AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch 76

1. SUBJECT CLASSIFICATION

A. PRIMARY: Food production and nutrition — AE70-0000-G136

B. SECONDARY: Distribution and marketing--Ethiopia

2. TITLE AND SUBTITLE

The transportation,processing,and storage of Ethiopian grains and pulses for domestic and export markets

3. AUTHOR(S)

(101) Experience,Inc.,Minneapolis,Minn.

4. DOCUMENT DATE: 1972

5. NUMBER OF PAGES: ~~80p.~~ 71p.

6. ARC NUMBER: ARC ET631.56.E96

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Experience

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(Rpt.no.4)

9. ABSTRACT

10. CONTROL NUMBER: PN-AAF-163

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Ethiopia
Exports
Grain crops
Legume crops
Processing
Storage
Transportation

13. PROJECT NUMBER

14. CONTRACT NUMBER: AID/afr-752 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

EXPERIENCE, INCORPORATED
DAIN TOWER • MINNEAPOLIS, MINNESOTA 55402

E. I. Contract No. 626
May 1972

REPORT NO. IV

THE TRANSPORTATION, PROCESSING, AND STORAGE OF ETHIOPIAN GRAINS AND PULSES FOR DOMESTIC AND EXPORT MARKETS

PART A Domestic Transportation of Ethiopian Grains and Pulses

PART B Processing and Storage of Ethiopian Grains and Pulses

Prepared for:

Planning and Programming Department
The Ministry of Agriculture
Imperial Ethiopian Government

The United States Agency for International Development
participated in the funding of this contract.

PREFACE

This report is one of several prepared under Contract No. 626 between Experience, Incorporated and the Ministry of Agriculture of the Imperial Ethiopian Government. The United States Agency for International Development was also involved in this program through participation in the funding of the contract. Field work on the project was initiated in October 1971 and continued through March 1972. In the course of work, eleven specialists were in Ethiopia for varying periods of time.

Initially, the purpose of the project was to conduct a reconnaissance survey to establish the export potential of feed grains (maize, sorghum, barley) and pulse crops. That particular activity made up Phase I of the contract program. Phase II involved the more detailed study of several aspects of the production and marketing of certain grains and pulses. It was determined that attention in Phase II should be focused particularly on the planning of a project through which production of pulses for export will be increased substantially. Other focal points in the second phase included multiplication and distribution of improved seeds (grains and pulses), outlook for the marketing of malting barley, and the prospects for export of durum wheat.

In conducting the field work in Ethiopia, the Experience, Incorporated specialists were assisted importantly by local counterpart personnel assigned temporarily to work on the contract program. Without the help of these persons it would not have been possible to complete the assignment effectively or on time. The contract program was attached to and received logistic support from the Planning and Programming Department of the Imperial Ethiopian Government Ministry of Agriculture where Ato Mulugetta Bezzabeh, Department Head, and Ato Ketema Desta, Project Coordinator, were especially helpful. Policy guidance and useful suggestions on procedure and findings were provided by the United States Agency for International Development staff, and by an Inter-Agency Steering Committee chaired by Ato Mulugetta Bezzabeh.

Experience, Incorporated staff members resident in Ethiopia at various times during the course of this contract program were:

Allan Q. Moore, Project Leader (Phase I) and Grain Marketing Specialist

E. R. Duncan, Project Leader (Phase II) and Extension Specialist

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In addition, several members of the Experience, Incorporated home staff in Minneapolis, Minnesota were involved in the project.

Counterpart Imperial Ethiopian Government personnel assigned to the contract program included particularly:

Ato Getachew Haile, Ministry of Agriculture

Ato Ghiorghis H. Mariam, Ministry of Agriculture

Ato Mamo Desta, Ethiopian Grain Corporation

Ato Hiruy Belayneh, Institute of Agricultural Research

Ato Wolde Yohanis Woldayes, Ministry of Agriculture

Reports prepared under auspices of this contract are:

A. Field Reports (prepared and presented in Ethiopia by field staff)

1. Production and Marketing of Pulse Crops in Ethiopia, Final Report, Phase I, December 1971

2. Production and Marketing of Feed Grains in Ethiopia, Final Report, Phase I, December 1971

3. Ethiopian Malting Barley, Draft Report, February 1972

4. Pulse Production Project, Ethiopia, Draft Report, February 1972

5. A Seed Improvement Program Proposal for Ethiopia, Draft Report, March 1972

B. Final Reports (submitted upon completion of the project work program)

1. The Feasibility of Producing Pulse Crops for Export Markets, Report No. I, May 1972

2. The Feasibility of Producing Cereal Grain Crops for Export Markets, Report No. II, May 1972

3. An Implementation Plan for a Seed Improvement Program in Ethiopia Report No. III, May 1972

4. The Transportation, Processing, and Storage of Ethiopian Grains and Pulses for Domestic and Export Markets, Report No. IV, May 1972

NOTE: Throughout the final reports the exchange rate used is Eth. $2.50 = US$1.00. Except where specifically stated otherwise, all monetary expressions refer to Ethiopian dollars. Tons are in the metric system = approximately 2,200 pounds. Feed grains are defined to include barley, maize, and sorghum; in Ethiopia, however, all grains are considered "food" grains.

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REPORT NO. IV

PART A

Domestic Transportation of Ethiopian Grains and Pulses

I. SUMMARY AND RECOMMENDATIONS

1. Ethiopia has about 16,000 kilometers of unimproved roads and an estimated 7,650 kilometers of all-weather roads; but it is likely that as much as 80 percent of the population does not have ready access to modern transportation. In addition to the road system, there are two railroads serving the Empire: one running from Addis Ababa to Djibouti and the other from Agordat to Massawa. Both the road system and the railroads are centered on Addis Ababa and Asmara; many of the outlying areas are either inaccessible or without interconnecting links. Domestic and export marketing in general and distribution among surplus and deficit areas in particular are hampered by an inadequate transportation infrastructure.

2. In the rural areas, the pack animals (donkeys, horses, and camels) are the principal means of transport from farm-to-market. Costs of using this means are reported to be substantially higher and much slower than truck or rail transport for comparable distances.

3. Areas served by all-weather roads have access to trucks operated by private entreprenures. There were about 3,400 trucks of all types operating in 1971, and perhaps 2,300 of these were truck /trailer combinations. Exporters of pulses and grains report no serious shortage of transportation service, although rates are said to be higher during the periods of peak movement after harvest and threshing.

4. There is active competition among truckers and between trucks in general and the railroads. In a setting of virtually no regulations, the result is a competitive tariff structure on commodities moving into both domestic and export trade, particularly the latter. Dealers and truckers customarily bargain to establish charges on a given lot of goods. Over the years, transportation rates have been decreasing in Ethiopia. Improved highways and roads, and increasing competition have been largely responsible for the decline.

5. It is estimated that the off-farm movement of grains ranged from 450,000 to 600,000 metric tons in 1971 and pulses from 150,000 to 200,000 metric tons, which required transportation from farm-to-market (domestic or export). With urban population growth and more export trade, these quantities are expected to increase steadily. The movement will also be affected by the shift of subsistence farmers into the market economy.

6. There is active competition between the railroad and trucks in the area served by the Franco-Ethiopian Railroad. In the north, however, the Northern Ethiopian Railway has in effect a monopoly position through an arrangement in which trucks must have the railroad's consent in order to operate. Completion of the Awash-Tendaho Highway should lead to lower rates on exports moving through Assab and Djibouti.

7. Ethiopia has need for an extensive system of farm-to-market and penetration roads. The present structural standards adopted by the Imperial Highway Authority for such roads are considered to be unduly stringent, which leads to very high costs per kilometer constructed. There is a place and need for low-cost feeder roads that would be adequate for the intended and prospective use; in fact, it is estimated that roads costing only 10 to 25 percent as much as IHA construction could easily be designed and built.

8. Roads are needed to form a network connecting all of the principal production areas and centers of population. This would not only lead to improved marketing efficiency, but it would also ease the serious surplus deficit problem in the Empire.

9. Maintenance of all-weather roads should be upgraded to improve safety and reduce vehicle operating costs.

10. Better utilization of the available transport capacity, smoothing of the seasonal fluctuations in shipments, and bulk transportation all hold promise as means of reducing transportation costs in Ethiopia.

II. BACKGROUND

Ethiopia's ability to increase its exports of pulses and feed grains depends, to a considerable extent, upon the progress that can be made in improving its transportation system and especially in the development of low-cost penetration and farm-to-market roads. This type of improvement will permit the substitution of a much lower cost and more rapid wheel transport for the pack animal transport in moving surpluses of grains and pulses from the farm to local or regional markets.

Although about 90 percent of Ethiopia's population of 25 million is dependent upon agriculture for a livelihood, approximately 80 percent of the total population lives in areas which are inaccessible to modern transport. Many of these areas have a promising production potential for many types of agricultural crops, including pulses and grains. The lack of penetration and farm-to-market roads is reported to be the most critical in Africa. Limited surveys of grain and pulse marketing in Ethiopia indicate that most surplus production moves from the farms to interior markets by animal transport.

Ethiopia has about 16,000 kilometers of unimproved roads and trails, some of which have infrequent truck service during the dry season but at high rates. None of these roads and trails are maintained by the Imperial Highway Authority (IHA), the government agency whose duties are to plan, design, construct, and maintain highways, roads, and bridges throughout the Empire.

The highway network maintained by the Authority consists of about 7,650 kilometers of all-weather roads of which about one-fourth have an asphalt surface and three-fourths are gravel. [1/] The all-weather network is oriented to the country's two largest cities, Addis Ababa in the central highlands, and Asmara in the northern highlands. All-weather roads, in turn, link the two cities with the nation's Red Sea ports of Massawa, about 115 kilometers east of Asmara, and Assab, about 460 kilometers (straight-line distance) southeast of Massawa. Rail connections also exist to the ports of Massawa and Djibouti. The latter is located in the French territory of Afars and Issas and serves as a second port for the Addis Ababa and Nazaret areas and the primary port for the eastern section of the country centered around Harar and Dire Dawa.

1/ See Appendix Table A-1

III. MEANS OF TRANSPORT

A. Introduction

Grains and pulses sold off-the-farm are transported by pack animals (donkeys, mules, and horses) in the highlands, and camels in the lowlands. Motive power consists primarily of large, single-unit trucks and trucks with separate trailers.[2/]

The choice of motive power over pack animal transport depends upon accessibility to the farmgate. As indicated, large segments of the farm population are completely inaccessible by road, while other segments are accessible only on a very limited and infrequent basis during the dry season.

B. Pack Animal Transport

Among 76 dealers interviewed recently in a limited market survey, 63 reported receiving all of their cereals and pulses by animal transport; 11 reported from 75 to 99 percent of their receipts by animal transport; and only two dealers reported truck receipts in excess of pack animal receipts. In the same survey, all 50 farmers interviewed in two provinces reported exclusive use of pack animal transport in moving their grains and pulses to market.[3/]

The General Road Study[4/] gives further evidence of using pack animals for transport. In a survey conducted during the second quarter of 1969, from 145 to 417 pack animals were reported to have entered 11 markets, such as Dese, Bichena, and Debre Tabor, on a single market day. Since the major commodity transported at nine of the eleven markets was cereals and the time of the survey was the off-season for this commodity, the above figures would undoubtedly be much higher during the harvest and threshing season, November through January.

Limited data are available that indicate there are thousands of pack animals in service throughout the country, each carrying only a small fraction of the payload capacity of trucks operating over the highway network. Load capacity of a donkey is estimated at one-half to one quintal; mules, one to one and a half quintals; and camels, two quintals. In contrast, the typical truck operating in Ethiopia has a payload capacity of nine to ten metric tons

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2/ Human transport is used on the farm, especially during harvesting, but is insignificant in off-the-farm movements.

3/ Unpublished study by the IEG, Ministry of Agriculture under the direction of Ato Ketema Desta and Dr. Kenneth Eubanks.

4/ Ethiopia General Road Study, Draft Final Report, Rendel, Palmer and Tritton and The Economist Intelligence Unit, Ltd., London, November, 1969.

(90 to 100 quintals), and the truck/trailer has a combined payload capacity of 22 metric tons (220 quintals).

The distances traveled by pack animals are, in many instances, substantial. Peasant merchants and farmers interviewed by the consultants in the Dese area during November, 1971, and who had just arrived at the market with their pack animals, listed origins ranging from 15 kilometers up to 120 kilometers. The longest distance represented trips from Borena, to the west of Dese, and required three days' travel in each direction. Although the average speed of pack animal transport varies, depending upon trail or track conditions, topography, and size of animal, information received directly from the transporters indicated a range of four to six kilometers per hour.

The slowness of animal transport and the small quantities carried result in hauling rates per metric ton/kilometer of at least three times those of trucks traveling on all-weather roads. Many times, the differential in the truck and animal transport rates may be even greater, depending upon the time of year, length of haul, amount of competition, quantity to be hauled, and other factors. This is indicated in Part V, Transportation Charges.

C. Truck and Rail Transport

Nearly all truck transportation of grains and pulses is performed by for-hire operators for the various types of merchants. In a few cases, however, a large grain merchant may supplement the for-hire transportation by use of his own private truck for assembling grains and pulses from the interior markets.

Pulses and grains for export via the port of Assab are moved primarily by truck/trailer combinations, with a truck payload capacity of ten metric tons and a trailer capacity of 12 metric tons. Similar export movements through the port of Djibouti are by rail, with the grain or pulses being hauled from the exporters' warehouses in Addis Ababa or Nazaret by truck or horse-drawn, two-wheel carts to the rail siding for loading. Spur tracks to individual warehouses are virtually nonexistent. Both rail and truck are used in export movements to the port of Massawa from Asmara and areas to the west and south.

The typical trucker in Ethiopia is an owner/operator, since the industry is made up of many small operators who own an average of two trucks each. For example, the National Transport Company S.C. is a cooperative of truck owners, with 400 members who own 690 trucks. This organization acts as a clearing house for consignments and distributes orders from shippers.

The total number of trucks of all types in use, as estimated in the General Road Study cited above, is about 3,400 as of July, 1971; whereas, the number of truck/trailers was nearly 2,000 in 1967, with perhaps 2,300 in use in 1971.[5/] Vehicle registration and license data are not sufficiently accurate to be considered exact figures.

Exporters of pulses and grains interviewed stated that there was no appreciable shortage of trucks for moving their products. The competitive nature of the trucking industry in Ethiopia, with its large number of small owner/operators and an adequate truck fleet, is a decisive factor in holding down the trucking rates on exports moving over the all-weather roads.[6/]

5/ The estimate of truck/trailers for 1971 is by Experience, Incorporated.

6/ See Part V, Transportation Charges.

IV. QUANTITIES TRANSPORTED

A. Total Transport Demand--Internal and Export

Only limited studies have been made of domestic consumption of foods in Ethiopia. From these studies, as well as consultations with agronomists and agricultural economists, on-farm consumption of pulses is estimated to range from 65 to 75 percent and cereals from 85 to 90 percent.[7/] An important share of the off-farm movement is consumed locally at points close to the producing area.

For the 1969/70 crop year, the volume transported off-the-farm is estimated to range from about 150,000 to 200,000 metric tons for pulses and from 450,000 to 650,000 metric tons for cereals, including teff, wheat, maize, barley and sorghum.[8/] The highs and lows are dependent upon the variation in percentages of farm consumption assumed for each of the two groups of commodities. Estimated tonnages transported for the two earlier years are about the same magnitude as 1969/70 because the indicated production did not vary greatly over the three years.

The figures on tonnage transported and domestic consumption off-the-farm are only estimates, as they are entirely dependent upon production data and assumptions of farm consumption, the accuracy of which can be questioned. However, they give order-of-magnitude estimates that are useful and are indicative of the transport demand for off-the-farm movements of pulses and cereals by pack animal and motive power.

B. Major Origins of Off-Farm Movements

The major sources of the off-farm surplus movement of pulses for domestic consumption and export are the provinces of Begemdir, Gojam, Shewa, Welo, Arusi, Tigre, and Harerge. A study by Eichberger shows only the first three of these as having surpluses, although another study by Muhlig-Versen shows Welo as having a very substantial surplus in 1969 and 1970.[7/]

7/ Eichberger, W. G., "Food Production and Utilization", US/AID, Addis Ababa, 1966.
Muhlig-Versen, P., "Grain Surplus and Deficit Provinces in Ethiopia and Efforts of the Ethiopian Grain Corporation to Stabilize the Market" Addis Ababa, 1971.

8/ These estimates reflect allowance for post-harvest shrink; they represent net quantities consumed or exported.

The major production and/or surplus areas for certain grains are

Barley -- Welo, Begemdir, Shewa, Gojam and Arusi
Maize -- Shewa, Welega, Kefa, Harerge, Sidam, Gemu Gofa, Illubabor and Arusi
Sorghum -- Begemdir, Gojam, Eritrea, Welo, Welega, and Harerge.

C. Destinations of Off-Farm Domestic Movements

Addis Ababa, Asmara, and Dire Dawa account for nearly half of the consumption of pulses and grains by the urban population. The balance is scattered among more than 200 towns in the various provinces, ranging in population from 1,000 to 50,000.[9/] This movement does not include quantities consumed by the segment of the population classified as "rural-nonfarm".

D. Movements for Export

1. By Ports

Exports of pulses move largely through the port of Assab, with smaller quantities moving through Massawa and Djibouti (Table 1). Over the period from 1968 to 1970, Assab's share ranged from 68 to 75 percent (37,000 to 48,000 metric tons) of pulse exports. In contrast, practically all of the small quantity of cereal exports move to Djibouti. Recently, these exports have consisted primarily of sorghum destined for nearby markets in the Red Sea area.

2. By Type of Pulse

The major pulses moving through Assab are horse beans, lentils, and haricot beans; for Massawa, horse beans and lentils; and for Djibouti, haricot beans and chickpeas (Appendix Table A-2).

3. Nonport Exports

Nonport export movements are of importance only for shipments to Sudan, which totaled 3,924 metric tons of lentils in 1969 but only 485 metric tons in 1970, a short crop year.

4. Seasonality

November through March are the major months for exporting pulses. There does not appear to be a clear pattern of seasonality for the small quantity of cereal exports (see Appendix Table A-3). Seasonality in pulse

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9/ Major Towns in Ethiopia, Central Statistical Office. 1968.

TABLE 1. EXPORTS OF PULSES AND CEREALS BY PORTS, 1968 - 1970

	Assab	Massawa	Djibouti	Total Three Ports
			(Metric Tons)	
Pulses[a]	36,972	6,122	6,048	49,142
Cereals[b]	7	-	3,879	3,886
Total 1970	36,979	6,122	9,927	53,028
Pulses[a]	48,201	7,203	11,057	66,461
Cereals[b]	-	-	3,711	3,711
Total 1969	48,201	7,203	14,768	70,172
Pulses[a]	44,289	7,850	13,067	65,247
Cereals[b]	51	-	919	970
Total 1968	44,330	7,850	13,986	66,217

[a] Includes chickpeas, field peas, haricot beans, horse beans, and lentils.
[b] Includes barley, maize, and sorghum

SOURCE: Data for Assab and Massawa were compiled by the consultant from monthly export records of the Marine Department, Ministry of Communications, while data for Djibouti were compiled from monthly export records of the Franco-Ethiopian Railway These data do not coincide exactly with quantities reported by other agencies.

exports has an important bearing on the freight rate shippers must pay to move the product to port. During this same five-month period, other important crops such as coffee and oilseeds are also moving to ports for export and thus compete with pulses for trucks and rail cars. Table 2 indicates the export movement of pulses during the months of November through March, 1969 and 1970.

TABLE 2. PERCENTAGE OF TOTAL ANNUAL EXPORTS SHIPPED IN THE FIVE-MONTH PERIOD, NOVEMBER-MARCH 1969 & 1970

	Percentage		Total Exported	
	1969	1970	1969	1970
	(%)		(mt)	
Coffee	55	60	88,528	70,860
Oilseed	56	56	56,090	56,314
Pulses	60	68	78,600	51,110

SOURCE: Percentages computed from export data of the National Bank of Ethiopia Quarterly Bulletin, No. 31 (89), September, 1971, pp. 42-43.

As truck and rail export rates are not regulated, the effect of this heavy demand for shipping during the five-month period is to substantially increase freight rates, especially by truck.

V. TRANSPORTATION CHARGES

A. Introduction

Rates are the same for transporting grains and pulses by domestic means, with the exception of rail movement from Dire Dawa to Djibouti, where rates on pulses are slightly higher (see Tables 3 and 4). There are no governmental or other regulations presently enforced that control rates charged for moving these products to local or central markets or to the ports for export. [10] Competitive factors, or the lack of them, largely determine the rates, and these vary in time and location.

The principal types of carriers are the two railroads, motor trucks, and pack animals. No distinction will be made between the different animal rates, since this information is not available. At times, donkeys, mules, and horses are used in the same train, although it is more common to use only donkeys and mules, as they travel at about the same speed.

Rates from the point of production to port usually result from a combination of at least two rates but may involve up to four or more. The first is the pack animal rate, which may be to a local market that is serviced by either an all-weather road, a dry-weather road, or a trail. During the wet season, the rate must be to an all-weather road or a railroad depot, the depot being used almost exclusively for through-haul to port.

B. Pack Animal Rates

Rates paid for pack animal transport are difficult to obtain because many transporters do not engage in a strictly for-hire type of operation. Farmers bring in their own produce and do not pay for transportation as such, or the product is brought in by another farmer, who purchases the products to add to his own. Another very typical operation is the peasant merchant, who buys from the farmer in very small lots, transports them to market, and sells to another middleman. His margin for transport is thus included in his gross margin.

A generalized statement that carrying charges by pack animals average over six times the truck freight rate on all-weather highways is often quoted in Ethiopia. Average rates, even on all-weather roads, are very deceiving since they vary so much, depending on time, length of haul, and nature of competition on a given piece of highway and in a specific location. It is estimated that about 80 percent of the grains and pulses received

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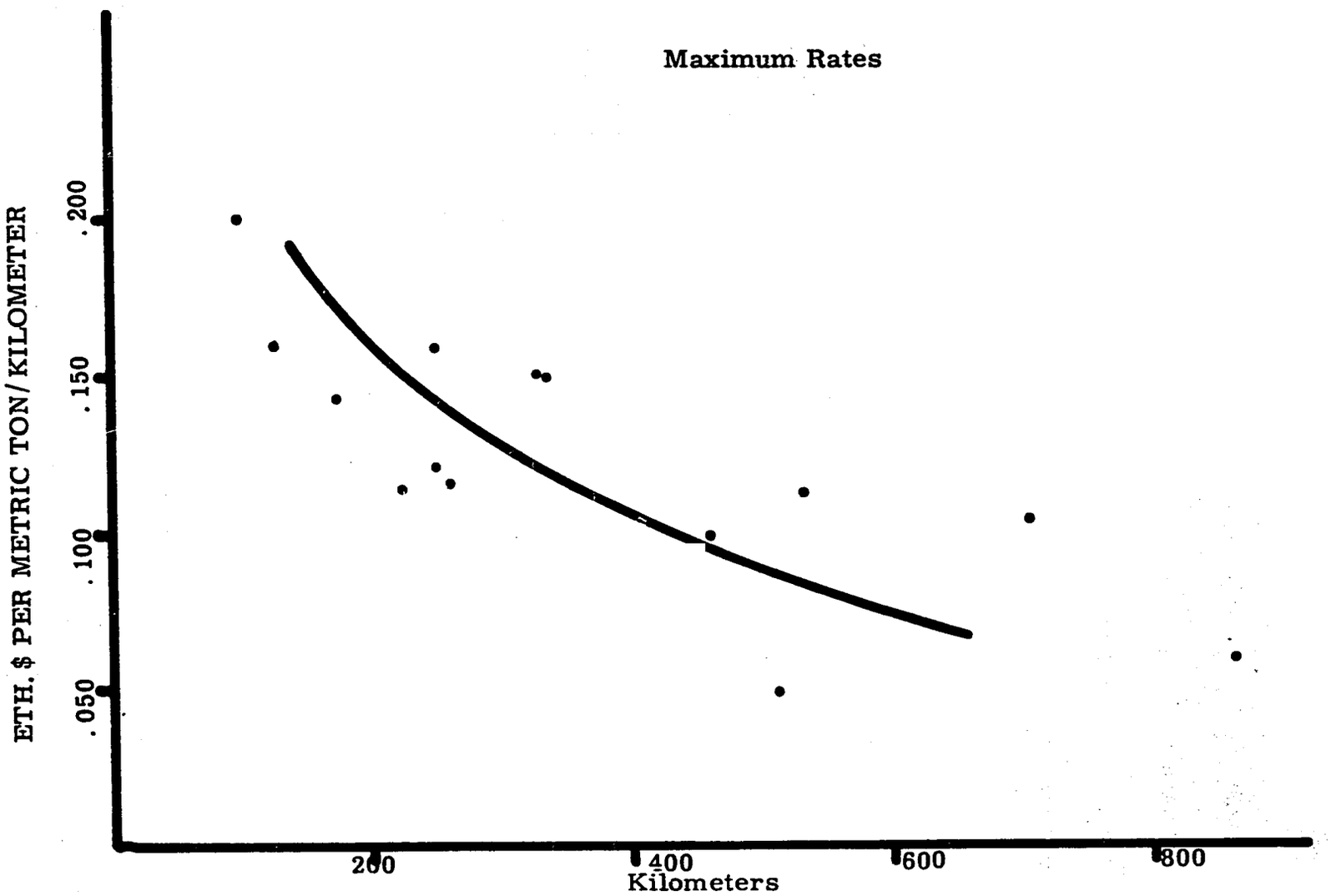
10/ In December, 1967, the IEG issued the Road Travel and Transport Proclamation which gives the government control over commercial road transport, including, among other powers, the right to fix and enforce tariffs. To date, this statutory authority over rates has not been exercised.

TABLE 3. MOTOR TRUCK RATES OF GRAINS AND PULSES [a]

From/To	Distance	Rates per Quintal			Metric Tons/Kilometer		
		Max	Med	Min	Max	Med	Min
	(km)	(Eth. $)					
Shashemene/Addis Ababa	249	3.00	2.50	2.00	0.120	0.100	0.080
Asella /Addis Ababa	175	2.50	2.00	2.00	0.143	0.114	0.114
Asbe Teferi/Addis Ababa	251	4.00	3.50	3.00	0.159	0.139	0.119
Nazaret /Addis Ababa	99	2.00	1.50	1.00	0.202	0.151	0.101
Jimma/Addis Ababa	335	5.00	4.00	2.50	0.149	0.119	0.075
Nekempte/Addis Ababa	331	5.00	4.00	3.00	0.151	0.121	0.091
Bako/Addis Ababa	258	3.00	2.75	2.50	0.116	0.106	0.097
Ambo/Addis Ababa	125	2.00	1.75	1.50	0.160	0.140	0.120
Addis Ababa/Assab	861	5.00	2.50	1.50	0.058	0.029	0.017
Korem/Dese	220	2.50	2.00	1.75	0.114	0.091	0.079
Dese/Assab	510	2.50	2.00	1.25	0.049	0.039	0.025
Korem/Asmara	460	4.50	3.50	3.00	0.098	0.076	0.065
Bahar Dar/Asmara	705	7.50	6.50	6.00	0.106	0.092	0.085
Gondar/Asmara	530	6.00	5.00	4.00	0.113	0.094	0.075

[a] From principal producing areas to transshipment points and ports.

FIGURE 1. RELATION BETWEEN MOTOR TRUCK RATES AND DISTANCE



SOURCE: See Table 3.

TABLE 4. HIGHWAY TRANSPORT TARIFFS ON PRINCIPAL ROADS IN ETHIOPIA, 1953 - 1967

Addis Ababa to:		Rates per Metric Ton		Metric Ton/Kilometer	
		1953	1967	1953	1967
	(km)	(Eth.$)			
Assab	861	75	15-40	0.087	0.017-0.046
Asmara	1,076	100	35-45	0.093	0.033-0.042
Dese	397	40	15-20	0.101	0.038-0.050
Jimma	335	60	15-25	0.180	0.045-0.074
Dilla	366	50	15-22	0.137	0.041-0.060
Nekempte	331	60	15-20	0.181 a/	0.045-0.076
Debre Marcos	305	50	15-20	0.164 a/	0.049-0.066
Nazaret	99	8-11 b/	2-5	0.081-0.111 b/	0.020-0.050
Nazaret to:					
Asella	76	25-30 b/	7.50-10	0.329-0.395 b/	0.099-0.132

a/ 1954 first available
b/ 1958 first available

SOURCE: Rates and Costs of Freight and Passenger Movement in Ethiopia, Planning and Programming Division, IEG, IHA, 1966.

at Dese are brought in by peasant merchants and about 20 percent by farmers. It is virtually impossible to obtain accurate costs of transportation by pack animals, but to give some idea of costs, two illustrations--dry-season and wet-season pack animal rates over substantial distances on rugged mountain trails--are shown:

	Dry-Season Rates			Wet-Season Rates	
	per quintal	mt/km	km	per quintal	mt/km
	(Eth. $)			(Eth. $)	
Borena/Dese	5-7	.417-.583	120	10-14	.834-1.167
Wereylu/Dese	4-5	.500-.625	80	8-10	1.000-1.250

C. Motor Truck Rates

During the dry season, it is not unusual for jeeps, large trucks, and tractor/trailers to penetrate some roads that are little better than trails. A cooperative in Kobo operating a tractor and trailer has been able to perform transport for a distance of 30 kilometers at a rate of Eth. $0.16 per metric ton/kilometer. However, on these roads, the truck rates are very much higher than on all-weather roads. For example, from Koshe to Zuai, 24 kilometers over a dry-weather road, the rate is Eth. $2.00 per quintal, whereas from Zuai to Addis Ababa, 160 kilometers via an all-weather road, the rate is Eth.$0.56 per quintal. Motor truck rates for grains and pulses moving from the principal producing areas to transshipment points and to ports range from a low of Eth. $.049 per metric ton/kilometer to a high of Eth. $.202 per metric ton/kilometer on the maximum scale. On the minimum scale, the low is Eth. $.017 and the high is Eth. $.120 per metric ton/kilometer (see Table 3). The rate per metric ton/kilometer for a short haul may be as much as seven times that for a long haul. Often there is a break point where the products must be unloaded for cleaning and grading and where ownership may change. In these situations, there are not applicable through-rates.

Rates are also influenced by local conditions. For example, the rate per quintal from Dese to Assab is much lower than might be expected by using the distance/rate relationship (see Table 3 and Figure 1). The reason is the greater flow of freight from the port than to it, and many empty trucks must go to the port. The truckers have hopes of picking up loads for their return trip until they get to Dese, which is the "last chance". Here they must strike a bargain or go the remainder of the way without a load.

On the Asbe Teferi/Addis Ababa route there is the opposite situation. Most of the freight goes from Asbe Teferi to Dire Dawa; therefore, a trucker hauling to Addis Ababa must take into account that he may return empty. Thus, he may set the initial rate high enough to cover the round trip.

It must be kept in mind that the trucker normally bargains with the shipper. When he has no alternative, he takes a low rate; when he can, he charges a higher rate. The latter occurs especially when coffee shipments are available. For example, after coffee shipments begin moving from Jimma to Addis Ababa, the rates are generally doubled. This reflects the ability of coffee to absorb the higher rates as well as the increased seasonal demand for truck transportation from other commodity exports such as oilseeds, fruits and vegetables, and hides and skins.

Motor truck rates have been decreasing over the years, not only because of improved vehicles and highways, but also because of increased competition (see Table 4). This is indicated in the following statement by the Imperial Highway Authority:

> "Perhaps the most important thing to be seen is the benefits brought by unrestricted competition in the trucking industry. Costs have been kept low and rates have been kept low and in line with costs, almost, it appears, at the expense of profit to the truck owner. Averaging the vehicle operating cost estimated on the Addis Ababa-Assab run of Natreco and an independent operator, we have a cost of Eth. $. 879 per vehicle/kilometer, or Eth. $0. 04 per metric ton/kilometer. It appears that rates per metric ton on the round trip are averaging Eth. $75 to Eth. $80 per metric ton, round-trip equivalent to Eth. $1. 00 per vehicle/kilometer or Eth. $0. 0455 per metric ton/kilometer. These are probably the lowest rates and costs in Africa. The National Transport Company functions in the nature of a cooperative serving its member truckers but rates are set by truckers individually."

D. Rail Freight Rates

Railroad freight rates vary with quantity shipped and are quoted on a metric ton basis in contrast to truck rates, which are based on quintals, regardless of volume. Full truck loads, however, are the general rule on movements to ports and on all but very short-haul, domestic movements of grains and pulses. The rates on the Franco-Ethiopian Railway, which runs from Addis Ababa to Djibouti, differ considerably from those on the Northern Ethiopian Railway, which runs from Agordat to Massawa. The nature of the competition is completely different for a variety of reasons, the most important being the truck competition.

Rail freight rates for grains and pulses via the Franco-Ethiopian Railway generally range from Eth. $16 to Eth. $25 per metric ton for 20 to 25-ton minimum loads (see Table 5). These are competitive rates that were put into effect to meet the growing competition from the truck-served port of Assab. Prior to the opening of Assab, the rail rates on

TABLE 5. RAIL RATES OF GRAINS AND PULSES

From/To	(km)	Rates per Metric Ton Max	Rates per Metric Ton Med	Rates per Metric Ton Min	Metric Tons/Kilometer Max	Metric Tons/Kilometer Med	Metric Tons/Kilometer Min
		(Eth. $)					
FRANCO-ETHIOPIAN RAILWAY							
Addis Ababa/Djibouti	781	25.00	20.00	16.00	.032	.026	.020
Debre Zeit/Djibouti	729	25.00	20.00	16.00	.034	.027	.022
Nazaret /Djibouti	678	25.00	20.00	16.00	.037	.029	.023
Dire Dawa/Djibouti	309						
Grains		20.30 a/		19.90 b/	.066		.064
Pulses		23.00		22.30 b/	.074		.072
NORTHERN ETHIOPIAN RAILWAY							
Agordat/Massawa	312		21.84			.070	
Keren/Massawa	226		15.82			.070	
Asmara/Massawa	122		8.54			.070	

a/ Minimum 20 metric tons
b/ Minimum 25 metric tons

SOURCE: Franco-Ethiopian Railway
Northern Ethiopian Railway

grains and pulses from Addis Ababa to Djibouti were Eth. $56.70 per metric ton for a 10-ton minimum, and Eth. $52 per metric ton for a 20-ton minimum. Recent changes in rail freight rates, designed mostly to meet truck competition are:

			Rate (Eth. $/mt)
Nov 1, 1969	-	Jan 5, 1970	20.00
Jan 6, 1970	-	Nov 23, 1970	22.50
Nov 24, 1970	-	Jan 26, 1971	16.00
Jan 27, 1971	-	Apr 3, 1971	20.00
Apr 4, 1971	-	Apr 23, 1971	25.00
Apr 24, 1971	-	Present (November 1971)	20.00

SOURCE: Franco-Ethiopian Railway

These rates reflect the factor of seasonality as well as truck competition, as can be seen from the increase of Eth. $16 to Eth. $20 on January 27, 1971, the midpoint of the heavy export movement for agricultural commodities.

The rates are the same from Addis Ababa, Debre Zeit and Nazaret and are for a minimum of 20 metric tons (Table 5). They remain the same for any quantity. Shipments are made in 20, 25 or 30-ton cars. The railroad also charges Eth. $24 to Eth. $36 for placing a car on a private siding or taking it off such siding. The rate is negotiated and depends on the length of the siding. 11/ At the port, 24 hours is allowed for discharging the cargo, after which a demurrage charge may be assessed.

From Dire Dawa to Djibouti, where no truck competition exists, the rate for pulses is Eth. $22.30 to Eth. $23.00 per metric ton. For grains the rate is Eth. $19.90 to Eth. $20.30 per metric ton. The lowest rate, which reflects truck competition via the port of Assab, is Eth. $.020 per metric ton/kilometer from Addis Ababa to Djibouti. Where there is no competition from trucks, direct or indirect, the rates per metric ton/kilometer may be more than three times as high. The rates on the Northern Ethiopian Railway are a flat Eth. $.070 per metric ton/kilometer. (See Table 5).

All grains and pulses are shipped in sacks, as the railroads have no bulk-handling facilities nor are there any present plans to acquire any such facilities. In a recent import shipment of bulk grain, it was necessary to bag the grain before reshipment inland by rail.

11/ Most cars, however, are loaded or unloaded from the railroad's own holding tracks (team tracks), since there are very few private sidings.

E. Miscellaneous Charges Related to Transport

Whether using truck or rail, it is necessary to employ special workmen to load and unload the cargo, since neither the trucker nor the railroad renders this service. Where no weighing is involved, the rate for either loading or unloading is Eth. $0.10 per quintal (sack). Where there is weighing, there is an additional charge of Eth. $0.05. In certain areas, where and when heat is considered excessive, there is a further charge of Eth. $0.05, making a total possible additional charge of Eth. $0.20 per quintal. Local transport rates among dealers, to and from storage and to the railroad, may range from Eth. $0.15 to Eth. $0.50 per quintal, depending upon distance, quantity, etc.

Another charge collected in many communities, is for the services of a truck broker, who brings trucker and shipper together. He usually collects Eth. $10 per ten-ton load and Eth. $20 per truck and trailer load of 22 metric tons from the shipper, and at times, he collects a like amount from the trucker, who, however, must absorb this in his transport charge.

F. General Conclusion

Though the Franco-Ethiopian Railway has reduced rates to meet truck competition, this is not the only consideration in choosing between the two. When the rail rate was reduced to a low of Eth. $16 per metric ton, the truck rate then went down to Eth. $15. Further, there is an additional local charge for transport to the railroad and an extra loading and unloading charge. The truck owners can also strike a bargain with an individual prospective shipper on the spot without extending the rate to others, as the railroad must do when it announces a rate to the public. With regard to service, the truck can be much more flexible in terms of time and place; as the railroad offers no door-to-door delivery service, and there are large segments of the country beyond the reach of the railroad. The port handling charges at Assab are lower than at Djibouti, which gives the trucks some further advantage. These charges have been kept low in order to attract traffic, and they are reported to be well below cost.

VI. RELATIONSHIP OF RATES TO COSTS

The operating costs of commercial motor carriers, as computed in the General Road Study, are Eth. $. 043 per metric ton/kilometer for a truck/trailer combination of 22 metric tons and Eth. $. 052 per metric ton/kilometer for a 10-ton truck (assuming a 100-percent load factor)[12/]. These data cover all costs of operation on a flat/rolling paved highway. Adjustments for a gravel surface and mountainous terrain, such as that experienced over much of the Addis Ababa-Assab route, increase the costs for the truck/trailer combination to Eth. $. 055 per metric ton/kilometer, with those of the 10-ton truck rising approximately in proportion.

When a per metric ton/kilometer cost of Eth. $. 055 is applied to the Addis Ababa-Assab route, a round-trip operating cost of Eth. $95 per metric ton is obtained. This compares with a seasonal range of Eth. $15 to Eth. $50 in the truck rates on exports to Assab and fixed rates on imports ranging from Eth. $48 to Eth. $80, depending upon the value of the commodity (Table 10). By assuming the midpoint of the export and import rates, a total revenue of about Eth. $97 per metric ton is indicated. This compares with costs of Eth. $95 per metric ton. In those cases where the minimum export rate applies, and assuming the same midpoint for imports of Eth. $64 per metric ton, total revenue per round trip would equal Eth. $79.

The above calculations of costs are somewhat understated, since they assume a 100-percent load factor. The load factor for petroleum tanks on this route is 50 percent and that for dry cargo carriers is higher but still less than 100 percent.

Operating costs for the Franco-Ethiopian Railway were estimated at Eth. $. 644 per metric ton/kilometer in 1967/68. For the Addis Ababa-Djibouti route of 781 kilometers, this gives a metric-ton cost of about Eth. $50 for a one-way trip and compares with the rail export rate on cereals and pulses for the same distance of Eth. $16 to Eth. $27 per metric ton. The rates on imports appear to range between Eth. $40 and Eth. $60 per metric ton. Utilizing the midpoint of this rate, plus the midpoint of the pulse and cereal export rate, gives a total round-trip revenue per metric ton of about Eth. $72. This compares with the round trip rail costs between Addis Ababa and Djibouti of about Eth. $100 per metric ton. To offset these low rates, rail rates to interior points are substantially higher than the export rates.[13/]

12/ Appendix Vol. 7, p. 12.9 - 40.

13/ Annual Report, Franco-Ethiopian Railway, 1969/70, p. 29.

Although cost data were available for the Northern Ethiopian Railway, the difficult terrain over which it operates plus the poor condition of the physical plant probably result in costs of at least half again as great as those of the Franco-Ethiopian Railway. 14/

14/ General Road Study, Vol. 2, p. 29, 1.

VII. POSSIBILITIES FOR INCREASING THE EFFECTIVENESS OF THE TRANSPORT SYSTEM

Increasing the effectiveness of the transport system would have a direct effect on the transport of pulses and grains. It would also have much broader implications, including the improved welfare of most of the agricultural community, which in turn is reflected in the national economy. These implications are made clear as the various possibilities of improvement are discussed.

A. Low-Cost Farm-to-Market and Penetration Roads

1. The Need

One of the most urgent needs of the Ethiopian transport system is the construction and improvement of low-cost penetration and farm-to-market roads. If accomplished, this will greatly increase the effectiveness of the system in serving much larger segments of the population and will also result in substantial savings in transport costs. The ultimate success of the proposed project in increasing the export of pulses depends partly on the access of promising production areas to truck transportation for moving products out and bringing in the necessary production supplies. The present dependence of the farm community on high-cost, slow-moving pack animal transport is an obstacle to development of commercial farming. This obstacle can best be overcome by emphasizing a program of low-cost farm-to-market roads in contrast to the present high-cost feeder road program of the Imperial Highway Authority (IHA).

2. IHA Feeder Road Design Standards and Costs

The existing design standards that the IHA applies to its road system have very little relationship to the anticipated volume of traffic to be carried. For example, the existing feeder road standards apply to an average daily traffic (ADT) of up to 200 vehicles per day (see Appendix Table A-4). Most of the farm roads in Ethiopia will not have even one-quarter of this volume of traffic over the next ten years. The application of these excessive design standards greatly increases the construction costs of the roads; thus, the IHA is providing very few kilometers of feeder roads for the expenditures it is making. [15/]

15/ During the first year of its Third Five-Year Plan, IHA constructed only 281 kilometers of feeder and service-to-traffic roads (60 percent of the year's programmed work); in the second year, 211 kilometers; and in the current year (the third year of the plan) the total is expected to drop to 112 kilometers, according to the IHA approved budget.

The Imperial Highway Authority currently estimates the construction costs of feeder roads on different types of terrain as follows:

Terrain	Average Cost per Kilometer Eth. $
Flat	39,559
Rolling	48,431
Hilly	94,838
Mountainous	166,175

For the Agaro-Gera feeder road in Kefa Province, which has been submitted to the World Bank for financing, the average cost per kilometer is about Eth. $110,000 over the 48 kilometers involved.

Among the major factors in the design standards that result in these high costs are: design speeds ranging from 30 to 40 kilometers per hour in mountainous terrain and up to 60 to 80 kilometers per hour in flat terrain; gradients of 6 to 10 percent in mountainous terrain and down to 4 to 8 percent flat terrain; a crushed stone surface of six meters in width (natural gravel is nonexistent in many areas); and expensive pipes, culverts and bridges.

3. Alternative Designs

a. Nicaragua. A recent feasibility study of farm-to-market roads in Nicaragua, Central America, in mountainous areas with a large amount of rainfall, recommended the following standards for an all-weather road, with an anticipated ADT of 100 vehicles, which was expected to be reached near the end of the projected ten-year period. 16/

Some of the key design specifications from the Nicaraguan study are:

Minimum Roadway Width..... 3.50 meters to 4.50 meters
Average Daily Traffic..... Max. 100
Maximum Grade:
- Level Terrain 6 to 8 percent
- Rolling Terrain to 12 percent
- Mountainous 12 to 15 percent

Design Speed
- Level Terrain 50 kilometers per hour
- Rolling Terrain 40 kilometers per hour
- Mountainous 30 kilometers per hour

Width of bridges 3.50 meters

16/ Ministry of Public Works, Plan for Improvement of Farm-to-Market Roads in Nicaragua, Report prepared by Consultora Latinoamericana Ltd., Guatemala, C.A., 1970/71.

In the above study, construction costs per kilometer were estimated to range from Eth. $15,950 to Eth. $49,000, with an average of about Eth. $37,500.

These costs, through the application of lower design standards, represent a reduction of two-thirds in the costs per kilometer, which the Nicaraguan government had been paying previously for their feeder road program.

b. Tanzania. A study of feeder road development in six areas of Tanzania in 1969 proposed design standards (Table 7), which are based on projected ADT's of under 10, 10 through 49, and 50 through 99. Higher design standards were proposed in the same study for ADT's of 100 through 149 and over 150.[17/] The standards for the minor feeder and penetration roads (ADT's below 50) allow for stage construction. The recommended improvements were also designed to conform to the general topography, which greatly reduces the heavy and extra-heavy grading. Estimated construction costs are shown in a review of three of the recommended projects (Table 6).[18/]

TABLE 6. ESTIMATED CONSTRUCTION COSTS FOR DEVELOPING FEEDER ROADS

Length (km)	Terrain	Structures	ADT	Surface (cm)	Avg. Cost (Eth. $/km)
29.0	Rolling to Hilly	62 metal pipe culverts	10	Gravel-10	14,642
56.3	Hilly	175 metal pipe culverts plus two single-lane, 20-foot span bridges and one 40-foot span.	10	Gravel-10	23,001
30.6	Hilly to Mountainous	62 metal pipe culverts plus four bridge-type culverts	25	Gravel-10	19,123

Construction costs for all minor feeder penetration roads in the program (516 kilometers) averaged Eth. $8,780 per kilometer.

Soil conditions on much of the above three roads are characterized by black cotton and plastic clays, thus gravel surfaces are recommended. Subgrades must also be properly shaped and compacted and adequate ditches constructed. The improvements apply to roads that in some cases, are only two-wheel tracks or footpaths.

17/ United Research Company, Vol. I, Chapters I-VII, Exhibit 1-8.

18/ Ibid. p. 21.

TABLE 7. PROPOSED DESIGN STANDARDS FOR FEEDER ROAD DEVELOPMENT

	Average Daily Traffic (ADT)					
	Under 10		10 through 49		50 through 99	
	Min.	Desirable	Min.	Desirable	Min.	Desirable
Design Speed (mph)						
Flat to Rolling	-	-	30	-	40	-
Hilly	-	-	20	-	30	-
Mountainous	-	-	-	-	20	-
Max. Gradients (%)						
Flat to Rolling	8	-	7	-	6	-
Hilly	10	-	9	-	8	-
Mountainous	12	-	11	-	10	-
Min. Radius (meters)a/						
Flat to Rolling	-	-	61.0	-	121.9	-
Hilly	-	-	30.5	-	61.0	-
Mountainous	-	-	-	-	30.5	-
Stepping Sight Distance (meters)						
Flat to Rolling	-	-	61.0	-	83.8	-
Hilly	-	-	42.7	-	61.0	-
Mountainous	-	-	-	-	44.2	-
Width of Surfacing (meters)b/						
Flat to Rolling	3.1	4.3	4.3	4.9	4.9	5.5
Hilly	3.1	3.7	3.7	4.3	4.3	5.5
Mountainous	3.1	3.1	3.1	3.7	3.7	4.9
Width of Roadway (meters)						
Flat to Rolling	4.9	6.1	6.1	6.7	6.7	7.9
Hilly	4.9	5.5	5.5	6.1	6.1	7.9
Mountainous, mod. cross slopes	4.3	4.9	4.9	5.5	5.5	7.3
Mount., steep cross slopes c/	3.7	3.7	3.7	4.6	4.6	5.8

a/ Based upon 10% superelevation.

b/ Width, if surfacing is provided. Does not include shoulders which are included in width of roadway.

c/ Width shown does not include four-foot wide concrete or masonry paved gutter next to face of roadway cut.

c. WADU. In addition to the above examples of low-cost design standards for farm-to-market and penetration roads, even lower cost construction work is underway at the WADU project (Wolamo Agricultural Development Unit) near Sodo in the southern part of Ethiopia. For many of Ethiopia's farm-to-market and penetration roads, the type of construction being conducted at WADU is perfectly adequate. These are unsurfaced, laterite roads, six meters in width from shoulder to shoulder, with lateral drainage provided. On some sections of the road where there is black cotton soil, aggregate will be added to the surface.

Locally made cement pipes are used for culverts in passing both the dry-weather and smaller permanent stream flows. Along with culverts and small, open-span bridges, paved and unpaved fords are also being constructed. With the exception of the steel reinforcing bars for the cement deck of the bridge, only local materials (stone, gravel--obtained by breaking stone by hand, and wood) are used in the culvert, ford, and bridge construction. Construction equipment at present consists of two bulldozers, two graders, one loader, and one dump truck. All of these are used for clearing and leveling agricultural land also.

The average construction cost per kilometer is estimated by the officials of the WADU project to be about Eth. $2,500 per kilometer, assuming a reasonable number of single-pipe cement culverts. The annual maintenance cost per kilometer is estimated to be Eth. $200 to Eth. $250, which involves a light grading about four times per year and cleaning the ditches.

Depending upon the availability of local construction materials, topography, type of soils, drainage and stream crossings, etc., construction costs in some areas of Ethiopia may be two or three times those of the WADU project; but even so, the costs per kilometer would still be only ten percent of the amount the IHA is currently spending on its feeder road program.

4. Recommendations

a. Although the WADU project is fortunate in having laterite readily available, there are other areas which also have satisfactory materials for this type of low-cost road construction. The essential element at this time is that the IHA and other government agencies recognize the value of these low-cost roads to the national economy in general and the agricultural community in particular. An active program should get under way as quickly as possible that is in cooperation with the provinces and on a priority-determined project basis.

b. For the longer run, a fully equipped soils laboratory should be established to determine the characteristics of the local soils and other construction materials. At the same time, experiments should be carried out in the construction of various low-cost types of pipes, culverts, fords and bridges utilizing local materials.

c. The need for feeder roads is overwhelming. For the Minimum Package program, alone, an estimated 13,000 kilometers of new roads will be required over the next 25 years.

d. Further recommendations relate to the maintenance of these non-surfaced or partially surfaced farm-to-market and penetration roads. Specifically, rain barrier gates, manned by responsible local people, must be established in order to keep vehicular and animal traffic off the roads immediately after a heavy rain. [19] In the WADU area, two to three hours after a rain are thought to be enough time for the road to be dry enough for light traffic, but the length of time will vary from area to area. Without such rain barriers, the new roads will soon be heavily rutted and become impassable.

e. It is also recommended that the roads be graded at the end of a rainy season, while there is still adequate moisture for soil compaction.

B. Need for Connecting Centers of Production

An examination of the Highway Map of Ethiopia reveals that the basic road network is centered around the two large cities of Addis Ababa and Asmara, with the roads radiating out from these two hubs as the spokes of a wheel. In the rural areas away from these hubs, lateral transportation between the major spokes of the network is, in most cases, impossible because of the lack of roads. Major production centers in many cases thus have no direct link with each other. Direct links would facilitate the exchange of commodities between surplus and deficit areas, reduce transportation costs, and tend to smooth price fluctuations.

It is recommended that future highway planning make provision for gradually linking up the various centers of production. Low-cost, all-weather roads utilizing a gravel surface and employing stage construction methods will serve this purpose very well.

C. Maintenance of All-Weather Roads

The asphalt surfaced portion of Ethiopia's all-weather road system is poorly maintained over certain lengths of the country. Personal observations by the consultant, who traveled over several hundred miles of the system by jeep, revealed lengths where the asphalt surface was completely broken up; while in other lengths, less serious failures were noted. These conditions probably stem from both lack of maintenance and poor construction. In some sections shoulders were not maintained, and in areas where the level of the shoulders had dropped below the running surface, the edges

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[19] Such rain barrier gates are used very successfully on the Fort Lamy-Maiduguri road, connecting northeast Nigeria with Chad.

of the asphalt surface had broken off. These become dangerous areas when vehicles are passing. Lateral drainage ditches were also nonexistent in some cases and in others, had not been cleaned.

The rough running surface has a very deteriorative affect on tires, shock absorbers, springs, axles and, in fact, the entire running mechanism and body of the truck. This makes for high operating costs, which in the medium to long run, must be reflected in higher rates, even under competitive conditions.

In contrast to the poor maintenance on many sections of the paved roads, maintenance on the gravel roads appears to be very adequate.

The General Road Study recommended a general increase in maintenance funds in accordance with the IHA formula, which reflects a flat amount per kilometer, whether paved or gravel surface, plus an additional sum reflecting the average daily traffic. 20/ Special grants were recommended for paved roads in poor condition, and it was further recommended that the "resealing" element of the maintenance allocation be accounted for separately. The study also recommended that IHA take over maintenance of local roads in the near future, both earth and gravel surface types. 21/ If both of these actions are taken, they should tend to reduce operating costs of the motor carriers, and in the case of maintenance of the local roads, improve the access to and frequency of truck service to local markets and production areas.

D. Better Utilization of the Transport System

1. Improved Load Factors

Improved utilization of the transport system makes for lower operating costs, which normally result in lower rates to shippers, especially in the generally competitive situation prevailing in Ethiopia. For example, (Table 5), the drastic drop in trip times between 1953 and 1966, due to improvement of dry-weather roads to all-weather standards, was followed by sharp reductions in the truck rates (Table 4). This was possible largely because the trucker was increasing the utilization of his equipment.

The results of an origin and destination survey, performed in February and March, 1969, under the General Road study, indicate there is still room for improvement in utilization. Load factors on the major road routes were found in the survey (Table 8).

20/ General Road Study, Vol. 3, p.5, 6-8.

21/ Ibid., p. 5, 6-9.

TABLE 8. LOAD FACTORS ON MAJOR ROAD ROUTES

Route	Inbound a/		Outbound b/	
	Empty trucks as a proportion of all trucks using routes	Ave. load for trucks carrying goods	Empty trucks as a proportion of all trucks using routes	Ave. load for trucks carrying goods
	(%)	(mt)	(%)	(mt)
Assab-Addis Ababa	4.0	19.7	64.6 c/	19.7
South Shewa-Addis Ababa	28.5	6.9	79.0	7.0
West Shewa-Addis Ababa	39.5	8.2	78.8	5.5
Southwest Shewa-Addis	25.0	7.6	60.6	8.3
Jimma-Addis Ababa	24.4	10.7	19.7	9.8
Gojam-Addis Ababa	11.9	9.7	56.2	7.2
Sidamo-Addis Ababa	27.5	9.3	34.0	6.7
Asmara-Massawa	31.8	7.5	7.6	1.8
North Eritrea-Asmara	41.8	10.9	44.7	9.9
Asmara-Addis Ababa	15.9	17.3	15.2	16.3

a/ Inbound is to Addis Ababa or Asmara.

b/ Outbound is from Addis Ababa or Asmara.

c/ One reason for this high percentage is that petroleum products account for 39 percent of the total weekly traffic. For these tankers, the outbound movement is an empty return haul to the refinery at Assab.

SOURCE: Volume 2, Draft Final Report, General Road Study, p.2, 4-12.

The previously cited origin and destination study showed that pulses, as a percentage of the total weekly volume, ranged from one percent on the Sidamo-Addis Ababa and Massawa-Asmara routes to five percent on the Addis Ababa-Asmara and six percent on the Addis Ababa- Assab route. On three routes, South Shewa-Addis Ababa, Gojam-Addis Ababa, and North Eritrea-Asmara, no pulses were reported.

In this survey, cereal movements were found to be much heavier than those reported for pulses. The Gojam-Addis Ababa route reported cereals as 45 percent of the total weekly movement; North Eritrea-Asmara, 32 percent; South Shewa-Addis Ababa, 17 percent; Southwest Shewa-Addis Ababa, 14 percent; and Jimma-Addis Ababa, 12 percent. All of the remaining major routes reported

percentages ranging from one to nine percent, with the former being the Addis Ababa-Assab route. Practically no cereals are exported through Assab; this is confirmed by the origin and destination study.

2. Off-Season Movements by Shippers

Based upon survey results, it would appear that there is ample opportunity for the exporters of pulses and cereals to ship via the port of Assab and take full advantage of the lower off-season rate. On this route the trucks have a low load factor on the outbound movement.

Similarly, discussions with officials of the Franco-Ethiopian Railway indicated that the railroad was operating at capacity only about three months of the year; this was during the heavy shipping season, December to March. At the same time, export traffic on that route has been declining since 1965, while imports have had a general upward trend. To try to offset the decline in exports, the railroad has introduced low seasonal rates.

From the discussion of seasonality of export movements of pulses and cereals, it does not appear that the exporters are presently taking full advantage of low truck and rail rates. Of course, there may be other considerations of greater economic importance; e.g., the condition of the world market at the time and the lack of storage.

3. Removal of Restrictions on Truck Operations in Eritrea Province

Better utilization of the transport system can also come about through eliminating the restrictions imposed by the Northern Ethiopian Railway on the operations of truckers to the port of Massawa, as well as throughout Eritrea Province. At the present time, trucks are not allowed to carry goods between Asmara and Massawa without authorization and payment of a license fee to the Northern Ethiopian Railway (NER). Licenses are granted by the railroad only when it is unable to carry all the traffic. The railway also controls the operation of the trucks throughout Eritrea Province through the same licensing procedure, even though the other road traffic may not be directly competitive with the railway. These license fees are reported to provide over ten percent of the NER's annual revenues.

In spite of this monopolistic control and near capacity operation, the railroad has run up a substantial deficit over the past four years. Much of this deficit stems from high operating costs--which reflect the short distance and difficult terrain over which the railroad operates, 22/ the poor

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22/ In the 115 kilometer section between Asmara and Massawa, there are 30 tunnels, 35 bridges and 667 curves with a minimum radius of 70 meters.

condition of the track and road bed, the small capacity and age of its rolling stock (mostly 50 to 70 years), and the slow conversion to diesel power. Since 1952, the railroad has been operated by the Ministry of Communications.

This type of monopolistic control of transport hampers the overall development of the province, including the port of Massawa, Asmara and the agricultural community.

4. Opening of the Awash-Tendaho Highway

The Awash-Tendaho Highway traverses the middle valley of the Awash River in the west central portion of Ethiopia and will connect Awash Station on Route 4 of the Nazaret-Dire Dawa road with Tendaho on Route 2 of the Addis Ababa-Kombolcha-Assab road. The new route is 303 kilometers long and will have an asphalt surface. It is expected to be opened to traffic in September, 1973.

This highway will provide ready access to a promising area, in which development is already underway or planned with such crops as maize, cotton, sugar cane, fruits and vegetables, and haricot beans. It will also provide a valuable alternative route to the port of Assab from such major internal shipping areas as Addis Ababa, Nazaret, Asella and Shashemene. The distances from these points will be shorter, as shown in Table 9. Of even greater importance, however, is the fact that the new paved route passes through the flat rolling terrain of the Awash Valley; this is in contrast to the present Addis Ababa-Kombolcha-Assab route, in which a substantial portion is rough, mountainous gravel road. This difference in terrain is especially reflected in the estimated savings in travel time. Over the new route, time savings of as much as 50 percent have been estimated between Addis Ababa and Assab.

Estimated savings in operating costs for a 22-metric ton, truck/trailer combination over the new route versus the existing route are expected to range from 25 percent to 40 percent. These prospective savings are based upon calculations for four of the major routes to Assab, with origins at Addis Ababa, Nazaret, Asella and Shashemene. The savings are based on average per metric ton/kilometer costs of Eth. $. 055 for the existing Addis Ababa-Assab route, as compared with Eth. $. 043 per metric ton/kilometer estimated for the new route (from the General Road Study). All distances south of Addis Ababa were computed at the rate of Eth. $. 043 per metric ton/kilometer on the assumption that this portion of the road is about equivalent to the new road.

A comparison of truck/trailer costs when utilizing the new road, with the maximum and minimum export and import rates in effect over the existing route, shows that the combined round-trip rate, even at the minimum level, exceeds the truck costs for three of the four routes (see

TABLE 9. DISTANCES TO THE PORT OF ASSAB

From	Via Kombolcha (Existing Route)	Via Awash (New Route)
	(km)	(km)
Addis Ababa	861	830
Nazaret	928	731
Asella	992	795
Shashemene	1,106	935
Ambo	973	942
Bako	1,072	1,041

SOURCE: Imperial Highway Authority

Table 10). The exception is Assab-Addis Ababa, with costs at about 13 percent above the round trip minimums. This is not a serious matter, however, since officials of the National Transport Company, the trucking cooperative, reported that if their members received a low-rate import load on one trip, the port officials would give them a higher rated load on the next trip. Thus, over the year they may about average out near the mid-point of the import range, or about Eth. $64 per metric ton. Under these circumstances, the minimum export rates could be lowered by perhaps 30 percent after allowing for a downward adjustment in the 100-percent load factor. The possibility of such a rate reduction would also depend upon whether the Imperial Ethiopian Government wishes to continue its high rates on imports, which in effect, subsidizes the exports. The present rate policy is consistent with the objective of improving the balance of payments.

TABLE 10. COMPARISON OF TRUCK/TRAILER OPERATING COSTS OVER THE NEW ADDIS ABABA-AWASH-ASSAB ROUTE WITH TRUCK RATES OVER EXISTING ROUTE

Route	Truck/Trailer-22 ton-Round Trip Operating Costs Over New Route a/	Export Truck Rates Over Existing Route	Import Truck Rates b/ Over Existing Route	Total
	(Eth. $ range per metric ton)			
Addis Ababa-Assab	71	50-15	80-48	130-63
Nazaret -Assab	63	70-25	80-48	150-73
Shashemene-Assab	79	80-35	80-48	160-83
Asella-Assab	68	75-35	80-48	155-83

a/ Based on metric ton/kilometer costs of Eth. $. 043.

b/ Rates to Addis Ababa only. Assume truck/trailer travels empty to pick up pulses south of Addis Ababa.

5. Bulk Transportation

At present there is no handling or transportation of pulses and cereals in bulk in Ethiopia. But the possibility of converting existing warehouse space to bulk handling and storage by installation of banks of small metal silos has been suggested in the series of reports listed in the Preface hereof. These bulk facilities could be used for handling grain for domestic consumption since very little is exported, as well as for imports of wheat; however, because of damage from breakage and abrasion, bulk handling is not considered suitable for pulses.

One method of bulk handling and transportation of pulses is through the use of containers. The possibilities of shipping bagged pulses in 40-foot containers should be thoroughly investigated. These containers could be used for bringing in imports and then filled with pulses, oilseeds, and even grain for the return movement. In the United States, for example, soybeans in bulk are now being shipped to Japan in containers on an experimental basis.

Officials of the Franco-Ethiopian Railway reported that they would experience no difficulty in handling containers of this size on flat cars over the Addis Ababa-Djibouti route. They also reported that by 1973 the railroad will have purchased four new diesel locomotives of 2,000 horsepower each, 100 flat cars, and 50 additional covered wagons (box cars). Forty-foot containers could also be transported by flat-bed trucks to or from Assab.

Railroad officials also reported that they have 55 steel box cars of 30-metric ton capacity on hand, of which about half are only five years old; the other half are nine years old. Some of these cars were inspected by the consultants and were found to be in excellent condition for hauling grain; they were lacking only grain doors, a minor item. In order to utilize these cars for transporting the present large wheat imports and, hopefully, increased exports of oilseeds and perhaps even cereals in the future, loading and unloading facilities must be installed at the port and at major shipping points. 23/

23/ The present charges at the port of Djibouti for bagging wheat in the ship's hold and transferring it to rail cars alongside the pier or to an adjacent warehouse is DF 1,400 (Djibouti francs) per metric ton. About 87 francs equal one Ethiopian dollar; thus, the charge is about Eth. $16, or US$6.40 per metric ton.

REPORT NO. IV

PART B

Processing and Storage of Ethiopian Grains and Pulses

I. SUMMARY AND RECOMMENDATIONS

1. New and/or additional facilities will be required in Ethiopia to process and store the added production of cereals and pulses required for domestic use and for export. These facilities should be designed in such a way that they may be adapted to bulk handling at some later date (such designs are included in the report).

2. Improved processing of pulses is essential to any program aimed at a substantial increase in exports. Ethiopian pulses can be upgraded through more efficient cleaning and sizing (calibration). Bulk handling of grains should lead to lower marketing costs.

3. Small storage units for individual farms are necessary. Bins of 5-metric ton and 12-metric ton capacity can be constructed at a cost of about Eth. $50 and Eth. $150, respectively. They may be used for storing a variety of crops.

4. Farm storage and processing units with up to 1,200 metric tons capacity are suggested for the large-scale commercial farms. The crops placed in these large bins may require in-storage drying; this can be accomplished through use of fans and special construction that provides aeration. These units may be used to provide service for other farmers on a fee basis.

5. Marketing and service centers are proposed for selected central locations in the rural areas. At these centers, the services provided may include storage, cleaning, calibrating, sale of farm supplies, purchase of farm products, and office space for credit and extension personnel. Storage capacity of the units recommended ranges from 7,200 metric tons to 26,000 metric tons, with provision for easy expansion in the midrange. Costs of construction are estimated at about Eth. $25 per metric ton of capacity. The design proposed is particularly adapted to bulk handling of farm products, especially grains and certain oilseeds and pulses.

6. Holding and/or warehousing space at the ports of Assab, Massawa and Djibouti is considered adequate to accommodate any increase in exports of farm products likely to occur in the near-term future (up to five years).

II. INTRODUCTION

An orderly, efficient marketing system for domestic distribution and for export of cereals and pulses in Ethiopia will eventually require the construction of a network of storage, handling, and processing facilities. Such a system would involve at least four types and sizes of units:

1. Small commercial farm storage--5 to 12 metric tons
2. Large farm storage and processing units--600 to 1,200 metric tons.
3. Rural marketing center storage and processing facilities (to serve also as agricultural supply centers) expandable to 20,000 to 30,000 metric tons.
4. Port holding or warehousing of 10,000 to 20,000 metric tons.

Obviously, the larger units should serve for handling all grains (cereals and pulses) produced on the farms or in the regions to be served by them. Under special programs, however, they may be specially designed to handle and process certain products; e.g. beans and other pulses. Pulses are more fragile and subject to breakage than most other grains such as wheat, maize, or sorghum and require special handling to avoid damage. Throughout the world most port and interior handling and shipping equipment for bulk grain is designed to handle the more durable grains; dried pulses are almost universally shipped in sacks. The ports serving Ethiopia now have adequate sack warehousing facilities for the present or prospective exports of cereals and pulses; they will serve the purpose for some time, with few, if any, changes.

For the interior rural marketing centers or the large, on-farm storage and processing units, however, there is need to develop new facilities for pulse cleaning and sizing, along with more efficient handling and storage of grains in general. The increased quantities of all grains expected to be marketed and the sack shipment required for pulses will logically call for both sack and bulk handling and storage facilities. The provision for both bulk and sacked grain storage units should therefore be considered. In view of the substantially increased production anticipated, this combined-type storage facility should be conveniently and efficiently expandable.

Plan-sketches of suggested designs for rural center storage units that will meet the above and other basic requirements are presented in Appendix B of this report. (Figures B-1, B-2, B-3 and B-5). The proposed units are briefly described and discussed below.

III. PROCESSING AND STORAGE NEEDS

A. Storage for Small Commercial Farms

A five-metric ton bin built with eight sheets of galvanized metal roofing, one meter by two meters, with two cross-partitions to form four bins, is proposed for this purpose (see Figure B-1). This small storage bin would require the purchase of metal, wire, lumber and rails at a probable total cost of less than Eth. $50, providing the materials are purchased in quantity by some organization or agency, and sold to the small producer at cost, in a storage promotion program. This roofless, four-bin unit, about two meters in diameter and two meters high, would need to be placed in another building, preferably in a room of the family house. With a well-fitted rock base and/or a hard-packed chika, this bin would be rodent-proof. By use of a moistureproof sheet to cover the surface of the grain, any properly dried grain could be kept for long periods of damp or rainy weather. If one or more of the small bins were to be kept full or unopened for more than four months, then those bins should be treated against possible insect infestation at the time they are filled.

If lighter than 28-gauge corrugated roofing is used, it should be stiffened and protected by the application of perhaps two coats of cement-sand plaster or chika to the outer wall surface. The spirally wound wire reinforcement would hold the plaster or chika until hard, and this in turn would hold the wire in place. The bin would be filled and emptied through the top, and at least two of the partitions could be made easily removable to facilitate emptying. More conveniently accessible flat storage can be constructed, but the cost would be higher.

A 12-metric ton bin (Figure B-2) can be built in a similar manner; but being larger it should probably be located away from other buildings. This bin would require its own roof, which could well be either a single slope or gable-type roof, supported on small poles placed inside the bin where they would also serve to support the cross partitions, as shown in the plan-sketch. Wire netting or fencing material, or coarse bamboo matting could be used to enclose the open areas between the bin and roof, which would offer protection against birds or other predators. In any event, the space above the bin should be sufficiently open to provide good cross-ventilation. As suggested for the smaller bin, the surface can be protected during damp weather by a removable plastic covering. A thin coat of concrete or plaster placed on a concrete base floor or well-packed dirt fill inside and outside the bin after the wall is in place would protect, seal and permanently hold the lower edge of the metal wall. Small discharge openings with well-fitted small steel slide gates could be formed into the concrete below the bottom edge of the bin wall to provide for grain removal from the bottom of the bin.

The cost for materials for this bin is estimated to vary from Eth. $125 to Eth. $175, depending upon the amount of concrete used and the type of roof and partition construction.

B. Large Farm-Storage and Processing Units

With the advent of the sweep auger, which provides both mechanical and central unloading of round bins, very large or giant-size, cylindrical grain bins that are structurally adequate are now being designed and built with relatively light-gauge, corrugated and curved, galvanized steel sheets. The use of sheet metal bins for grain storage in tropical regions has been discouraged by some observers because of moisture migration problems caused by the large diurnal temperature variations in grain adjacent to sun-exposed walls. However, the Experience, Incorporated consultant has not observed grain spoilage caused by these severe diurnal temperature fluctuations where the grain was initially adequately dried and provided with periodic aeration and good cross-ventilation over the top surface. A conical roof on a round, metal bin should not be sealed or tightly fitted to the wall at the roof eaves. Rather, it is highly advisable to support the roof two or three centimeters above the wall by special cleats and to provide for some rainproof air escape at the peak. Good cross-ventilation over the surface will dissipate moisture migration to the surface as it occurs when caused by diurnal temperature fluctuations. Periodic aeration (the slow movement of air, created by a relatively small fan, through already dried grain) will prevent build-up of moisture in certain spots or regions due to migration. A combination of cross-ventilation over the grain surface and mechanical aeration through the grain mass will dissipate any moisture migration in dry grain stored in a metal bin or in any kind of grain bin. Then, protection against surface infestation in top-ventilated bins must be provided. This can be readily accomplished by regular, periodic spraying of the grain surface with an acceptable insecticide.

The types of construction and sizes, as well as the costs of cylindrical grain bins with conical roofs, are fairly well standardized. Table B-1 is a partial list of the standardized sizes of bins available for farm installation and shows the capacity and unit costs of each size. Estimated costs are included for the concrete floor and reinforced ring foundation, which is always provided locally. The approximate shipping weights for the wall only and the wall and roof combined are also given. Figure B-3 is a suggested grain handling, conditioning, storing and processing layout for a maximum of 1,200 metric tons of bulk storage, plus a warehouse for sacked grain, machinery or other general storage. The layout consists of two 11-meter x 7.3-meter-high steel bins complete with conical roof, concrete floor and either a raised, perforated, steel drying floor (shown for one bin) or a duct system for drying (shown for the other bin). Such equipment, together with one or more mechanically driven fan is provided for drying grain after it is placed in storage. Appendix Table B-3 lists the costs of building and equipment required for a complete handling, drying, storing, aerating, cleaning and processing unit. The warehouse should be so located that it can serve as a weather protection for handling and processing as well as for a general storage warehouse.

To minimize breakage of beans when filling the bottom portions of the high bins, the elevator can be inserted through the manhole door in the fourth ring as shown in the plan-sketch. This would reduce the maximum distance of bean free-fall to less than five meters, but even this may be too high for beans with very low moisture content.

1. In-Storage Drying

Double-cropping of beans with maize or cotton will probably necessitate harvesting the first crop before it would be sufficiently dry for safe storage. A study of the weather data for mean monthly relative humidity values for the agricultural regions of Ethiopia (Figure B-4) indicates that only during the months of May, July, August and September is the average relative humidity too high for atmosphere or unheated air drying or safe storage if the grain is exposed to the outside air. As indicated on the graph, the relative humidity equilibrium for safe grain storage is 65 percent. This level provides a small margin of safety; that is, the moisture content of any grain or bean brought to equilibrium with 65 percent relative humidity air (at normal temperatures) is low enough for safe storage. The graph gives the mean values for full 24-hour days. If a drying fan were operated only during the best 12-hour period of each day, usually from 9 a.m. to 9 p.m. the average relative humidity of the air forced through the grain would be considerably less, by as much as 10 to 20 percent. But the daily rate of drying would be reduced, as fan operation would be reduced by one-half.

A more thorough analysis of the weather data available from the Awasa Station, used as an example, indicates that in-storage, unheated air drying during the months of June and September can be expected to dry maize to about 15 percent moisture content or less, with 24-hour (continuous) fan operation, or to 14 percent or less with only the best 12-hour periods of daily operation. Pea beans would be dried to about 16 to 17 percent, since their moisture values' equilibrium is somewhat higher than that of maize. Further calculations indicate that providing a fan power intensity of one horsepower per ten square meters of floor area (ten horsepower per 11-meter diameter bin), a total depth of 4.9 meters of beans, harvested and placed in the bin at 20 percent moisture, could be dried to 16 percent or less in about 20 days of continuous fan operation. The fan should be started as soon as the floor is well covered with beans. The cost of 20 days of continuous operation of two 5-horsepower electric motors, assuming electricity to cost Eth. $0.06 per kilowatt-hour, would be about Eth. $280, or Eth. $0.07 per quintal.

With the large, farm-storage and processing units, beans can be graded, hand-picked and sacked as taken from the storage bins. They can then be sold for export in large enough quantities to permit direct delivery to the port.

C. Rural Marketing, Storage, and Service Center

The plan-sketch in Figure B-5 shows a suggested grain marketing and agricultural supply service center unit designed for both bulk and sack handling and storage, with cleaning facilities for any grain and processing facilities for pulses. The unit consists of a warehouse-type roof structure, under which sets of large, three-bin units (two 11-meter diameter x 7.3 meters high and one 11-meter diameter x 12.2 meters high) can be installed progressively as expansion is required. Table B-4 gives a list of equipment and cost estimates for (1) a minimum recommended unit of about 7,200 metric tons capacity and (2) what is considered to be about a maximum expanded capacity unit. The latter would consist of ten sets of the three-bin units plus a separate large sack warehouse, the total storage capacity of which would be around 26,000 tons. The necessary handling and processing equipment, along with the cost estimates taken from Table B-2, are given in Table B-4 for these minimum and maximum-size units. It will be noted that the initial costs per metric ton of the minimum and maximum sizes are nearly equal--about Eth. $25 per metric ton.
$10

These service center units will be able to handle and store more than one kind of grain; but if intended primarily to further the pulse program, they should be designed and equipped specifically to handle and process beans. Special precautions should then be taken to prevent undesirable cracking or breakage when elevating and spouting beans into bulk storage. Elevator and auger speeds may need to be reduced, and any auger elevator should be operated with the tubes kept nearly full. Any long runs of spouting should be at the minimum slope possible to provide only the rate of flow necessary, and free-fall distances should be limited, probably to something less than three to four meters. For nearly vertical, round-tube down-spouting, excessive velocity build-up can be prevented by one or more "velocity-breaks" installed in the tubing, as shown in the sketch in Figure B-5.

In large central storage units, it is generally cumbersome and sometimes difficult to keep several lots of the same kind of grain separated. The usual practice is to accept only grain suitable for storage or marketing, except that slightly damp grain, otherwise of suitable quality, will be received at a discount if drying facilities are available. The weight, grade and dockage (including any high moisture discount) are immediately determined for each lot upon delivery, and the grain is bought outright or warehoused on this grade and dockage basis, and then comingled with other lots of the same kind of grain in the bulk storage. When the identity of small lots of sacked grain must be maintained, a special charge or price discount for extra handling could justifiably be made, which would accommodate but tend to discourage the practice of keeping small lots separated.

The flow system of the layout suggested in Figure B-5 is believed to be about as uncomplicated as can be designed and yet provide the desired convenience and efficiency of handling large quantities of grain. It provides

for immediate dumping of up to 20-metric ton loads of bulk grain and the simultaneous dumping of sacked grain into the large dump pit. From there it is elevated by a cup-belt elevator, conveyed horizontally, and then spouted into the proper bin at a maximum rate of 70 metric tons per hour, using the equipment indicated in Table B-4. For cleaning, grading, hand-picking, etc. and sacking, the grain or beans are withdrawn by gravity (or by use of the sweep auger for the last portions) from the bulk bins at a rate determined by conveyor or elevator capacity or by the size of the gate opening in the center discharge sump of the bin. A subfloor auger and a lower U-trough conveyor move the grains to the processing area. This conveyor should be reversible. At the desired point, grain or beans are discharged into a short, portable auger elevator that feeds into the cleaner-grader, from which the discharge is fed directly onto the sorting belt for hand-picking and then put into sacks. After weighing and closing, the sacks are then piled on a small dolly and wheeled to the base of the sack conveyor for temporary stacking or for loading directly onto a truck or into a railcar. Provision can also be made for the direct loading-out of grains from bulk bins.

To facilitate drying, it is recommended that perforated materials be used to cover subfloor ducts and for raised floors in bulk bins. Fumigation of bulk bins can be readily accomplished by covering the grain with a gas-proof tarpaulin, which is well weighted or sealed to the bin wall. With suitable regulations, bin sanitation and inspection, all grains or beans for export could be fumigated in these bulk bins before processing and shipping. Otherwise, they would likely be fumigated at the port in sacks; and this is a much more tedious and costly process.

APPENDIX A

TABLE A-1. ROADS UNDER MAINTENANCE, BY STANDARD TYPE (1970/71)

District	Asphalt	Gravel					Total Road System
		Primary	Secondary	Feeder	Service to Traffic	Total Gravel	
	km						
1. Alemgena	770	519	80	247	-	846	1616
2. Kombolcha	295	661	-	-	-	661	956
3. Adigrat	37	466	-	-	-	466	503
4. Dire Dawa	52	494	-	60	452	1006	1058
5. Gondar	15	525	-	25	-	550	565
6. Shashemene	181	351	476	60	-	887	1068
7. Jimma	45	423	46	80	-	549	594
8. Asmara	558	287	-	40	-	327	885
9. Debre Marcos	-	347	-	61	-	408	408
TOTAL	1953	4073	602	573	452	5700	7653

SOURCE: Imperial Highway Authority

TABLE A-2. EXPORTS OF PULSES AND CEREALS BY TYPES AND BY PORTS, 1968-1970

	Assab	Massawa	Djibouti[a]	Total
	(metric tons)			
Pulses				
Chickpeas	99	60	1,264	1,423
Field Peas	375	15	36	426
Haricot Beans	9,889	-	4,349	14,238
Horse Beans	11,883	2,371	399	14,653
Lentils	14,726	3,676	-	18,402
Subtotal-1970	36,972	6,122	6,048	49,142
Cereals				
Barley	-	-	-	-
Maize	-	-	-	-
Sorghum	7	-	3,879	3,886
TOTAL-1970	36,979	6,122	9,927	53,028
Pulses				
Chickpeas	1,900	-	3,782	5,682
Field Peas	1,385	-	365	1,750
Haricot Beans	6,877	-	5,904	12,781
Horse Beans	22,162	3,743	420	26,325
Lentils	15,877	3,460	586	19,923
Subtotal-1969	48,201	7,203	11,057	66,461
Cereals				
Barley	-	-	-	-
Maize	-	-	-	-
Sorghum	-	-	3,711	3,711
TOTAL-1969	48,201	7,203	14,768	70,172
Pulses				
Chickpeas	2,325	-	6,272	8,597
Field Peas	994	60	-	1,054
Haricot Beans	7,494	-	6,233	13,727
Horse Beans	17,576	4,243	-	21,819
Lentils	15,941	3,547	562	20,050
Subtotal-1968	44,289	7,850	13,067	65,247
Cereals				
Barley	-	-	-	-
Maize	-	-	-	-
Sorghum	51	-	919	970
TOTAL-1968	44,340	7,850	13,986	66,217

a/ Tonnages of pulses by type for Djibouti were allocated by totaling Assab, Massawa, and non-port exports, subtracting these sums from total exports of each type of pulse for the country as a whole and allocating each year's total to the port in proportion to these differences.

SOURCE: Data for Assab and Massawa by types of pulses and cereals were compiled from monthly export records of the Marine Department, Ministry of Communications, while data for Djibouti were compiled from monthly export records of cereal and pulse totals only of the Franco-Ethiopian Railway. These data do not coincide exactly with quantities reported by other agencies.

TABLE A-3. MONTHLY EXPORT OF PULSES AND CEREALS BY PORTS, 1968 THROUGH JUNE 1971.

Months	Chickpeas	Field Peas	Haricot Beans	Horse Beans	Lentils	TOTAL PULSES
PORT OF ASSAB			(metric tons)			
			1971 - (6 months)			
January	-	44	270	4,050	946	5,310
February	7	46	758	2,211	1,669	4,691
March	-	-	317	1,098	814	2,229
April	-	-	548	184	601	1,333
May	-	-	152	112	-	264
June	-	-	516	812	-	1,328
			1970			
January	-	91	970	4,080	733	5,874
February	-	20	1,222	2,096	1,727	5,065
March	20	30	186	1,174	1,534	2,944
April a/	-	71	62	750	1,355	2,238
May	75	129	142	422	505	1,273
June	-	-	167	844	-	1,011
July	-	-	547	250	983	1,780
August	4	34	123	948	1,010	2,119
September	-	-	22	688	2,729	3,439
October	-	-	1,043	252	2,738	4,033
November	-	-	1,116	30	909	2,055
December	-	-	4,289	349	503	5,141
			1969			
January	146	-	924	1,782	1,006	3,858
February	1,107	10	483	2,855	2,182	6,637
March	557	161	59	1,152	2,556	4,485
April	10	16	279	2,289	1,230	3,824
May	-	30	1,472	1,308	533	3,343
June	20	4	285	1,888	508	2,705
July	10	30	140	1,761	248	2,189
August	-	300	20	2,399	2,334	5,053
September	-	65	52	2,933	1,916	3,051
October	30	65	180	1,723	1,916	3,849
November	20	768	1,396	2,056	2,001	6,241
December	-	-	1,587	16	1,363	2,966
			1968			
January	-	152	101	2,927	1,465	4,695
February	12	152	1,271	1,319	2,060	4,814
March	542	161	444	4,421	86	5,654
April	151	-	509	1,308	1,768	3,736
May	102	40	-	1,935	939	3,016
June	-	-	325	1,318	1,042	2,685
July	-	60	469	996	1,089	2,614
August b/	287	16	204	695	1,089	2,291
September	-	40	447	1,252	716	2,455
October	758	15	-	718	658	2,149
November	281	-	1,913	30	2,340	4,564
December	192	358	1,811	657	2,689	5,707

TABLE A-3. MONTHLY EXPORT OF PULSES AND CEREALS BY PORTS, 1968 THROUGH JUNE 1971..continued

Months	Chickpeas	Field Peas	Haricot Beans	Horse Beans	Lentils	TOTAL PULSES
			(metric tons)			
PORT OF MASSAWA c/						
			1971 - (6 months)			
January	-	20	-	824	522	1,366
February	-	141	-	409	1,539	2,089
March d/	-	99	-	1,061	1,204	2,415
April	-	-	-	535	316	851
May	-	59	-	548	393	1,000
June	-	-	-	353	78	431
			1970			
January	-	-	-	403	26	429
February	-	15	-	205	364	584
March	-	-	-	171	489	660
April	60	-	-	26	770	856
May	-	-	-	33	23	56
June	-	-	-	106	-	106
July	-	-	-	155	678	833
August	-	-	-	5	-	5
September	-	-	-	-	1,208	1,208
October	-	-	-	226	43	269
November	-	-	-	307	5	312
December	-	-	-	734	70	804
			1969 e/			
January	-	-	-	596	729	1,325
February	-	-	-	85	53	138
March	-	-	-	263	1,128	1,391
April	-	-	-	322	124	446
May	-	-	-	202	663	865
June	-	-	-	141	55	196
July	-	-	-	269	136	405
August	-	-	-	139	-	139
September	-	-	-	187	20	207
October	-	-	-	340	-	340
November	-	-	-	262	252	514
December	-	-	-	937	300	1,237
			1968 f/			
January	-	-	-	482	650	1,132
February	-	-	-	334	418	752
March	-	-	-	587	1,045	1,632
April	-	60	-	382	188	630
May	-	-	-	139	141	280
June	-	-	-	190	45	235
July	-	-	-	425	38	463
August	-	-	-	286	-	286
September	-	-	-	512	383	895
October	-	-	-	311	42	353
November	-	-	-	262	252	514
December	-	-	-	333	345	678

TABLE A-3. MONTHLY EXPORT OF PULSES AND CEREALS BY PORTS, 1968 THROUGH JUNE 1971..continued

Month	1971 (6 months)		1970		1969		1968	
	Pulses g/	Cereals h/	Pulses g/	Cereals h/	Pulses g/	Cereals h/	Pulses g/	Cereals h/
				(metric tons)				
PORT OF DJIBOUTI								
January	2.327	172	1,168	1,039	2,757	217	2,026	94
February	2,808	232	429	237	1,688	172	2,065	132
March	1,174	384	769	504	1,199	197	1,591	128
April	1,193	258	412	95	423	182	590	176
May	56	103	197	232	514	313	250	21
June	313	411	247	899	96	309	268	10
July	-	-	152	89	192	474	220	10
August	-	-	101	40	192	192	563	105
September	-	-	10	45	212	384	976	91
October	-	-	86	61	128	700	308	79
November	-	-	13	237	1,732	242	1,591	42
December	-	-	2,464	392	1,924	329	2,619	31

a/ 7 metric tons of cereals (barley, maize and sorghum) were exported.

b/ 51 metric tons of cereals (barley, maize and sorghum) were exported.

c/ No cereals were exported from Massawa in 1968-1970.

d/ 51 metric tons of cereals.

e/ No chickpeas, field peas, or haricot beans were exported from Massawa in 1969.

f/ No chickpeas or haricot beans were exported.

g/ Data by type of pulses are not available.

h/ All cereal exports are sorghum.

SOURCE: Data for Assab and Massawa by types of pulses and cereals were compiled from monthly export reports of the Marine Department, Ministry of Communications, while data for Djibouti were compiled from monthly export records of cereal and pulse totals only of the Franco-Ethiopian Railway.

TABLE A-4. IMPERIAL HIGHWAY AUTHORITY DESIGN STANDARD FEEDER ROAD

(Up to 200 ADT)

Terrain	Mountainous	Rolling	Flat
1. Design Speed (kph)	30-40	40-60	60-80
2. Degree of Curve	30°-20°	20°-9°	9°-5°
3. Gradient (% grades)	10-6	9-5	8-4
4. Bituminous Pavement Width	None	None	None
5. Untreated Aggregate Width (on) a/	6.00	6.00	6.00
6. Shoulders - Both wts and fills b/	0.90	0.90	0.90
7. Non-passing Sight Distance	30m-48m	48m-77m	77m-110m
8. Super Elevation	10% (max)		
9. Widening & Casements	2.0 m	(max)	
10. Structure-Clear Right of Way Width	7.32 m		
11. Structure Clear Between Trusses	8.92 m		
12. Pavement Crown	3% - 4%		

a/ Width is from shoulder to shoulder with edges.
b/ No shoulder delineations.

APPENDIX B

TABLE B-1. CAPACITIES AND COSTS OF CYLINDRICAL, CORRUGATED

Standard US Bin Sizes Diameter (in meters)	Height	Capacity bu a/	Capacity mt b/	Weight - Pounds c/ Wall Only d/	Weight - Pounds c/ Wall & Roof e/	Cost - Eth. $/mt Steel f/	Cost - Eth. $/mt Concrete g/	Cost - Eth. $/mt Total
5.5	4.9	3,710	99	1,780	2,880	29.60	3.23	33
6.4	4.9	4,860	130	2,170	3,600	27.60	3.24	31
7.3	4.9	6,760	181	2,660	4,370	23.00	2.95	26
8.2	4.9	8,680	232	3,330	6,440	23.80	2.84	27
11.0	4.9	16,069	430	4,450	9,470	22.80	2.60	25
5.5	7.3	5,389	144	3,400	4,570	30.40	2.25	33
6.4	7.3	7,413	198	4,020	5,640	25.40	2.13	28
7.3	7.3	9,766	261	4,600	6,510	24.00	2.04	26
8.2	7.3	12,550	336	5,810	9,150	22.00	1.97	24
11.0	7.3	22,868	612	7,750	13,410	19.85	1.83	22
14.6	7.3	42,000	1,120	11,260	24,300	21.40	1.68	23
7.3	h/ 9.8	12,788	342	7,770	10,650	28.40	1.56	30
8.2	9.8	16,400	439	9,020	13,490	30.90	1.50	32
11.0	9.8	29,666	793	13,840	21,080	26.20	1.41	28
7.3	12.2	15,810	423	11,020	13,570	28.20	1.26	29
8.2	12.2	20,200	540	12,960	16,990	31.20	1.22	32
11.0	12.2	36,463	975	20,560	27,260	26.60	1.15	28
14.6	12.2	66,289	1,770	31,240	41,030	21.20	1.08	22

a/ Maximum capacity - utilizing space under roof with grain heaped to angle of repose, plus a 5% pack factor.

b/ Based on 37.4 bu/mt, or a grain density of 58.8 lb/bu, which is 0.757 mt/cubic meter.

c/ One pound - 0.454 kilogram; 2.2 lb = 1 kg

d/ Weight of wall only - each ring of proper gauge steel for structure stability.

e/ Approximate shipping weight of wall and roof sheets, and structural members.

f/ Typical, suggested US fob retail price, multiplied by 2.50 (to convert to Eth. $) for steel wall and roof only - no floor or equipment.

g/ Based on estimated cost of concrete floor and steel reinforced foundation ring, with PVC vapor barrier in floor, to be Eth. $80 per cubic meter of concrete.

h/ All bin walls higher than 7.3m are provided with Z-bar or channel, vertical stiffeners - one per foot of diameter.

TABLE B-2. GRAIN HANDLING, CONDITIONING, AND PROCESSING EQUIPMENT

Item	Approx. Weight Pounds a/	Cost New Eth. $
1. Raised, perforated, corrugated drying floor		
For: 4.9m bin	517	470
6.4m bin	689	600
7.3m bin	872	790
8.2m bin	1,121	970
11.0m bin	1,840	1,650
2. Steel support framework for above floors		
4.9m bin	701	620
6.4m bin	874	780
7.3m bin	1,178	1,050
8.2m bin	1,438	1,280
11.0m bin	2,551	2,280
3. Aeration and/or drying fan -motor units		
3/4 hp - 30cm	110	450
1 1/2 hp - 46cm	160	620
3 hp - 56cm	165	730
5 hp - 58cm	235	1,150
7 1/2 to 12 hp - 66cm	295	1,840
10 to 14 hp - 69cm	330	2,320
4. Heater, for bin drying (for LP - gas only) (69cm)	120	750
5. Spiral wire duct - (18 cm), covered with screening per 30m	100	120
6. Transition duct - fan to bin - for 69cm fan	46	230
7. Bin wall entrance collar for transition	25	120
8. Flush-type perforated floor duct, for aeration (20 x 46cm) to be installed before placing concrete floor:		
5.5m bin	-	240
6.4, 7.3, 8.2 m	-	320
11.0m	-	860
Unloading well at bin center for insertion of 36 cm subfloor auger into above duct.		30
9. Rotary grain spreader	85	460
10. Subfloor auger, tube and center sump with control gate - 11m bin	143	310
11. Sweep-auger unit - for 11m bin	40	200
12. Round tube auger - 12 gauge heavy duty tube per foot (30cm) length:		
15cm - 30 mt/hr capacity	8	16
18 cm - 45 mt/hr capacity	10	20
20cm - 60 mt/hr capacity	14	23

TABLE B-2. GRAIN HANDLING, CONDITIONING, AND PROCESSING EQUIPMENT. . . . continued

Item	Approx. Weight Pounds	Cost New Eth. $
13. Portable grain augers, with chassis (less tires), motor-mount, and drive -		
Heavy duty (20cm) auger - 50 mt/hr:		
10.7m long (7 1/2 bhp required)	680	1,250
14m long (10 bhp required)	1,130	1,570
16m long (12 bhp required)	1,190	1,760
18m long (15 bhp required)	1,240	1,880
20m long (17 bhp required)	1,420	2,020
15cm auger - 30 mt/hr:		
6.4m long (3 bhp required)	290	480
8.2m long (4 bhp required)	338	560
10.3m long (5 bhp required)	402	730
14.0m long (6 bhp required)	698	1,050
15.8m long (7 1/2 bhp required)	758	1,150
18.3m long (10 bhp required)	842	1,250
14. Air-cooled gasoline engines for above augers		
12 1/2 hp	245	690
18 hp	302	870
24 hp	347	1,060
15. Power-take-off drive for above augers (for tractor operation)	-	255
16. Utility augers, hand portable - with head-drive assembly and motor-mount brackets - 15cm - 25 mt/hr		
3.7m long (1 hp required)	104	125
5.2m long (2 hp required)	140	150
6.4m long (3 hp required)	176	185
8.2m long (5 hp required)	181	210
17. U-trough horizontal auger conveyor, with normal equipment less motor (maximum length per unit - 30m)		
23cm auger - 35 mt/hr/30m unit	-	3,400
30cm auger - 75 mt/hr/30m unit	-	4,200
36cm auger -100 mt/hr/30m unit	-	4,750
18. Cup-belt vertical elevator - less motor		
15m discharge height		
15cm x 10cm cup - 15cm spacing, 30 mt/hr		3,900
23cm x 12cm cup - 15cm spacing, 70 mt/hr		5,300
21m discharge height		
15cm x 10 cm cup		5,500
23cm x 12cm cup		8,500

TABLE B-2. GRAIN HANDLING, CONDITIONING, AND PROCESSING EQUIPMENT....continued

Item	Approx. Weight Pounds	Cost New Eth. $
19. Overhead truck, trailer hoist		2,500
20. Truck, trailer scales - 25 mt capacity		10,000
21. Portable Platform Scales		600
22. Portable, 40cm wide endless belt, sacked grain conveyor 8m long, 5m maximum lift	600	3,000
Canvas-belt conveyor for hand picking beans	-	2,000
23. Integrated bag weigher, filler, conveyor, and sewer	500	5,300
24. Bagging scale - filler	110	1,800
25. Scalper, 30 mt /hr	600	3,500
26. Seed cleaner - graders		
25 to 30 q/hr capacity	500	2,000
35 to 50 q/hr capacity	1,200	9,000
Rotating cylindrical wire screen cleaner	150	500
27. Moisture testers		
Electric (1 minute)	20	1,000
Brown - Duval (2 units)	25	625
28. Weight per unit volume (grain density) tester	5	200
29. Gram scale - 600 grams capacity	3	100
30. Bin sampling probes		
Deep bin probe - single sample	10	40
Multi-compartment probe 100cm long	6	65
165cm long	10	85
31. Selection of official grain dockage sieves	-	125
32. Official Boerner sampler	34	320
33. Single-phase - 1750 rpm electric motors		
1 hp	50	210
1 1/2 hp	75	260
2 hp	100	320
3 hp	150	440
5 hp	200	720
34. Automatic shipping grain scales		
(for bulk, rail car loadout, 70/mt /hr)	-	6,250
35. Two-wheel bag truck	60	150
Four-wheel bag truck	150	250
36. Portable bag closer	40	700

a/ One pound = 0.454 kilogram; 1 kilogram = 2.2 pounds.

TABLE B-3. STORAGE AND CONDITIONING (ELEVATING, CLEANING, DRYING, AERATION) EQUIPMENT AND COSTS FOR 1,200 METRIC TON UNIT

Structure or Equipment	Cost Eth. $
1. 2 - 11m x 7.3m round steel bins with concrete floor	27,000
2. 1 - Raised, perforated floor with steel supports - 11m	3,930
3. 1 - Floor duct system (see Appendix Fig. B-3)	
22m of main duct - 60 x 60cm cast in concrete with perforated cover -	976
76m of 20cm spiral - wire screen duct -	300
4. 4 - 5-hp fan motor units	4,600
5. 4 - Transitions and collars	1,400
6. 1 - Sub-floor and sweep auger set with 3 hp motor, 11m bin	950
7. 2 - 6.4m x 15cm roof-mounted augers (with motors)	1,250
8. 1 - 6.4m x 15cm portable auger with chassis and 3 hp electric motor	920
9. 1 - 14m x 15cm portable auger with chassis and 12 1/2 hp gas engine	1,740
10. 1 - Cylinder - screen cleaner	500
Subtotal	43,560
Plus 10% for erection and installation	4,356
11. 1 - 10m x 30m open wall, pole truss-type warehouse and machine storage @ Eth. $20/m^2	6,000
TOTAL COST NEW	Eth. $53,922
NEW COST PER QUINTAL	Eth. $ 4.40

Annual Cost in % of Cost New:

Depreciation (30 yr life)	3.33%
Interest (average 10%/2)	5.00%
Maintenance, insurance & taxes	2.66%
TOTAL	11.00%

Annual Cost (11%):	Eth. $5,930
Cost/quintal/year: 5930/12,000 =	Eth. $0.50

TABLE B-4. PROPOSED RURAL GRAIN MARKET CENTER STORAGE EQUIPMENT

Unit	Bulk	Sacks
Minimum, recommended initial capacity:	2,200	5,000 mt
Roofed over storage area	31 m x 80m	
Desired size of lot	76m x 90m	
Maximum expanded capacity:	22,000	4,000 mt
Roofed-over storage areas	31m x 140m	30 x 32m
Desired size of lot	76m x 152m	

Note: Bulk capacity can be expanded in units of 2,200 mt

COST ESTIMATES FOR MINIMUM CAPACITY UNITS

7,200 Metric Tons

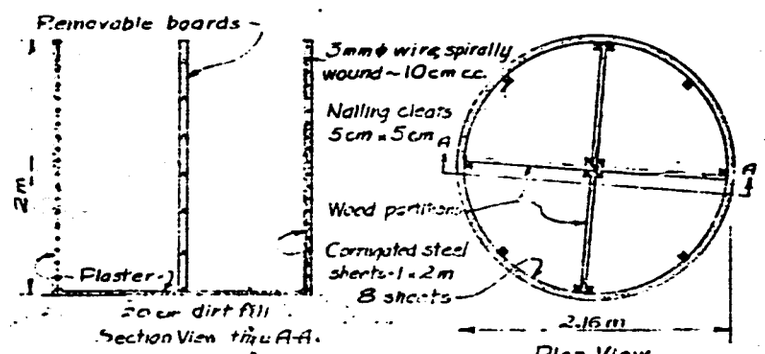
I T E M	Est. Cost Eth. $
1. Site preparation and fence 750 m^2 @ Eth. $5.00	3,750
2. Office building, 6m x 6m and truck, trailer scales	10,000
3. Concrete foundation, subfloor alley and ducts, and floor not included with bin costs 160 cu m @ Eth. $80	12,800
4. 2-11m x 7.3m bins, walls only	
2 x 7750 lbs @ Eth. $0.90/lb	13,950
1-11m x 12.2m bin - 20,560 lbs. @ Eth. $0.90	18,500
plus 10% for erection	3,245
5. Roof-structure (columns, trusses, metal roof, and erection):	
over dump pit - 6.1 x 10.3m @ Eth. $32/$m^2$	2,000
over storage area - 31m x 73m @ 32/m^2	72,400
6. Dump pit & grate (10 mt)	2,000
7. Over-head truck / trailer hoist	2,500
8. 15 m vertical leg (23 cm x 13 cm cup-belt elevator with 7 1/2 hp 3ph motor)	5,700
9. 15 m leg (15 cm x 10 cm with 5 hp, 3 ph motor)	4,200
10. Upper U-trough conveyor 30 cm x 12 m with motor	2,200
11. Lower U-trough conveyor 30 cm x 18 m with motor reversible)	2,800
12. Subfloor and sweep auger unit with 3-hp motor	950
13. Down spouting with connections and velocity - breaks (for beans) 40m @ Eth. $ 10	400
14. 2 - 3.7m x 15cm portable augers with 1-hp motors	800
15. Cleaner, grader (30 mt /hr max)	2,000
16. Sorting belt-conveyor (for picking beans)	2,000
17. Portable bag closer	700
18. Portable sack conveyor	3,000
19. Portable platform scales	600
20. Laboratory, grain testing equipment	1,600
21. 3-hp aeration fan motor unit	730
Total Cost - Eth. $	168,825
Cost per metric ton-Eth. $	23.40

TABLE B-4. PROPOSED RURAL GRAIN MARKET CENTER STORAGE EQUIPMENT... continued

COST ESTIMATES FOR MAXIMUM CAPACITY UNIT
26,000 Metric Tons

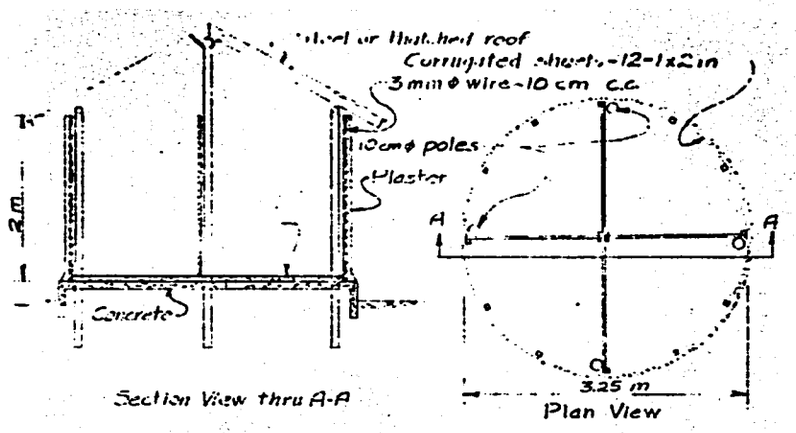
ITEM	Est. Cost Eth. $
1. Site preparation & fence 11,600 m^2 @ Eth. $5.00	5,800
2. Office building, 6m x 10m and 25-mt scales	16,000
3. Sack warehouse (separate building) 30m x 32m x 7.3m @ Eth. $50/$m^2$	48,000
4. Concrete foundation, sub-floor alley and ducts, and floor not included with bin costs 350 cu. m. @ Eth. 80	28,000
5. 20-11m x 7.3 m bins, walls only 20 x 2890 kg @ Eth. $2.40	139,500
10-11m x 12.2 m bins, walls only 10 x 7670 kg @ Eth. $2.40	185,000
plus 10% for erection	32,450
6. Roof-structure (columns, trusses, metal roof, and erection)	
Over dump-pit	2,000
Over storage bins - 31m x 121m - 3750m^2 @ Eth. $25	93,800
7. Dump-pit and grate - 10 mt	2,000
8. Overhead truck, trailer hoist	2,500
9. 15m vertical leg (23cm x 13 cm cup, with 7 1/2 hp 3 ph motor)	5,700
10. 15m (50') vertical leg (15cm x 10cm cup, with 5 hp 3 ph motor)	4,200
11. Upper U-trough conveyor - 30 cm auger 4- 30m units, each with 10 hp, 3 ph motor	18,960
12. Lower (alley) U-trough conveyor - 30 cm (12") auger 4- 30m units	18,960
13. Down spoating, connections, and velocity breaks (for beans)- 400m @ Eth. $10.	4,000
14. 10 - sets (movable) sub-floor & sweep auger units with 3 hp motors	7,600
15. 2-3.7m x 15cm portable augers - 1 hp motors	800
16. Scalper, cleaner, grader (30 mt /hr.)	3,500
17. Automatic shipping grain scales with 20m spouting (for bulk loading railcars)	6,500
18. 2 - sorting belt - conveyors (for beans)	4,000
19. 2 - integrated bag weigher, filler, closer	10,600
20. Z-Portable sack conveyors	6,000
21. Platform scales	600
22. Laboratory grain testing equipment	2,000
23. 5 - 3 hp aeration fan motor units	3,650
Total	Eth. $ 652,120
Cost per metric ton	Eth. $25.40

For a total annual cost (overhead and operating) of 15% of first cost and two complete turnovers per year, the cost for processing and storage calculates to be Eth. $0.19 per quintal per year.



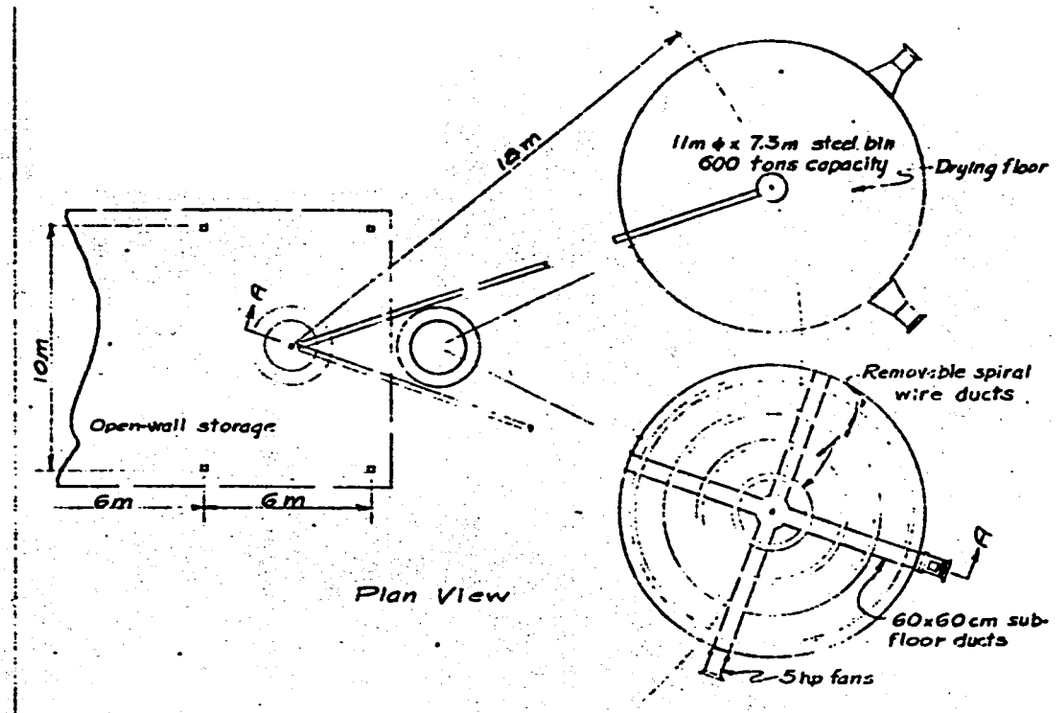
Household Storage Bin
5 tons (4 bins)

Figure B-1

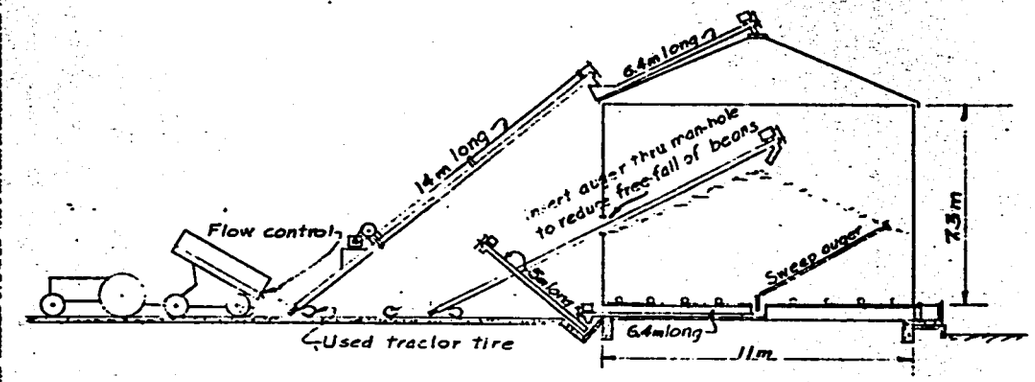


Small Farm Storage Bin
12 tons (4 bins)

Figure B-2



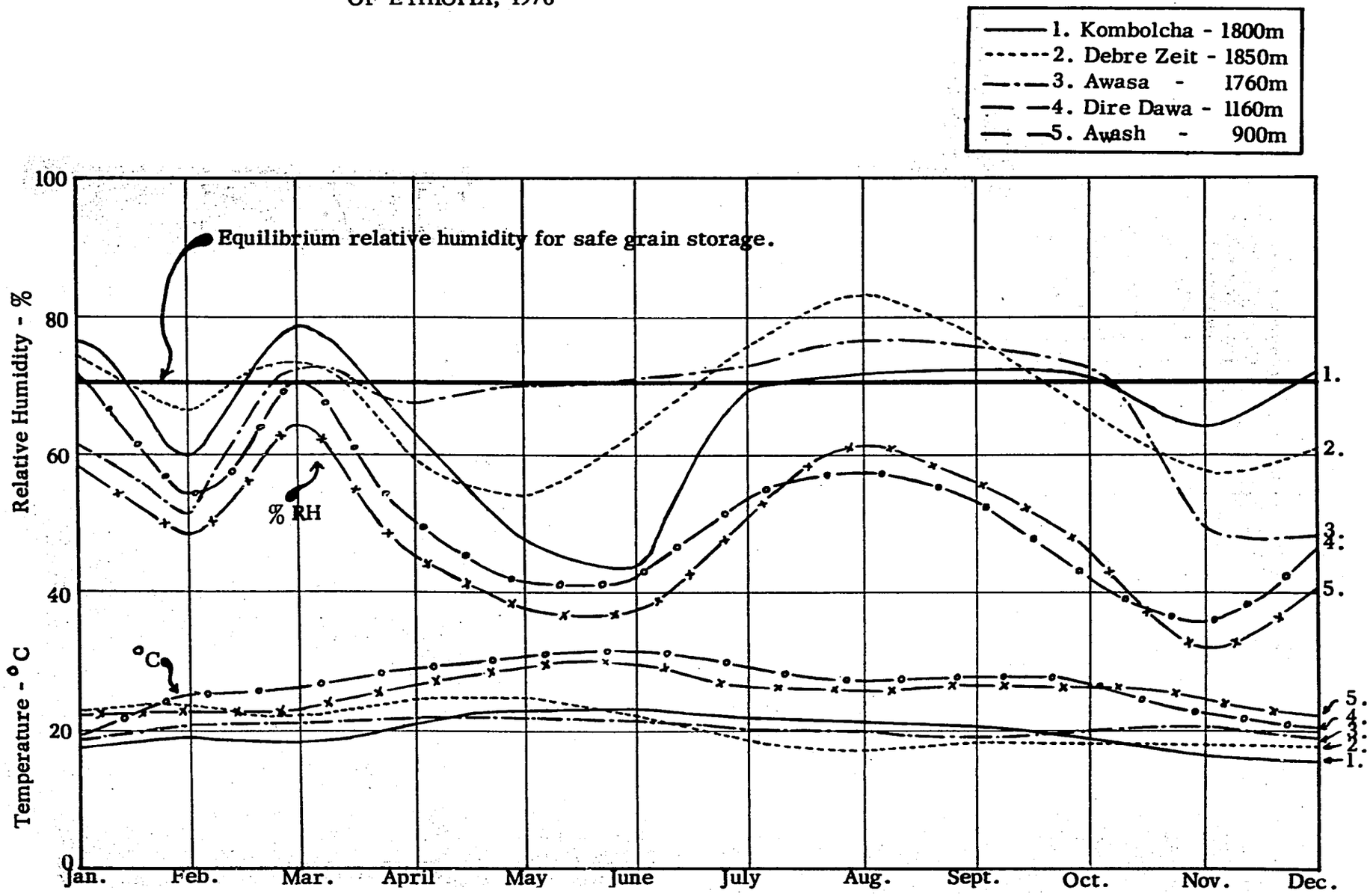
LARGE FARM GRAIN STORAGE & PROCESSING
1200 Tons Bulk & 10x12m+ Sack & General Storage
Addis Ababa Feb 6, 1972 N.C.I.



Section View thru A-A

Figure B-3

FIGURE B-4. MEAN MONTHLY RELATIVE HUMIDITIES AND TEMPERATURES FOR FIVE SELECTED AREAS OF ETHIOPIA, 1970



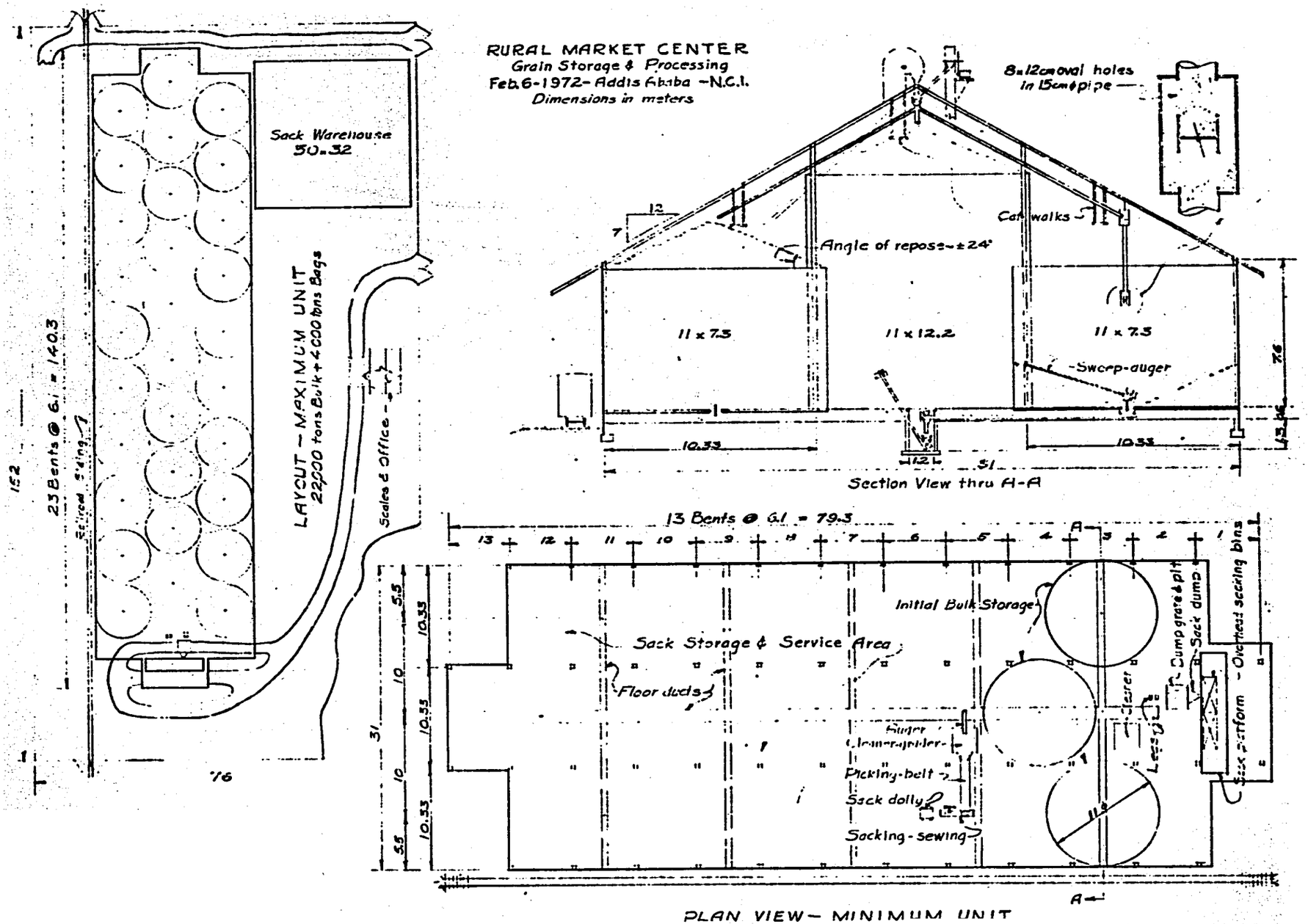

RURAL MARKET CENTER
Grain Storage & Processing
Feb. 6-1972- Addis Ababa -N.C.I.
Dimensions in meters
Sack Warehouse
50.32
LAYOUT - MAXIMUM UNIT
22,000 tons Bulk + 4000 bins Bags
23 Bents @ 6.1 = 140.3
Scales & Office
76
8-12cm oval holes in 15cm ϕ pipe
Cat walks
Angle of repose ~ ±24°
11 x 7.5
11 x 12.2
11 x 7.5
Sweep-auger
10.33
10.33
31
Section View thru A-A
13 Bents @ 6.1 = 79.3
Initial Bulk Storage
Sack Storage & Service Area
Floor ducts
Sugar
Cleaner-grader
Packing-belt
Sack dolly
Sacking-sewing
Cleaner
Legs
Dump grate & pit
Sack dump
Sack platform
Overhead sacking bins
PLAN VIEW - MINIMUM UNIT

Figure B-5