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Evaluation of

Proposed "Rural Family Grain Storage Project"

By CARE In Chad

FOOD & FEED GRAIN INSTITUTE
KANSAS STATE UNIVERSITY

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Author: Dr. Do Sup Chung, Associate Professor, Kansas State University.

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SUMMARY STATEMENT

The objectives of the TDY service in Chad were to review and evaluate the "Rural Family Grain Storage Project" proposed by CARE/Chad and to provide recommendations for the course of action to be taken by USAID/Chad and USAID/Washington.

The report deals with a brief review of farm or village structures and situations in Chad, and, technical and economical evaluations of the proposed project.

Based on the overall review, and technical and economical evaluations of the proposed project, the following recommendations are made: (1) an immediate funding of the project with the provision that the project evaluation be made at the end of the first and second year of the project's implementation; (2) participation of the four Chadians in the USAID sponsored short course on Grain Storage and Marketing to be held at Kansas State University; (3) preparation of an instructional manual for the proposed silo by CARE/Chad with technical input from the Food and Feed Grain Institute, Kansas State University; and (4) purchase of various equipment and devices for monitoring grain quality changes, and periodic inspections of grain quality changes under the proposed silos at several selected sites.

EVALUATION OF PROPOSED "RURAL FAMILY GRAIN STORAGE" BY CARE IN CHAD

by

Dr. Do Sup Chung
Department of Agricultural Engineering
Kansas State University

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and Agribusiness Development

at the
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Kansas State University
Manhattan, Kansas 66506

Dr. C. W. Deyoe, Acting Director
Dr. Leonard W. Schruben, Associate Director

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PREFACE

Objectives of the TDY service in Chad are:

1. To review and evaluate the "Rural Family Grain Storage Project" proposed by CARE/Chad (O.P.G.) which was submitted to USAID/Chad.
2. To provide recommendations for the course of action to be taken by USAID/Chad and USAID/Washington.

This report deals with a brief review of farm or village structures and situations in Chad, a review and evaluation of Rural Family Grain Storage Project Proposal by CARE/Chad and finally, recommendations for the course of action to be taken by USAID/Chad and USAID/Washington.

The author acknowledges with gratitude the generous assistance of Mr. Peter Reitz, Director of CARE/Chad, and his staff for information regarding on-farm grain storage situations in Chad during the 1 week stay in Chad.

Also sincere appreciation is expressed to Mr. Raymond Fontaine, USAID/Chad for his assistance and cooperation.

BRIEF REVIEW OF FARM OR VILLAGE STRUCTURES AND SITUATIONS

The total area of Chad is about 495,700 square miles (Mi^2), occupied by about 4.0 million people. Chad can be divided into four climatic zones: Tropical Zone of about 50,000 Mi^2, occupied by about 41 percent of the total population; Sahelian Zone of about 96,000 Mi^2, occupied by about 45 percent of the population; Sub-Desert Zone covering some 350,000 Mi^2, occupied by about 12 percent of the population; and the Desert Zone covering nearly half of Chad's land surface with a population of less than 100,000. Meteorological data of a few selected locations in Chad are shown in Table 1.

It should be noted that there are more than 9,000 villages in Chad with an average of 260 people per village. Nearly two-thirds of the population live in villages of less than 200 people and less than one-third live in villages ranging from 200 to 1,000 people. Only 4 percent of the people in the Tropical Zone and less than 1 percent of those in the Sahelian Zone live in settlements of more than 1,000 people. Each village is a cluster of several extended farm families and an average farm family consists of six persons.

Cereal grains produced in Chad are grain sorghum, millet, corn, rice and wheat. Among them, grain sorghum and millet are by far the most important crop in Chad with respect to the total production and consumption for dietary requirements of the major portion of the population. The average per capita consumption of sorghum and millet is estimated at 250 Kg/year for food and beer.

It was estimated that over 80 percent of the population are subsistence farm families whose average land holdings are about 2 hectares. Therefore, a significant part of the total harvested grains is stored and consumed on the farms. It is reported that the current average sorghum or millet yield is 750 Kg/hectare. Thus, the average total production for each farm family

TABLE 1. METEOROLOGICAL DATA

N'DJAMENA (Sahelian Zone)

	Temperature, °C		R.H., %		Rainfall	
Month	Min.	Max.	Min.	Max.	mm	Days
Jan	13.5	33.2	11	62	0	0
Feb	15.8	35.8	8	54	0.1	0.1
Mar	20.3	39.0	9	48	0.2	0.1
Apr	24.3	40.5	12	55	7.2	1.4
May	25.2	40.2	20	68	31.2	5.0
Jun	24.0	46.8	29	79	62.2	8.0
Jul	22.8	33.3	45	88	154.0	13.0
Aug	21.4	30.7	58	93	237.3	17.7
Sep	22.4	32.9	49	92	99.1	10.2
Oct	21.3	36.3	26	85	20.7	2.7
Nov	17.4	35.9	14	68	0.4	0.1
Dec	14.1	34.3	12	64	0.1	0.1

D'ATI (Sahelian Zone)

	Temperature, °C		R.H., %		Rainfall	
Month	Min.	Max.	Min.	Max.	mm	Days
Jan	14.1	33.7	15	39	0	0
Feb	16.4	36.3	13	32	0.1	0
Mar	21.1	40.0	12	30	1.7	0.3
Apr	24.4	41.4	15	39	19.4	3.0
May	25.5	41.4	19	50	65.7	6.5
Jun	25.8	38.9	27	67	124.5	8.6
Jul	24.0	35.0	42	83	195.0	12.4
Aug	22.6	31.6	54	92	279.8	14.9
Sep	22.8	33.9	42	89	156.6	10.2
Oct	21.5	37.9	17	65	32.5	3.4
Nov	18.3	36.9	17	41	0	0
Dec	15.4	32.1	14	53	0	0

TABLE 1 - Continued

BOL-BERIM (Sahelian Zone)

Month	Temperature, °C Min.	Max.	R.H., % Min.	Max.	Rainfall mm	Days
Jan	13.6	30.5	14	53	0	0
Feb	15.8	33.8	11	45	0	0
Mar	19.8	35.2	9	46	0	0
Apr	23.8	39.4	12	59	0.1	0.2
May	25.3	38.6	21	72	6.9	0.7
Jun	26.0	36.8	26	82	10.8	2.0
Jul	25.5	33.7	42	89	64.9	6.1
Aug	23.1	32.0	53	94	153.9	10.8
Sep	24.4	33.9	42	94	47.6	5.5
Oct	21.9	37.1	18	72	4.5	0.5
Nov	17.8	34.7	14	56	0	0
Dec	15.4	32.1	14	53	0	0

MOUNDOU (Tropical Zone)

Month	Temperature, °C Min.	Max.	R.H., % Min.	Max.	Rainfall mm	Days
Jan	14.7	34.4	14	64	0	0
Feb	17.7	37.4	11	49	0.4	0.1
Mar	22.1	39.1	15	54	8.3	1.5
Apr	23.8	37.8	29	79	47.5	5.3
May	23.2	34.9	41	86	113.9	8.7
Jun	21.9	32.4	51	93	162.4	11.0
Jul	21.3	30.3	59	96	248.0	15.4
Aug	21.1	29.7	61	97	298.5	18.1
Sep	20.8	30.4	49	97	234.8	15.6
Oct	21.1	32.6	47	94	89.0	8.2
Nov	17.9	34.8	26	80	3.9	0.7
Dec	14.7	34.4	18	78	0.1	0.1

is considered to be 1.5 tons annually. Sorghum and millet produced in 1969-70 (normal year) was officially estimated at about 651,000 tons. In the drought year 1971-72, the production fell to 600,000 tons. The total domestic supplies were inadequate for the total domestic needs, and continued shipment of food grains by foreign aid agencies has been needed. The Sahelian Zone in Chad is considered to be a chronical food grain shortage area while the Tropical Zone is a surplus area.

Grain sorghum and millet are generally harvested during the months of September and October in the Sahelian and Sub-desert Zones. In the Tropical Zone they are harvested during the months of October and November. Cereal crops in Chad are harvested completely by hand. Sorghum or millet heads are cut from plants and dried gradually in storage by a natural sun-drying method. Just prior to consuming or marketing, sorghum or millet heads are threshed on mats on the ground by beating with sticks or by walking back and forth over the grain. All crops harvested are stored on the farms at some time whether they are destined eventually for sales or for on-farm consumption. The storage period of grains, intended for sales, may vary from a few days to a few months but in most cases the farmer sells his crops at the time of harvest.

Food crops, such as millet and sorghum, are stored on the farm or in the village under various forms of storage, generally for periods up to 9 months. The different types and sizes of traditional storage units are constructed from locally available materials such as mud, sticks, trees, straw, cow dung, stalks, poles and gourds. The storage methods range from all types of open storage to thatch or clay/stalk storage. Containers are stored on raised, wooden platforms and small baskets or pots are stored in the family dwelling.

All storage methods used at farm or village level leave grain supply vulnerable to insect, rodent and bird infestation and, in some areas where high temperatures and humidities exist, to deterioration due to molds. Loss estimates for stored grains are cited anywhere from 5 to 40 percent. CARE/Chad estimates 20 to 30 percent loss. Limited observation in Chad leads the author to believe that an estimated 20 percent post-harvest loss of grain quantity and quality might be a reasonable figure. It should be pointed out that these figures are estimates and no documented studies are available to show the actual extent of grain quantity and quality losses in Chad.

The farmers may be aware of the physical losses but probably are not aware or concerned with the biochemical changes which occur in grain stored under adverse conditions which reduce the nutritional quality of the grain as a food for humans. Some grain losses result from the lack of understanding of grain storage fundamentals (grain moisture, temperature, humidity and condition of grain relationships) and of the proper management practices necessary to maintain the grain.

It should be emphasized that cereal grain quality loss is equally, if not more, important as grain quantity loss for subsistence farm families because their dietary requirements are mainly derived from cereal grains. Sorghum and millet loss, with respect to nutritional values due to inadequate and improper storage methods, undoubtedly attributes to a poor state of health and inadequate child growth in subsistence farm families. Although definite conclusions cannot be drawn from my brief observation, several cases of abnormal child growth and children in a poor state of health were witnessed in several villages.

It is reported that because of low yields, inadequate storage facilities and grain losses by various pests during storage, many farmers do not produce an adequate surplus of grain to carry them over the last 2 or 3 months before the next harvest. In poor years during this period of almost universal shortage known as the "Soudure", entire villages occasionally go hungry and grain prices in the towns are often prohibitive for the poor.

It is evident from limited review and observation in Chad that the introduction of reasonably low cost storage facilities and storage practices for subsistence farmers' use, especially in the Sahelian Zone, is not only a noble venture but also a practical solution in order to reduce food grain losses and also to possibly increase the income of the farmers.

REVIEW OF RURAL FAMILY GRAIN STORAGE PROJECT BY CARE/CHAD

To alleviate some of the storage problems of subsistence farm families in Chad, CARE/Chad had been experimenting with a few improved storage facilities and existing village level construction technology by utilizing local materials for the last several years. The results of experiments showed that a more durable base or footing for storage units is essential in order for the storage unit to last longer, to have fewer maintenance problems and better grain quality preservation. Photos of experimental storage models tested are shown in Figures 1 through 4 in the Appendix.

Based on CARE/Chad's studies on the improved rural family grain storage facilities and also recognizing an urgent need for improved storage methods which would reduce grain storage losses for subsistence farm families in Chad, the following rural family grain storage project proposal was submitted to USAID/Washington and USAID/Chad for financial assistance in August, 1975:

I. Project Purpose

The purpose of the project is to establish a replicable system of low-cost grain storage facilities at the village level. The project is designed to promote and make maximum use of existing village level construction technology with improvements to the footings and platforms which are made of reinforced concrete to assure that the facilities will last at least 15 years with only a minimum amount of maintenance.

II. Expected Benefits or Outputs of the Project

a) "Protect their stored crops from insects, birds and rodents and reduce losses equivalent of up to 20 percent of the entire crop yield.

b) Increase the food supply available to each participating rural family by up to 20 percent.

c) Increase the food supply of the village and adjacent areas by the amount saved from destruction by insects, which is not sold elsewhere or consumed by the family itself.

d) Increase the income of the rural family participating in the project by a percentage which will vary in accordance with seasonal price fluctuations, the length of time the grain is stored, and the amount of grain which is sold.

e) Encourage villagers to apply their existing technology to construct a semi-permanent grain storage facility."

III. The Proposed Grain Storage Facility

a) Unit capacity: 8 ton (bulk storage)

b) Number of families for each silo: four families of an average size of six members each.

c) Overall silo dimensions given in the proposal:

1. 2 meters circumference and 2.5 meters in height (clay pot).
2. The legs are sunk 80 cm into the ground and 40 cm above the ground (reinforced concrete).
3. The base plate is 10 cm thick (reinforced concrete).
4. Straw cover for the top opening and clay pot.

d) Material, labor and cost for a silo given in the proposal:

Item	Cost U.S.$
1. Steel rods, 5 mm thickness 0.55 m^3/silo-cost: $82.5/$m^3$	$ 45.38
2. Cement, 9 sacks/silo-40kg/sack @ $13.75/sack	123.75

3.	Wood for forms, plaster, binding chemical	44.00
4.	Specialized labor ($143/silo) 82.50 for mud jar 62.50 for concrete work	143.00
5.	Transportation from N'Djamena to villages (fuel, etc.)	28.88
	TOTAL	$ 385.01

It should be noted that there are obvious errors in the overall silo dimensions given in the original proposal. It yields only 0.57 ton capacity. The original silo design was revised and checked by an engineer. The revised silo design, materials and labor costs are given below:

e) Revised overall silo dimensions:

1. 3m-inside deameter, 2.5m-height (base plate to the top of manhole) and 5cm-thickness, clay pot.
2. The legs are sunk 30 cm into the ground and 30 cm above the ground - seven legs (reinforced concrete).
3. The base plate is 10 cm thick (reinforced concrete).
4. Straw cover.

Detailed design plans are shown in Appendix Figures 5 and 6.

f) Revised bill of materials given by CARE/Chad:

Item				Cost U.S.$
1. Steel rods, 6mm dia. $0.45/m.				
	Quantity	Unit length m	Total length m	
a.	2	2.9	5.8	
b.	4	2.8	11.2	
c.	4	2.65	10.6	
d.	4	2.30	9.2	
e.	4	1.70	6.8	
f.	1	9.30	9.3	
g.	28	0.45	12.6	
h.	14	0.75	10.5	
			76.0	34.00

2.	Cement, 8 bags @ \$12.5/bag	100.00
3.	Sand, 1 m^3 @ \$12.0/m^3	12.00
4.	Gravel, 0.6 m^3 @ \$50/m^3	30.00
5.	Straw -	
6.	Ant Hill -	
7.	Cow Dung -	164.00
8.	Labor -	
	TOTAL	\$ 340.00

It should be noted that unit cost of constructing the proposed silo, \$340, did not include the transportation cost (\$30) and the cost of a ladder needed for loading and unloading the grain (\$20). Therefore, the actual unit cost per silo should be \$390 rather than \$340.

g) Total time required to construct a silo:

The total time required to acquire all the necessary materials, labor, including transportation, site preparation, straw work, concrete mixing and clay work is estimated to be about 3 weeks. The following are approximate times required for various construction phases:

Site preparation, footing and floor (concrete work)	1 day
Preparation and construction of clay jar	19 days
Straw cover	5 days

Photos depicting various phases of construction of the proposed silo are shown in the Appendix figures 7 through 16.

h) Expected life of silo:

Footing and Base	:	15 years
Clay Jar	:	8-10 years with a minor repair every 3 years
Straw cover	:	3 years

IV. Duration of the Proposed Project: 4 years.

V. Targets for the Project.

CARE/Chad has originally proposed the construction of 800 silos, total capacity of 6,400 tons, for the next 4 years. These will benefit 3,200 rural farm families each with an average of 6 people or a total of 19,000 people. Construction of 200 silos, each with an 8 ton capacity which would be used by four families of six members will be made each year for the next 4 years.

However, the plan has been revised to serve five families instead of four families in the original plan by each 8 ton silo. Therefore, the total number of farm families benefiting from the proposed project will be 4,000 or a total of 24,000 people.

VI. Project Design and Implementation.

a) Beneficiary selection processes - The selection of the beneficiaries will be made jointly by CARE/Chad and the Ministry of Territorial Management and Environment. The following factors will be considered for selecting beneficiaries:

1. The characteristics of the farmers to be served and the nature of their needs.
2. The resources available to these farmers.
3. The extent to which various infrastructures exist - agricultural extension agents, input supplies, transportation, etc.

4. Current food storage practices.
5. Kinds and degrees of crop losses - insects, birds, rodents.
6. State of development of the area and level of construction skills at village level.

The project is designed to reach the less affluent but progressive small farmers who really do need the help, especially in the Sahelian zone. The current plan is to construct about three-fourths of the total silos (800 silos) in the villages in the Sahelian zone and one-fourth of the total silos in the Tropical zone.

A sample questionnaire that is used for selecting beneficiaries is included in the Appendix. It should be noted that about half of the beneficiaries of the proposed project were already identified but not verified yet by CARE/Chad and Rural Agriculture Development Fund (FDAR). Recently, FDAR has requested CARE/Chad to construct the proposed silo at 20 selected Agriculture Professional Training Centers in Chad for future extension efforts and for encouraging village farmers to adopt such systems.

VII. Personnel

The staff personnel who will supervise construction of silos and administer the proposed project are:

a) CARE/Chad

1. Country Director - 0.1 time.
2. International Field Representative - 0.75 time
3. National Staff (Field Inspector) - 1.0 time
4. Bookkeeper (local employee) - 0.5 time.

b) FDAR

1. Deputy Director

2. Extension Agent - 0.6 time

3. Driver

VIII. Budget [1/]

a) The total cost of the proposed project from all funding sources: $568,409.

b) Inputs and percentages of inputs:

USAID (requested) - $466,000 - 82 percent.

CARE (Committed) - 76,072 - 13 percent.

GOC (Committed) - 26,337 - 5 percent.

c) Cost per silo:

800 silos with a capacity of 6,400 tons.

Cost/silo (construction cost only) - $385

Cost/ton (construction cost only) - $ 48/ton

Cost/silo (including all overhead costs) - $710

Cost/ton (including all overhead costs) - $ 89/Ton

d) Cost per direct beneficiary:

3,200 farmers Cost per farmer $177

19,200 total beneficiaries Cost per beneficiary $30

1/ Note that budgets shown above are taken from the original proposal. Therefore, the figures in the budget will be slightly changed after the revised construction costs and the revised number of beneficiaries are considered.

It should be noted that the submitted proposal was strongly endorsed by the Government of Chad. If the project is funded by USAID initially, all of the silos will be built using the construction methods indicated in the proposal. However, during the life of the project, different designs and adaptations will be used in those villages where the silo proposed is not fully accepted, or when new methods of construction become more expedient.

EVALUATION OF CARE/CHAD RURAL GRAIN STORAGE PROJECT

I. Overall Evaluation

It is a well recognized fact that a substantial proportion of food grain production in Chad is lost every year during the post-harvest period at the farm or village level, due to improper and inadequate post-harvest storage methods. In addition to the quantity of grain lost, it is believed that considerable food grain quality loss is experienced in Chad. This is of vital importance to the subsistence level families (about 80 percent of the total population) because their daily nutritional requirements are extracted mainly from cereal grains.

Therefore, as the CARE/Chad rural storage project proposal stated, "The significance of proper farm or village level storage units cannot be overemphasized. It is the subsistence farm families' food supply and the family bank." Currently, in most developing countries, emphasis has been placed on increased food grain production through the use of production inputs, especially improved seeds, fertilizers, chemical pest control measures and irrigation. Practically no attention has been given to farm or village level storage aspects. It is indeed ironic to spend large sums of money on increasing production only to lose a substantial amount of grains produced through improper and inadequate storage methods.

Therefore, this reviewer commends the GOC's and USAID's interest on the improved on-farm storage problems and especially CARE/Chad's rural grain storage project proposal. Any improved on-farm grain storage

programs with reasonable costs are a vital necessity not only in Chad but also in many developing countries where a majority of the population is subsistence level farmers.

CARE/Chad's rural storage project is proposed as a joint effort with GOC and USAID. In general, it is a sound, reasonable and practical proposal. It is safe to assume that the benefits or outputs of the proposal stated in the previous section, namely, reduction of grain losses, increase of food supply and income of subsistence farm families could be adequately delivered by the project. In addition to the benefits stated in the proposal, a better quality food grain will be available for on-farm consumption from the proposed project.

One of the weaknesses of the proposal is that it gives an impression that the improved storage facility is only a solution for reducing the grain losses and would stop all the grain losses. It should be emphasized that the grain cannot be safely stored in any type of storage facility for a long period without proper care and management practices. Another weakness of the proposal is that it fails to discuss various storage units constructed by CARE/Chad for tests and their results. The inclusion of such discussion would have strengthened the proposal. Also, several unit construction costs of an 8-ton silo are given in the proposal. These should be corrected.

II. Technical Evaluation

At a glance, three major questions concerning the designs of the proposed silo are:

a) Is an 8-ton capacity silo too big for subsistence level farmers?

b) Are the reinforced concrete footings and base too expensive or sophisticated in design?

c) Are the walls of a silo made of clay strong enough to withstand lateral pressures the bulk grain exerts on the walls?

In answer to the first question, an 8-ton capacity silo is definitely too big for a subsistence farmer, however, the proposed project is that one 8-ton silo will serve five subsistence farm families. Since an average of the total grain production by five families in Chad is estimated to be 7.5 tons, the 8-ton unit size is adequate for five families, with consideration for the future expansion of their grain production. As mentioned previously, a Chadian village is a cluster of many extended farm families. Since an objective of the submitted proposal is to reach as many farmers as possible and to encourage community participation in the project, the 8 ton unit storage size is well justified. Furthermore, such an idea is well accepted by many extended families. However, it should be cautioned that the larger the storage size, the more difficulties in managing grain quality though the unit cost of constructing a large unit is cheaper than that of a small unit.

For the second question, in order to consider alternative solutions to the proposed design, the reviewer briefly investigated the availability of various construction materials, their unit costs and construction techniques in Chad. Even common construction materials such as wood, lime, and rock are extremely scarce and expensive in the Sahelian Zone. During a visit to a local brick factory, it was found that the quality of bricks manufactured is poor with respect to the strength and uniformity.

Because of the fuel shortage (even wood), the cost of bricks are very expensive, i.e. semi-fired brick costs 8-10 cents per brick and fired brick costs 27 cents per brick. Also, the supply of bricks is very unreliable. Only a few different gauges of galvanized sheet metals are available in N'Djamena. They are relatively expensive (4.5 mm thickness - $5.50/m^2$) and sheet metal workers are very scarce. Though cement and steel rods are expensive in Chad ($12.50/40Kg bag and 6mm diameter rod - $0.45/m), a reliable supply of both items and cement workers are available.

Based on tests of several pilot models constructed by CARE/Chad, it was concluded that durable base and footing are essential for longevity, maintenance of structure and better grain maintenance because of termites, other insects, rodents and moisture migration. Ground swells in Chad and soils are washed away during the rainy season. The soil also contracts severely during the dry season. This process causes storage built on the ground to crack and reduces the longevity of such a structure considerably. Also, Chadian farmers believe that if a structure is built on the ground, it will provide a direct passage for insects, rodents and moisture to their grains in storage. Furthermore, a few prototype silos raised off the ground on concrete footings are well accepted by farmers. By considering all the factors mentioned above, (availability and costs of various construction materials, availability of skilled labor, weather conditions, longevity and maintenance of the structure, grain quality preservation, acceptability by farmers, efficiency of construction) the technical design of the concrete base raised off the ground on concrete footings is very sound. Such a design is durable with an expected life of at least 15 years.

Evaluation of detailed design of concrete base and footings showed that the concrete mixture used was 1 (cement) : 5 (sand) : 3 (gravel). It appeared to be a coarse mixture for the base and footings. It would be better to use a finer mixture such as 1 (cement) : 3 (sand) : 4 (gravel). There are some errors in evaluating the amounts of cement, sand and gravel needed for constructing the base and footings.

According to the figures of the mixture given in the proposal, the concrete mixture would yield 40 ft^3. However, the actual volume of the concrete mixture (1 : 5 : 3) needed to construct the base and footings are 32.6 ft^3. Therefore, about 7 ft^3 extra volume of concrete mixture is used for estimating the cost of construction. Based on the actual volume needed for the proposed design of 32.6 ft^3, the amount of cement needed is five sacks (5 ft^3). It is suggested that an additional 20 percent over the estimated amount of the cement should be used because of the poor quality of cement available in Chad. Thus the total amount of cement needed is six sacks rather than eight sacks shown in the proposal. The volumes of sand and gravel needed are 25 ft^3 (0.708m^3) and 15 ft^3 (0.425m^3), respectively. Therefore, about a $37 savings from the total unit construction cost will be realized.

If one uses a finer concrete mixture (1 : 3 : 4) as suggested by this reviewer, the total amount of the cement needed is 6.7 sacks which included an additional 20 percent cement. The volumes of sand and gravel needed are 16.8 ft^3 (0.48m^3) and 22.4 ft^3 (0.63m^3), respectively. The total cost of a concrete mixture of 1 : 3 : 4 needed for one 8-ton capacity silo would be about $122, as opposed to $142 for the revised design of the silo given in the proposal. Thus, about $20 savings is realized even if one uses a finer mixture. Therefore, it is suggested that the budgets in the proposal should be revised accordingly. Detailed calculations showing the above problems are included in the Appendix.

Thirdly, the storage container is made of locally available materials and by using existing village technology. The composition of the wall materials is a mixture of clay, straw, cow dung, ant hill (binding agent) and water. After proper mixing, the material is slowly and carefully sun cured and the walls are constructed with 5 cm thickness of mud. Without knowing the actual strength of the 5 cm thickness mud used (compressive, tensile, shear strength and other physical properties), it is impossible to perform the structural analysis on the wall. Rough calculations showed that for a given 8-ton capacity unit, unit lateral pressure exerted by grain sorghum on the wall is about 175 to 200 lbs/ft^2, the wall tension is about 800 to 1,000 lbs/ft and the total vertical load on the wall is about 400 to 500 lbs/ft. It is noted that a scientific evaluation of the structural analysis of the wall could not be performed under the current situation in Chad.

However, by pounding and kicking the walls of prototype silos that were visited, it appears the wall is reasonably strong enough to withstand the above forces mentioned. Mr. Peter Reitz, Director, CARE/Chad stated that the bulk storage tests with the first prototype silo built at Kandoul 2 years ago indicates no structural failure. For the future evaluation, Mr. Peter Reitz has agreed to send three representative samples of 2 inch, 4 inch and 6 inch thicknesses of the wall material used to Kansas State University.

In observing the current farm practices, it is unlikely that a silo will be used fully for bulk grain storage by the farmers. A major portion of harvested grain will be stored in the form of heads and a small portion of grains will be stored in bulk form. Since the above situation would be prevailing, the structure proposed would be sound and reasonably durable for grain sorghum and millet storage in Chad. However, the

proposed silo does not have an unloading port or door, causing inconvenience in loading and unloading the grains.

A clay container is completely covered by straw cover. It should be mentioned that such a design is an excellent idea. A straw cover will reduce the moisture migration through the wall and temperature inside the container so that the grain quality can be more closely maintained.

In addition, a straw cover will prevent direct rainfall from the container. Thus, the container can be better maintained and its life expectancy will increase. With proper care and maintenance, it is expected that a storage container will last 8 to 10 years, provided that a straw cover is replaced every 2 or 3 years.

A metal cap or plastic cover should be provided to close the manhole at the top. Also a straw cover should not be overhung below 60 cm from the ground (note that some rodents can jump 60 cm from a standing position). The bottom of the straw cover should be curved so that water would not directly drip on the walls of the silo.

It should be mentioned again that the importance of grain storage fundamentals and proper grain management practices for grain quality preservation in the proposed silo is overlooked in the proposal. The grain moisture content should be relatively low (below 13 percent), the grain should be relatively clean, and uniform moisture distribution between grain lots is very desirable before storing. The cleanliness around the storage premise and inside a storage unit is also very desirable.

It is strongly recommended that CARE/Chad prepare a user's guide or instruction manual including grain management practices for the proposal silo, for farmers and extension agents, with technical assistance from Kansas State University.

Grain sorghum and millet are generally harvested during the months of September and October in the Sahelian Zone and the months of October and November in the Tropical Zone. Therefore, the meteorological data given in Table 1 indicate that sorghum and millet harvested in the Sahelian Zone can be easily dried to a safe, storage moisture content (13 percent) by a natural sun drying method except several days during September in the Sahelian Zone and several days during October in the Tropical Zone. Climatic data show that when properly dried, the grain can be stored relatively well under the proposed silo in the Sahelian Zone except during the months of July, August and September. However, this reviewer has some reservations on the use of such a system in the Tropical Zone because of high humidity and higher rainfall throughout the year.

Therefore, it is strongly recommended that such a system be introduced only in the Sahelian Zone until further tests of the proposed silo can be conducted in the Tropical Zone. For future tests, technical assistance from Kansas State University through USAID can be provided.

In summary, the proposed silo is technically sound. Its base and footings are durable and the walls are reasonably stable. It appears to be a reasonably waterproof, rodentproof and birdproof structure. The proposed silo is suitable for the Sahelian Zone in Chad.

III. Economic Evaluation

As stated in the previous section, there are some discrepancies in the actual construction costs given in the proposal. Therefore, these should be corrected. Based on the revised design of a silo suggested by the reviewer, the estimated cost of constructing an 8-ton silo, which includes the costs of transportation and ladders, is $370.00. About 42 percent of the total cost is the concrete base and footings. In spite of the high cost of the concrete base and footings, the overall unit cost of the proposed silo appears to be relatively low in Chad. This takes into consideration the longevity of the silo base and footings, and compares with the costs of other types of improved grain storage facilities available for on-farm use in developing countries. At the present time, any improved grain storage facility developed for on-farm use whose unit cost is less that $50/ton would be considered as a relatively low-cost structure.

Any investment is normally justified by estimated flow of returns or benefits over the life of the investment or any other relevant period. The useful life of a well constructed silo would likely exceed 10 years, with proper maintenance. However, investment planning periods for Chadian farmers may not exceed 10 years. The estimated cost of the proposed silo (after revision) of 8-ton capacity is $370. Annual benefits required over various benefit periods equal $370 of current value at 8 percent and 10 percent discount rates and are indicated in Table 2.

Table 2. Annual Benefits Required over 1 to 10 years Benefit Periods for Current Investment Value of $370 at Discount Rates of 8 and 10%.

Benefit Periods (year)
(U.S. Dollars)

Discount Rate	1	2	3	4	5	6	7	8	9	10
8%	$399.60	207.50	143.60	111.70	92.70	80.00	71.10	64.40	59.20	55.10
10%	407.00	213.20	148.80	116.70	97.60	84.90	76.00	69.40	64.20	60.20

If annual benefits exceed those indicated for a 10-year benefit period, returns will equal benefits in less than 10 years.

Historically, a wide seasonal variation in price of food crops is known to exist in Chad. For example, a seasonal variation in the price of grain sorghum during the past 3 years ranged from 20 CFA/Kg to 90 CFA/Kg (250 CFA = $1.00). The floor price of grain sorghum set by the government of Chad is 26 CFA/Kg. Currently, the price of sorghum at the N'Djamena market is 70 CFA/Kg (March, 1977).

Let us assume that normally 15 percent of grain sorghum produced is to be marketed for a cash need by the farmers at the harvest period. Because of the improved storage facility, the farmers will be able to take advantage of seasonal variation in price. If the five farm families (who will use the proposed silo of 8-ton capacity) would sell 15 percent of their grain sorghum produced at a price of 52 CFA/Kg rather than 26 CFA/Kg at the harvest period, annual benefits resulting from it would be about $125. Therefore, they would pay for a silo within 4 years (refer to Table 2) even without considering benefits from reduction in grain storage loss.

Supposing that 50 percent of a 20 percent grain storage loss incurred by the farmers was saved by using the proposed silo, then, 800 Kg of additional grain sorghum would be available for either consumption or market by the five farm families who will use the proposed silo. Annual benefits for the five farm families, resulting from reduction in grain storage loss at different prices of grain sorghum, are computed in the table below:

Table 3. Annual Benefits for the Five Farm Families Resulting from Reduction in Grain Loss at Different Prices of Grain Sorghum.

Price of Grain Sorghum, CFA/Kg [1/]

	20	26	30	40	50	60	70	80	90
Annual Benefit $U.S./Yr	$ 64	83.20	96	128	160	192	224	256	288

[1/] 250 CFA = $1.00

Annual benefits resulting from reduction in grain loss alone at a price of 40 CFA/Kg would pay for a silo within 4 years. If the farmers would take full advantage of seasonal price variations for their crops and additional grains available resulting from reduction in grain loss by the proposed silo, they would pay for a silo in a lot shorter period of time. Therefore, it is the author's judgement that annual benefits would definitely justify investment of the proposed silo for on-farm storage in Chad.

The recent review on the CARE/Chad Grain Storage Proposal by Dr. Roe Borsdorf, Kansas State University states that "the long-run potential benefits of stabilization of consumer prices will be greater by the addition of more cereal grain products in the market." He further

stated that the adoption and implementation of the proposed plan by CARE/Chad is deemed critical as it is an essential link in developing a future food chain system for Chad. This reviewer concurs with the above statement by Dr. Borsdorf.

In addition to the technical and economic evaluations on the proposal, it should be pointed out that the proposed project is a joint effort between the Government of Chad and CARE/Chad through USAID/Chad. Such a multi-lateral approach to the project should be encouraged and commended. The proposed project is designed to utilize a substantial amount of local materials and labors, and also to encourage community involvement.

It is expected that the success in implementing the project would be reasonably high. This is due to several factors including a keen awareness of CARE and the Chadian Government as to the need of such a project to assist subsistence farm families; a good knowledge and understanding of the Chadian village culture by CARE/Chad; the competence of CARE/Chad to supervise the implementation of the project based on several years of their experience in Chad; and also an expressed willingness to accept the proposed silo by many families in the villages.

RECOMMENDATIONS

The following recommendations are made, based on personal observation in Chad and technical and economical evaluations on the proposal, "Rural Family Grain Storage Project," by CARE/Chad:

1. It is strongly recommended that the proposed project be funded for immediate implementation after a minor change in the budget of the construction phase is made. The provision of a project evaluation, at the end of the first and second year of the project implementation, is necessary for assessing whether the project needs redirection or reorientation. It is suggested that technical assistance on the above project evaluation be provided by the Food and Feed Grain Institute, Kansas State University under the technical assistance contract, USAID/ta-C-1162.

As stated in the previous sections, the proposed project is technically and economically sound. Furthermore, it will serve as a catalyst for the overall rural development and future development of the national grain marketing system in Chad. In addition, adoption of such a project in other countries in the Sahelian Zone would be possible if the proposed project proves to be successful. In this reviewer's opinion, various benefits resulting from the project would outweigh the capital investment requested.

2. It is highly recommended that Mr. Zakaria Ousman, Agricultural Engineer, Chief of the Division of Training, Office of Teaching and Professional Training of the Ministry of Agriculture, Chad; Mr. Isseni Mahamat, Chief of the Family Grain Storage Project, CARE/Chad; and two more selected candidates from the Ministry of Agriculture, Chad, be sent to Kansas State University to attend the USAID sponsored short course on "Grain Storage and Marketing" to be held from June 13, 1977 to August 6, 1977.

A tentative prospectus, with a general outline of course content for the short course, is included in the Appendix as a reference. It should be mentioned that simultaneous translation in French and Spanish will be provided for the short course. Participation of the Chadians in the above short course will definitely enhance the success of the proposed project and other future programs on grain storage and marketing in Chad.

3. It is also recommended that a user's guide, or a simple instructional manual for proper facility maintenance and grain quality management practices for the proposed silo, be prepared by CARE/Chad with technical assistance from the Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas, U.S.A.

4. It is recommended that CARE/Chad, in cooperation with the Ministry of Agriculture, Chad, conduct periodic inspections of grain quality changes during storage in the proposed silos located at several selected sites. These inspections should include noting changes in grain moisture and temperature and insect and mold development. Therefore, it is also recommended that CARE/Chad or the Ministry of Agriculture, Chad, purchase the following grain testing devices and equipment for periodic inspections of grains stored in proposed silos:

- laboratory oven for grain moisture determination (standard method)
- balances
- two portable moisture testers
- several thermometers for grain temperature measurement
- sample probes
- Boerner sample divider
- sieves
- sample pans and cans
- magnified glasses
- sling psychometers
- germinator (optional).

It should be emphasized that these recommendations are one of the essential means for evaluating the success of the proposed project. Therefore, careful planning of inspection procedures for monitoring grain quality changes should be made with technical inputs from a qualified grain storage specialist.

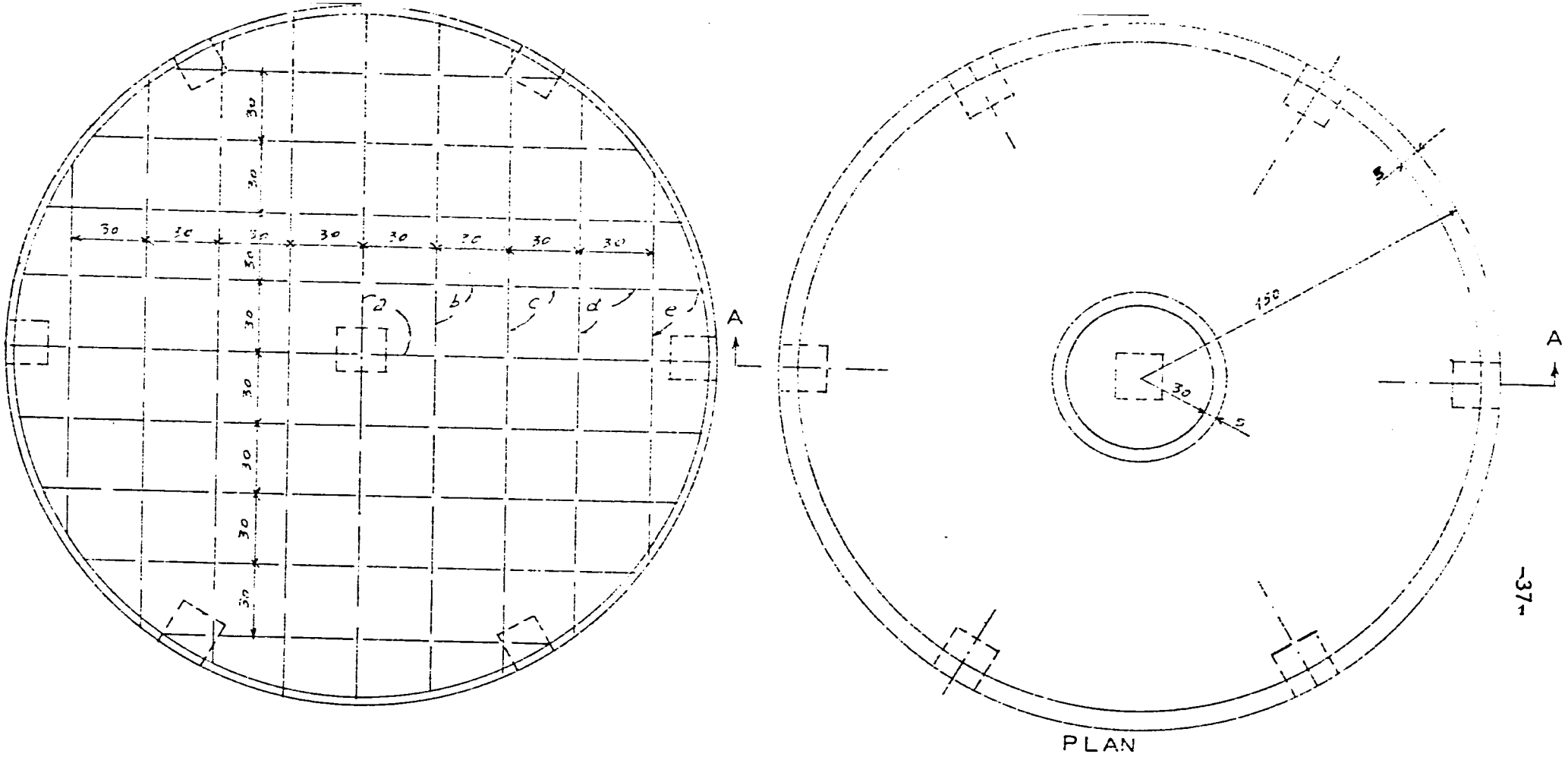
APPENDIX

Figure 1. A storage facility made of mud blocks plastered with mud.

Figure 2. A storage facility made of Ferro-cement.

Figure 3. A storage facility made of mud, placed on a wooden platform.

Figure 4. A storage facility made of mud, placed on concrete base and footings.



PROJET POUR L'EMMAGASINAGE DE GRAINS DE LA FAMILLE RURALE	PROJET COMMUN GOUVERNEMENT DU TCHAD ET CARE CHAD	0 50 100 SCALE IN CENTIMETERS ECHELLE EN CENTIMETRE
RURAL COMMUNITY GRAIN STORAGE PROJECT	JOINT PROJECT GOVERNMENT OF CHAD AND CARE CHAD	DESIGNED BY DESIGNE PAR CARE PETER PEITZ DIRECTOR CHAD / CHECKED BY REVISE PAR R.M. DUNGAN REDSO/VVA C.E. CALIF 7644
		NDJAMENA TCHAD / NOV. 9 1976

Figure 5. Detailed design plan of the proposed silo (top view and reinforced base).

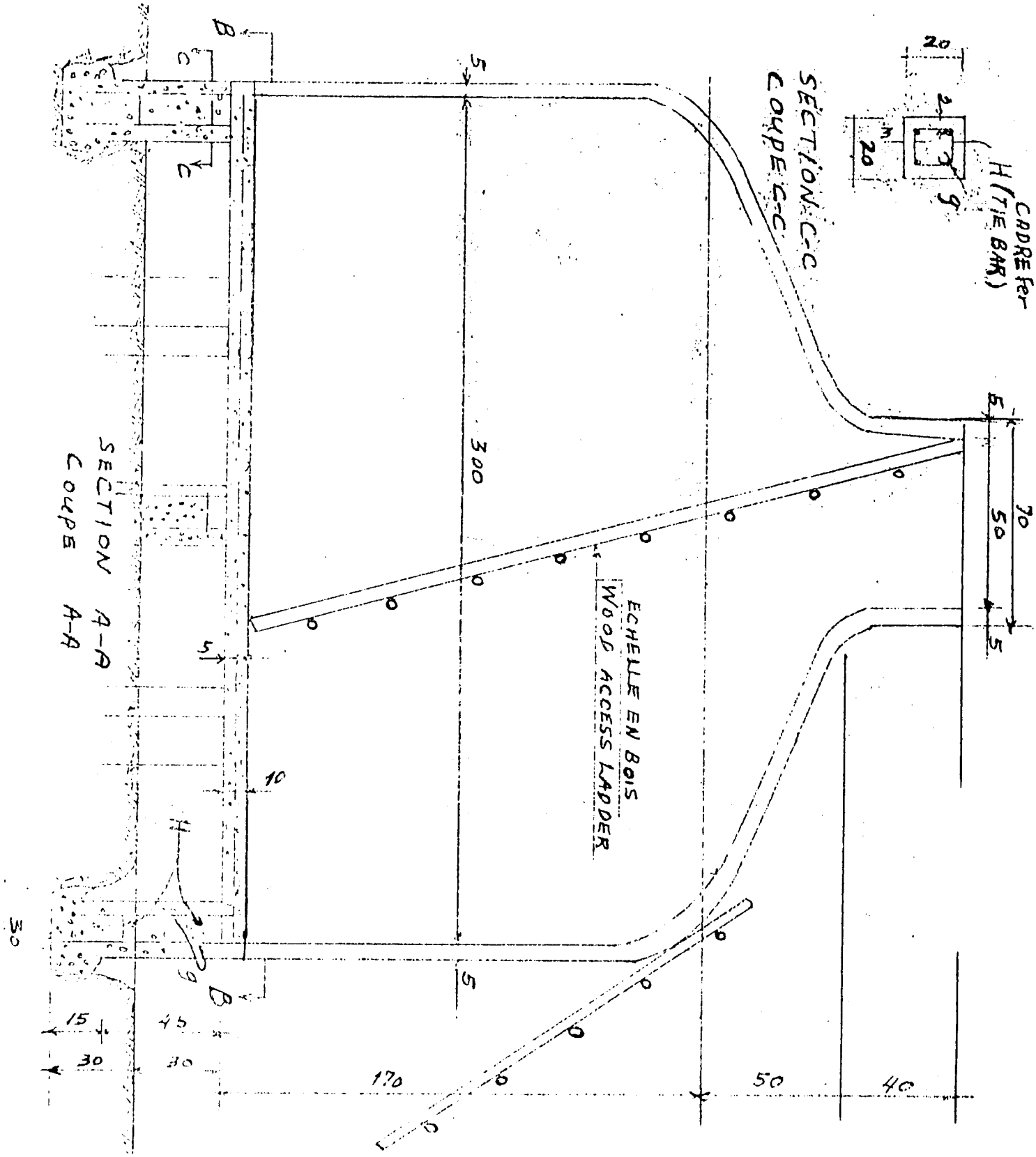


Figure 6. Detailed design plan of the proposed silo (side view).

PROJET POUR L'EMMAGASINAGE DE GRAINS DE LA FAMILLE RURALE RURAL COMMUNITY GRAIN STORAGE PROJECT	PROJET COMMUN GOUVERNEMENT DU TCHAD ET CARE CHAD JOINT PROJECT GOVERNMENT OF CHAD AND CARE CHAD	0 50 100 SCALE IN CENTIMETERS ECHELLE EN CENTIMETRE

Figure 7 Pour une pleine réussite de ce projet, la participation de la communauté est vitale. Les fondations sont creusés par la communauté. Durant la période entière de la construction, l'approvisionnement en sable et en eau est effectué par les villageois.

Community participation in the project is vital to its success. Foundations are dug by the community. Sand and water are provided at the work site during the entire period of the construction phase by the village participants

Figure 8. Le coffrage est installé pour le placement des poteaux.

Forms are installed for the footings.

Figure 9.

Les poteaux sont faits en béton armé et le bois de coffrage est enlevé.

On laisse dépasser un peu le fer à béton pour l'attacher avec le plancher.

The cement footings are cast and the forms are removed. Reinforcement rods are left for attaching to the floor.

Figure 10. Le ciment est posé. Les villageois aident le maçon pour apprendre à fabriquer un silo.

The cement base is poured. Villagers do the work so they learn how a silo is built.

Figure 11.

Le moule est enlevé et le ciment durcit peu à peu en le tenant humide pendant 48 heures.

La boue est mélangée pour la préparation de la paroi.

Forms are removed and the cement is cured.

The mud mixture is prepared and work on the walls begins.

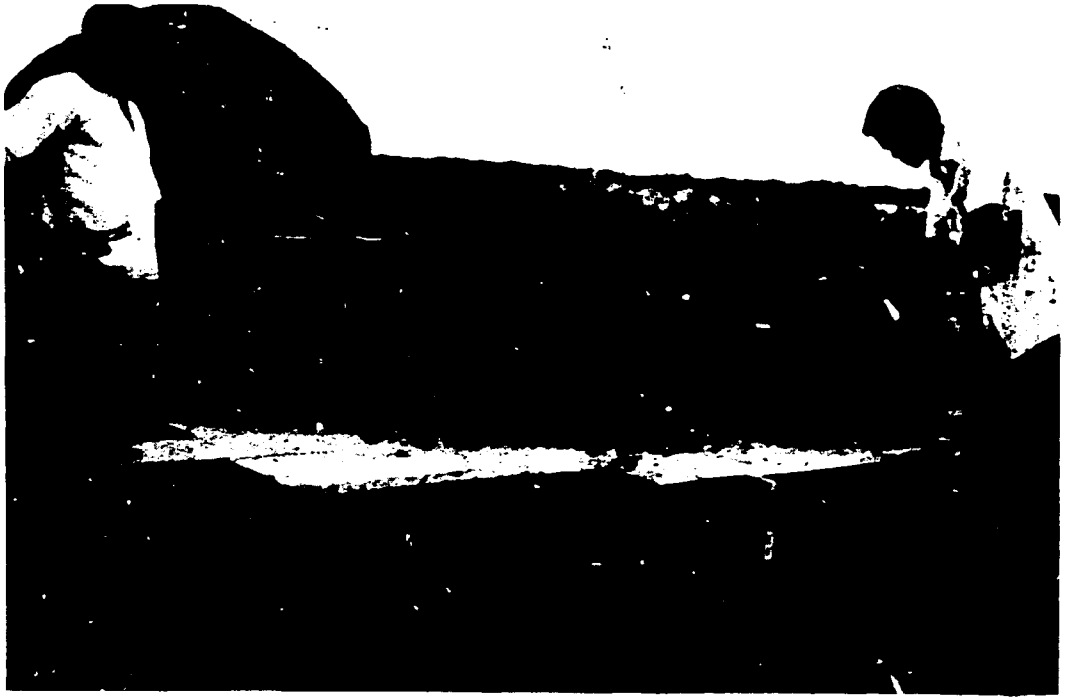


Figure 12.
La paroi est construite par un expert, technicien, pour montrer aux villageois comment faire.

The walls are built by an expert technician in mud work who teaches the village participants.

La paroi est terminee

The walls are completed

Figure 14. L'encolure est finie. Observez qu'une personne peut monter sur le silo quand il est sec. La paille est choisie pour la robe et le chapeau qui protège la paroi de boue contre la pluie.

The lip or neck is mouled at the top. Note that one can walk on top of the silo when it is dry. Straw is gathered for the skirt and hat to protect the mud walls from rain damage. All straw work is done with village participation as a learning process.

Figure 15.

La robe de paille est tressée et installée autour du grenier.
Le chapeau est ajusté pour entrer dans l'encollure.

The straw hat is completed and fitted to the silo. The grass skirt is completed and fitted as well.

Le silo est terminé. Figure 16.

The completed silo.

ENQUETE SUR L'EMMAGASINATION DES GRAINES

1° Nom du village:.....ALLAYA.Chikete.....

2° Depuis combien d'années ce village a été crée?.....29.ans.....

3° Canton de: ..SUBUBRAIN.....

4° Sous-Préfecture de:..N'DJAMENA.Rurale....Préfecture de:..CHARI-BAGUIRNI..

5° Nombre de cases:.....18CASES.....

6° Quels sont les noms des cinq familles groupant sur ce grenier, et le nombre de personnes dans chaque famille?.CE.GRENIER.GROUPE.....
.....CINQ.FAMILLES.....

7° A - Nom:.....CHAKATE.....Nombre de personnes:.....7 PERSONNES.....
B - " .....HAMID DJIBRINE..... " " " ..3...".....
C - " .....OUMAR IDRISS..... " " " 3 ".....
D - " .....ADOUM AZMAK..... " " " 4 ".....
E - " .....IDRISS ZAKARIA..... " " " 4 ".....

8° Quel est le nombre d'hectares cultivés par ces cinq familles?..ces.....
cinq familles cultivent à peu près 25 hectares
.....

9° Quelles sortes de graines sont-elles cultivées?.....le Sorgho et le Mil.....

10° Le nombre de sacs de graines que récoltent les cinq familles?...à.....
..peu.près.80.sacs.....

11° De cette quantité, combien de sacs sont vendus?...pas plus de.....
.....20.sacs.vendus.de.cette.quantité.....
et combien de sacs sont réservés pour leur nourriture?.....60 sacs.....
sont réservés pour leur nourriture
.....

12° Quel est le prix moyen d'un sac quand il est vendu?.....1.500 Francs.....
CFA
.....

13° Dans quel mois les graines sont vendues?.....au mois de.....
.....DECEMBRE.....

14° Si les graines sont gardées pendant 3 mois, quel prix par sac ils obtiendront pour la vente?....Ils.obtiennent.3.000.francs.CFA.sac.quand.
ils gardent leurs graines pendant cette période.
.....

15° S'il est possible d'obtenir un bon prix en vendant les graines, ou elles sont gardées 3 mois, pourquoi les gens ne gardent pas leurs graines pendant cette période?.Parce qu'ils n'ont pas un moyen d'emmagasiner.....
leurs graines et ils ne veulent pas perdre toute la quantité.....

16° Est-ce que les gens estiment que leurs graines sont dérangées par les insectes, oiseaux, rats, rongeurs, moutons, etc.? .Certainement, les gens sont dérangés par ces espèces: oiseaux, insectes, rongeurs.....

17° Est-ce qu'il existe un grenier dans ce village ? .Non il n'existe pas un grenier dans ce village.....

18° Quelle est l'emmagasination des graines actuelles ? ..les gens..... emmagasinent leurs graines dans de trous on sous un hangar.....

19° Est-ce qu'il y a des gens qui connaissent construire un grenier ? ... NON .....

20° Quel genre de grenier connaissent-ils construire? .Ils ne connaissent pas construire un grenier.....

21° S'il y a des gens qui connaissent construire un grenier, s'il n'existe pas un grenier, pourquoi ils n'ont pas construit dans ce village? ... ./////...../////.....

22° Si on choisit le village dont on a fait le grenier, est-ce que les cinq familles choisies donneront-elles la boue et la paille pour les murs? ..Oui, ces cinq familles feront ce travail.....

23° Si on a choisi le village dont on a fait le grenier, est-ce que les villageois comptent remplacer la paille à chaque fin de saison des pluies et veillez à son entretien ou non? .Oui, ils sont d'accord de changer la paille pendant chaque fin d'année et l'entretien.....

24° CONCLUSION: (Est-ce qu'on peut choisir ce village pour construire un grenier ou non? ...Oui, on peut choisir ce village pour un grenier...

FAIT A N'DJAMENA LE_____ 197__

CALCULATIONS OF CONCRETE MIXTURE NEEDED

1. Volume of Concrete Mixture Needed:

   a) Floor

   I.D. = 300 cm
   O.D. = 310 cm thickness = 10 cm

   $$\text{Volume} = \pi r^2 \times h = 3.14 \times \left(\frac{3.1}{2}\right)^2 \times 0.1 = 0.754\ m^3$$
   $$\text{or } 26.64\ ft^3$$

   b) Footings

   Dimensions: 20 cm x 20 cm x 60 cm

   No. of Footings: 7

   $$\text{Volume} = 0.2 \times 0.2 \times 0.6 \times 7 = 0.168\ m^3$$
   $$\text{or } 5.94\ ft^3$$

   c) Total Volume

   $$0.754\ m^3 + 0.168\ m^3 = 0.922\ m^3$$
   $$\text{or } 32.58\ ft^3$$

2. Yield Volume/batch of 1 : 5 : 3 Concrete Mixture, Based on the Proposed Silo

			Mass Volume		
Cement	:	1 x	0.478	=	0.478 ft^3
Sand	:	5 x	0.665	=	3.325
Gravel	:	3 x	0.605	=	1.815
Water (7 gal)	:	7 x	0.134	=	0.938
					6.556 ft^3/ batch

3. Volume and Cost of Each Component Needed:

	Cost U.S.$
a) Cement : $\frac{32.6}{6.556}$ = 4.97 sacks	
5 sacks + 20% addition = 6 sacks	$75.00
b) Sand : 5 x 5 = 25 ft^3 or 0.7075 m^3	8.50
c) Gravel : 3 x 5 = 15 ft^3 or 0.425 m^3	21.20
	$104.70

Note that the cost given in the proposal is $142.00,

$142.00 - $104.70 = $37.30 savings.

4. Yield Volume/batch of 1 : 3 : 4 Concrete Mixture, suggested by reviewer.

		Mass		Volume
Cement	:	1 x 0.478	=	0.478 ft^3
Sand	:	3 x 0.665	=	1.995
Gravel	:	4 x 0.605	=	2.42
Water (7 gal)	;	7 x 0.134	=	0.938
				5.831 ft^3/batch

5. Volume and Cost of Each Component Needed, Based on the Suggested Concrete Mixture.

	Cost U.S.$
a) Cement: $\frac{32.6}{5.831}$ = 5.6 sacks	
5.6 sacks + 20% addition = 6.7 sacks ($12.50/sack)	$84.00
b) Sand : 3 x 5.6 = 16.8 ft^3 or 0.475 m^3 ($12/$m^3$)	5.70
c) Gravel : 4 x 5.6 = 22.4 ft^3 or 0.634 m^3 ($50/$m^3$)	31.70
$142 - $121.40 = $20.60 savings.	$121.40

6. Actual Total Construction Cost per Silo, Based on Reviewer's Suggestion.

Item	Cost U.S.$
Concrete Mixture	$121.40
Steel Rod	34.00
Mud Jar, Straw Cover and Labors	164.00
Ladders	20.00
Transportation	30.00
	$369.40 = $370

TENTATIVE PROSPECTUS

USAID GRAIN STORAGE AND MARKETING SHORT COURSE - 1977

The Food and Feed Grain Institute, Kansas State University, is offering a Grain Storage and Marketing Short Course for AID participants and other interested individuals from developing countries under Contract AID/ta-C-1162 technical assistance in grain storage, processing and marketing and agribusiness development.

The Short Course is tentatively scheduled to be held June 13 through August 6, 1977. This provides for a 1 week orientation in Washington, D.C., six (6) weeks intensive training on the KSU campus from June 20 to July 30, 1977, and a 1 week field trip to rice producing areas and port facilities. The eight (8) week long course will have a limited enrollment of thirty (30) participants. Instruction will be in English with simultaneous Spanish and French translation if justified. Participants will be accepted on a pre-registration basis only.

Instruction will be directed at the technical level rather than the administrator and will consist of lectures, discussions, laboratory work sessions, and field trips. Areas covered in the Short Course are shown on the attached outline (approximately 280 class hours).

Outlines, laboratory worksheets, manuals, and other materials and equipment needed for the Short Course will be provided; however, participants will be required to bring with them data and information on climate, topography, modes of transportation, crops, production, storage, and marketing as it exists at present in their specific countries. The information is requested so that the participants can present a brief description of existing grain

storage and marketing in their country to the group and provide for an exchange of ideas in group discussions. Participant Country Information Summary Manuals will be distributed as soon as Missions indicate the intention to send participants to the Short Course. AID Missions should help the participants in assembling the required information.

Participants are required to provide transportation to travel to Washington, D.C. Travel within the United States will be provided by USDA/AID International Training from course fees. Housing will be made available for participants in University dormitories. Meals will be provided and served cafeteria style. The charge for dormitory and three (3) meals per day (except Sundays, no evening meals) is $312 (2 men/room) or $370 (one man/room) for the six weeks at KSU.* Linen and soap are provided. Participants are responsible for their own toilet articles. Appropriate per diem will be provided participants by USDA/AID International Training for the orientation in Washington, D.C., the six (6) week short course in Manhattan, and (1) week travel in rice areas in the U.S. Travel from the U.S. (Houston, Texas) and any additional time the participant may be authorized to spend in the U.S. should be provided by the Mission.

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*1976 prices may be subject to change.

GENERAL OUTLINE

Grain Storage and Marketing Short Course

I. Introduction to Course.

- A. Importance of Grain Storage and Marketing
- B. Purpose and scope of course
  1. Provide basic fundamentals of Grain Storage and Marketing
  2. Provide practical knowledge and techniques needed in Grain Storage and Marketing.

II. Review of Grain Production, Storage, Marketing and Utilization in Participants Countries.

III. Fundamentals of Grain Storage.

- A. Grain kernel structure
- B. Moisture and its measurement
- C. Mold: moisture relationships
- D. Chemical, physical, and nutritive changes during storage

IV. Grain Inspection - Standards, Sampling, and Grading.

V. Grain Handling.

- A. Movement of grain
- B. Methods and facilities for conditioning grain
- C. Aeration - cooling of grain
- D. Grain drying - principles, types of drying, types of driers, and drier operation
- E. Equipment maintenance

VI. Storage.

- A. Storage methods and procedures
- B. Types of structures - farm, warehouse, and elevator storage
- C. Structural maintenance

VII. Sanitation Program.

- A. Inspection - methods and equipment
- B. Housekeeping - storage sites, structures and equipment
- C. Insect control - Biology and identification; physical, mechanical, and chemical methods; pesticide safety
- D. Rodent and bird control - biology, identification, and methods of control
- E. Microbial control - molds, mycotoxins, and control methods

VIII. Economics of Marketing Management and Operations.

A. Principles of management
B. Principles of operation
C. Organization of the grain business - business, financial, operational structure, and facilities planning
D. Facilitating grain operations - public warehousing, financing and rise, crop forecasting, price reporting, standardization, and price differentials
E. Bookkeeping, accounting and inventory control
F. Government and marketing

IX. Field Trips to Demonstrate Classroom Instruction.

X. Laboratory Work Sessions to Complement Lectures.

A. Grain inspection
B. Moisture determination
C. Effects of grain drying and aeration
D. Insect identification
E. Demonstration of pest control methods
F. Business procedures and marketing analysis methods
G. Records keeping for warehouses and elevators
H. Assessment of grain storage and marketing economy