 Major Crops, Sudan, 1961/62 - 1983/84, Planning and Agriculture Economics Administration, Ministry of Agriculture, Khartoum 1984.

El Khidir, E., A study of Sack Storage in Different types of Stores in Gedarif Area, National Grain Storage Seminar - Sudan, November 1982.

El Khidir, E., A Survey of Grain Storage Practices and Losses in Sudan, National Grain Storage Seminar - Sudan, November 1982.

El Zaki and I. A. Abbasher, The Marketing and Storage of Grain as Executed by the Agricultural Bank of Sudan, National Grain Storage Seminar - Sudan, November 1982.

Gregg, Russel B. and Ahmed Hummeida Ahmed Ali, Western Sudan Kordofan Region Agricultural Credit Study, Checchi and Company, December 1983.

Itto, Anne, Report on a Survey of Local Storage Systems and Their Pests, National Grain Storage Seminar - Sudan, November 1982.

Louis Berger International, Inc., Sudan, Kordofan Region Agricultural Marketing and Transport Study, March 1983.

Obermeyer Project, Management GmbH, Grain Storage Study, Sudan, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), May 1983.

Omer El Farouk Abbelaziz, Production and Marketing of Food Grains in the Sudan with Particular Reference to Sorghum, National Grain Storage Seminar - Sudan, November 1982.

Reeves, Edward B. and Timothy Frankenberger, Socio-Economic Constraints to the Production, Distribution, and Consumption of Millet, Sorghum, and Cash Crops in North Kordofan, Sudan, Report No. 1, Intsormil, November 1981.

Reeves, Edward B. and Timothy Frankenberger, Farming Systems Research in North Kordofan, Sudan, Report No. 2, Intsormil, November 1982.

Reeves, Edward B., Marketing in Farming Systems Research: Roles of Village Shopkeepers in North Kordofan, Sudan, Intsormil, May 1983.

USAID, Kordofan Rainfed Agriculture Project (650-0054), Project Identification Document, May 1984.

Yousif, Ismail and Mirghani Hamza, A Study of Establishing Grain Stores, National Grain Storage Seminar - Sudan, November 1982.